Topic 1

Units, Trigonometry, and Vectors

QUICK QUIZZES

1.1 Choice (c). The largest possible magnitude of the resultant occurs when the two vectors are in the same direction. In this case, the magnitude of the resultant is the sum of the magnitudes of $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$: $R = A + B = 20$ units. The smallest possible magnitude of the resultant occurs when the two vectors are in opposite directions, and the magnitude is the difference of the magnitudes of $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$: $R = | A - B | = 4$ units.

1.2

Vector	*x*-component	*y*-component
$\vec{\mathbf{A}}$	−	+
$\vec{\mathbf{B}}$	+	−
$\vec{\mathbf{A}} + \vec{\mathbf{B}}$	−	−

1.3 Vector $\vec{\mathbf{B}}$. The range of the inverse tangent function includes only the first and fourth quadrants (i.e., angles in the range $-\pi/2 < \theta < \pi/2$). Only

vector $\vec{\mathbf{B}}$ has an orientation in this range.

ANSWERS TO EVEN NUMBERED CONCEPTUAL QUESTIONS

1.2 Atomic clocks are based on the electromagnetic waves that atoms emit. Also, pulsars are highly regular astronomical clocks.

1.4 **(a)** ~0.5 lb ≈ 0.25 kg or ~10^{-1} kg

(b) ~4 lb ≈ 0.25 kg or ~10^{0} kg

(c) ~4 000 lb ≈ 2 000 kg or ~10^{3} kg

1.6 Let us assume the atoms are solid spheres of diameter 10^{-10} m. Then, the volume of each atom is of the order of 10^{-30} m^3. (More precisely, volume = $4\pi r^3 / 3$.) Therefore, since 1 cm^3 = 10^{-6} m^3, the number of atoms in the 1 cm^3 solid is on the order of $10^{-6} / 10^{-30} = 10^{24}$ atoms. A more precise calculation would require knowledge of the density of the solid and the mass of each atom. However, our estimate agrees with the more precise calculation to within a factor of 10.

1.8 Choice (d). For an angle θ from 0° to 360°, the sine and cosine functions take the values

$$-1 \le \sin\theta \le 1 \quad \text{and} \quad -1 \le \cos\theta \le 1$$

1.10 In the metric system, units differ by powers of ten, so it's very easy

and accurate to convert from one unit to another.

1.12 Both answers (d) and (e) could be physically meaningful. Answers (a), (b), and (c) must be meaningless since quantities can be added or subtracted only if they have the same dimensions.

1.14 The correct answer is (a). The second measurement is more precise but, given the number of reported significant figures, each measurement is consistent with the other.

1.16 The components of a vector will be equal in magnitude if the vector lies at a 45° angle with the two axes along which the components lie.

ANSWERS TO EVEN NUMBERED PROBLEMS

1.2 **(a)** L / T^2 **(b)** L

1.4 All three equations are dimensionally incorrect.

1.6 **(a)** kg · m/s **(b)** $Ft = p$

1.8 58

1.10 **(a)** 22.6 **(b)** 22.7 **(c)** 22.6 is more reliable

1.12 **(a)** 3.00×10^8 m/s **(b)** $2.997\,9 \times 10^8$ m/s

(c) $2.997\,925 \times 10^8$ m/s

1.14 **(a)** $346\ m^2 \pm 13\ m^3$ **(b)** $66.0\ m \pm 1.3\ m$

1.16 **(a)** 797 **(b)** 1.1 **(c)** 17.66

1.18 132 m^2

1.20 3.09 cm/s

1.22 **(a)** 5.60×10^2 km = 5.60×10^5 m = 5.60×10^7 cm

(b) 0.491 2 km = 4.912×10^4 cm

(c) 6.192 km = 6.192×10^3 m = 6.192×10^5 cm

(d) 2.499 km = 2.499×10^3 m = 2.499×10^5 cm

1.24 10.6 km/L

1.26 9.2 nm/s

1.28 2.9×10^2 m^3 = 2.9×10^8 cm^3

1.30 2.57×10^6 m^3

1.32 ~10^8 steps

1.34 ~10^8 people with colds on any given day

1.36 **(a)** 4.2×10^{-18} m^3 **(b)** ~10^{-1} m^3 **(c)** ~10^{16} cells

1.38 10^{-14} kg

1.40 2.2 m

1.42 8.1 cm

1.44 $\Delta s = \sqrt{r_1^2 + r_2^2 - 2r_1 r_2 \cos(\theta_1 - \theta_2)}$

1.46 2.33 m

1.48 **(a)** 1.50 m **(b)** 2.60 m

1.50 8.60 m

1.52 1.44×10^3 m

1.54 **(a)** 6.1 units at $\theta = +113°$ **(b)** 15 units at $\theta = +23°$

1.56 **(a)** 484 km **(b)** 18.1° N of W

(c) Because of Earth's curvature, the plane does not follow straight lines.

1.58 $\vec{\mathbf{R}} = 9.5$ units at 57° above the $+x$-axis

1.60 **(a)** 13.4 m **(b)** 19.9 m

1.62 1.31 km northward, 2.81 km eastward

1.64 **(a)** 10.0 m **(b)** 15.7 m **(c)** 0

1.66 42.7 yards

1.68 788 mi at 48.0° N of E

1.70 **(a)** 185 N at 77.8° from the x-axis **(b)** 185 N at 258° from the x-axis

1.72 **(a)** 1.609 km/h **(b)** 88 km/h **(c)** 16 km/h

1.74 **(a)** 7.14×10^{-2} gal/s **(b)** 2.70×10^{-4} m^3/s

(c) 1.03 h