Physics 16 – Spring 2009 – Problem Set 1

1.10. **IDENTIFY:** Convert units.

SET UP: Use the unit conversions given in the problem. Also, $100 \text{ cm} = 1 \text{ m}$ and $1000 \text{ g} = 1 \text{ kg}$.

EXECUTE: **(a)** $\left(60\dfrac{\text{mi}}{\text{h}}\right)\left(\dfrac{1\text{h}}{3600\text{s}}\right)\left(\dfrac{5280 \text{ ft}}{1\text{mi}}\right) = 88\dfrac{\text{ft}}{\text{s}}$

(b) $\left(32\dfrac{\text{ft}}{\text{s}^2}\right)\left(\dfrac{30.48\text{cm}}{1\text{ft}}\right)\left(\dfrac{1 \text{ m}}{100 \text{ cm}}\right) = 9.8\dfrac{\text{m}}{\text{s}^2}$

(c) $\left(1.0\dfrac{\text{g}}{\text{cm}^3}\right)\left(\dfrac{100 \text{ cm}}{1 \text{ m}}\right)^3\left(\dfrac{1 \text{ kg}}{1000 \text{ g}}\right) = 10^3\dfrac{\text{kg}}{\text{m}^3}$

EVALUATE: The relations $60 \text{ mi/h} = 88 \text{ ft/s}$ and $1 \text{ g/cm}^3 = 10^3 \text{ kg/m}^3$ are exact. The relation $32 \text{ ft/s}^2 = 9.8 \text{ m/s}^2$ is accurate to only two significant figures.

1.43. **IDENTIFY:** Vector addition problem. $\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$.

SET UP: Find the x- and y-components of $\vec{A}$ and $\vec{B}$. Then the x- and y-components of the vector sum are calculated from the x- and y-components of $\vec{A}$ and $\vec{B}$.

EXECUTE:

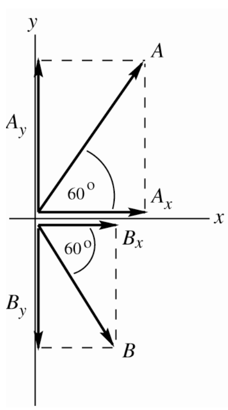

Figure 1.43a

$A_x = A\cos(60.0°)$

$A_x = (2.80 \text{ cm})\cos(60.0°) = +1.40 \text{ cm}$

$A_y = A\sin(60.0°)$

$A_y = (2.80 \text{ cm})\sin(60.0°) = +2.425 \text{ cm}$

$B_x = B\cos(-60.0°)$

$B_x = (1.90 \text{ cm})\cos(-60.0°) = +0.95 \text{ cm}$

$B_y = B\sin(-60.0°)$

$B_y = (1.90 \text{ cm})\sin(-60.0°) = -1.645 \text{ cm}$

Note that the signs of the components correspond to the directions of the component vectors.

(a) Now let $\vec{R} = \vec{A} + \vec{B}$.

$R_x = A_x + B_x = +1.40 \text{ cm} + 0.95 \text{ cm} = +2.35 \text{ cm}.$

$R_y = A_y + B_y = +2.425 \text{ cm} - 1.645 \text{ cm} = +0.78 \text{ cm}.$

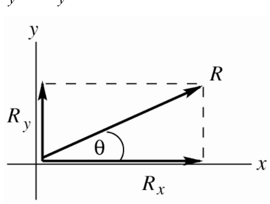

Figure 1.43b

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(2.35 \text{ cm})^2 + (0.78 \text{ cm})^2}$

$R = 2.48 \text{ cm}$

$\tan\theta = \dfrac{R_y}{R_x} = \dfrac{+0.78 \text{ cm}}{+2.35 \text{ cm}} = +0.3319$

$\theta = 18.4°$

EVALUATE: The vector addition diagram for $\vec{R} = \vec{A} + \vec{B}$ is

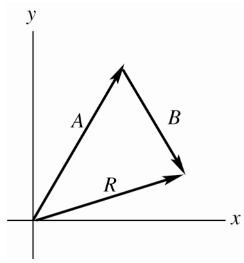

Figure 1.43c

$\vec{R}$ is in the 1st quadrant, with $|R_y| < |R_x|$, in agreement with our calculation.

(b) EXECUTE: Now let $\vec{R} = \vec{A} - \vec{B}$.

$R_x = A_x - B_x = +1.40 \text{ cm} - 0.95 \text{ cm} = +0.45 \text{ cm}.$

$R_y = A_y - B_y = +2.425 \text{ cm} + 1.645 \text{ cm} = +4.070 \text{ cm}.$

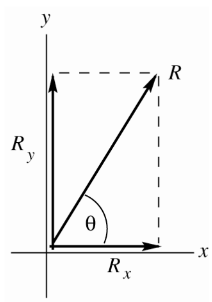

Figure 1.43d

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(0.45 \text{ cm})^2 + (4.070 \text{ cm})^2}$

$R = 4.09$ cm

$\tan\theta = \dfrac{R_y}{R_x} = \dfrac{4.070 \text{ cm}}{0.45 \text{ cm}} = +9.044$

$\theta = 83.7°$

EVALUATE: The vector addition diagram for $\vec{R} = \vec{A} + \left(-\vec{B}\right)$ is

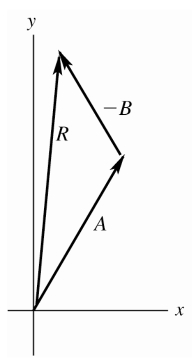

Figure 1.43e

$\vec{R}$ is in the 1st quadrant, with $|R_x| < |R_y|$, in agreement with our calculation.

(c) EXECUTE:

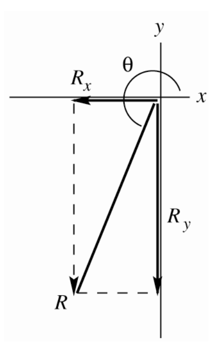

Figure 1.43f

$\vec{B} - \vec{A} = -\left(\vec{A} - \vec{B}\right)$

$\vec{B} - \vec{A}$ and $\vec{A} - \vec{B}$ are equal in magnitude and opposite in direction.

$R = 4.09$ cm and

$\theta = 83.7° + 180° = 264°$

EVALUATE: The vector addition diagram for $\vec{R} = \vec{B} + (-\vec{A})$ is

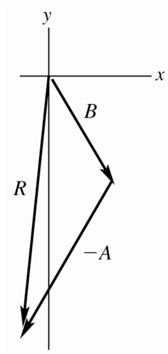

Figure 1.43g

$\vec{R}$ is in the 3rd quadrant, with $|R_x| < |R_y|$, in agreement with our calculation.

1.49. **IDENTIFY:** Use trig to find the components of each vector. Use Eq.(1.11) to find the components of the vector sum. Eq.(1.14) expresses a vector in terms of its components.

SET UP: Use the coordinates in the figure that accompanies the problem.

EXECUTE: **(a)** $\vec{A} = (3.60\text{ m})\cos 70.0°\hat{i} + (3.60\text{ m})\sin 70.0°\hat{j} = (1.23\text{ m})\hat{i} + (3.38\text{ m})\hat{j}$

$\vec{B} = -(2.40\text{ m})\cos 30.0°\hat{i} - (2.40\text{ m})\sin 30.0°\hat{j} = (-2.08\text{ m})\hat{i} + (-1.20\text{ m})\hat{j}$

(b) $\vec{C} = (3.00)\vec{A} - (4.00)\vec{B}$

$= (3.00)(1.23\text{ m})\hat{i} + (3.00)(3.38\text{ m})\hat{j} - (4.00)(-2.08\text{ m})\hat{i} - (4.00)(-1.20\text{ m})\hat{j}$

$= (12.01\text{ m})\hat{i} + (14.94)\hat{j}$

(c) From Equations (1.7) and (1.8),

$C = \sqrt{(12.01\text{ m})^2 + (14.94\text{ m})^2} = 19.17\text{ m}$, $\arctan\left(\frac{14.94\text{ m}}{12.01\text{ m}}\right) = 51.2°$

EVALUATE: C_x and C_y are both positive, so θ is in the first quadrant.