Worksheet - Phys 105

Chapter 3

Q1. A baseball "diamond" is a square with sides 90ft in length. If the positive x axis points from home plate to first base, and the positive y axis points from home plate to third base, find the displacement vector of a base runner who has just hit

(a) a double (runner goes from home plate to second base

(b) a triple (Runner goes from home plate to third base)

(c) a homerun. (Hit a home run: the runner returns to the starting point)

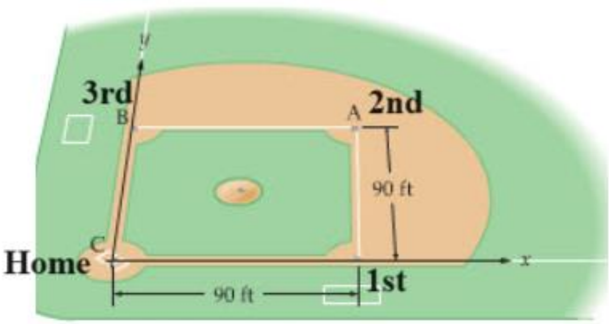


FIGURE 3–32 Problem 9

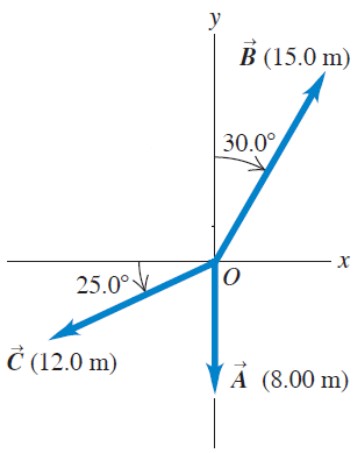
Q2. Given two vectors, $\vec{A} = 2\vec{\imath} - 3\vec{\jmath}$ and $\vec{B} = 5\vec{\imath} + \vec{\jmath}$, find

(a) Find the magnitude of $|\vec{A}|$ and $|\vec{B}|$

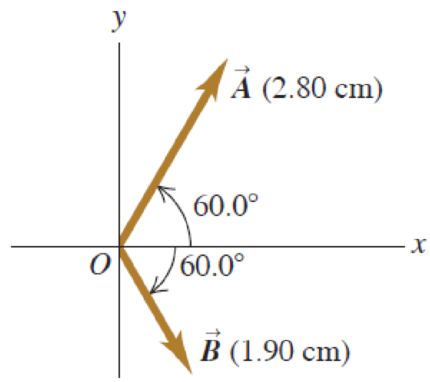
(b) Find the magnitude and direction of the vector sum $(\vec{A} + \vec{B})$

(c) Find the magnitude and direction of the vector difference $(\vec{A} - \vec{B})$

Q3. (1.42) For the vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ in Figure below, find the scalar products (a) $\vec{A} \cdot \vec{B}$; (b) $\vec{B} \cdot \vec{C}$; (c) $\vec{A} \cdot \vec{C}$



Q6. (1.44) For the two vectors in Figure below, find the magnitude and direction of (a) the vector product $\vec{A} \times \vec{B}$; (b) the vector product $\vec{B} \times \vec{A}$



Q7.

EXERCISE 3–1

a. Find A_x and A_y for the vector $\vec{\mathbf{A}}$ with magnitude and direction given by $A = 3.5$ m and $\theta = 66°$, respectively.

b. Find B and θ for the vector $\vec{\mathbf{B}}$ with components $B_x = 75.5$ m and $B_y = 6.20$ m.

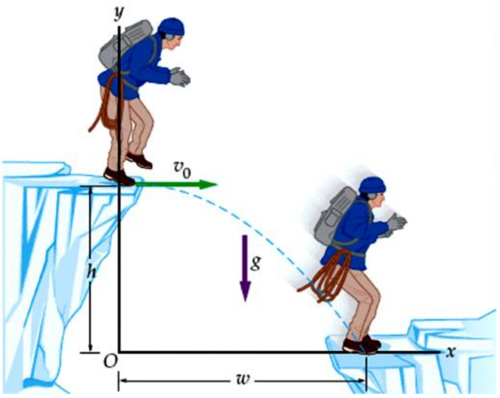
Chapter 4

Q.1

16. •• **IP** A crow is flying horizontally with a constant speed of 2.70 m/s when it releases a clam from its beak (Figure 4–14). The clam lands on the rocky beach 2.10 s later. Just before the clam lands, what is **(a)** its horizontal component of velocity, and **(b)** its vertical component of velocity?

Q2.

A mountain climber encounters a crevasse in an ice field. The opposite side of the crevasse is 2.75 m lower, and is separated horizontally by a distance of 4.10 m. To cross the crevasse, the climber gets a running start and jumps in the horizontal direction. **(a)** What is the minimum speed needed by the climber to safely cross the crevasse? If, instead, the climber's speed is 6.00 m/s, **(b)** where does the climber land, and **(c)** what is the climber's speed on landing?



Q3. A cork shoots out of a Pepsi bottle at an angle of 35.0˚ above the horizontal. If the cork travels a horizontal distance of 1.30 m in 1.25 s, what was its initial speed.

Q4. John is on top of the building and jack is down. If john throws a ball at an angle of 60º and with initial velocity 20 m/s. At what height will the ball reach after 2 s?

Q5. A golfer gives a ball a maximum initial speed of 34 m/s. The ball left the club 45.0˚ above the horizontal.

(a) What is the longest possible hole-in-one for this golfer? Neglect any distance the ball might roll on the green are at the same level.

(b) what is the minimum speed of the ball during this hole-in-shot?

Answer key

Chapter 3

Q1. A baseball "diamond" is a square with sides 90ft in length. If the positive x axis points from home plate to first base, and the positive y axis points from home plate to third base, find the displacement vector of a base runner who has just hit
(a) a double (runner goes from home plate to second base)
(b) a triple (Runner goes from home plate to third base)
(c) a homerun. (Hit a home run: the runner returns to the starting point)

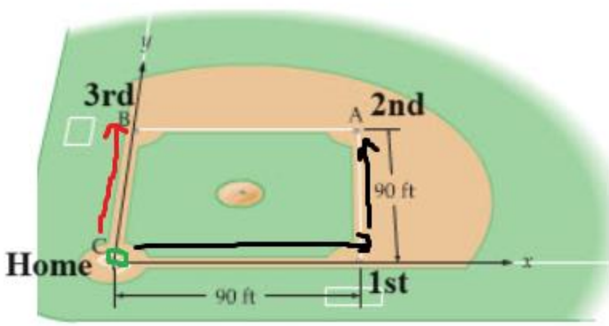


FIGURE 3–32 Problem 9

Solution: 1. (a) Write the displacement vector from C to A in terms of its *x* and *y* components:

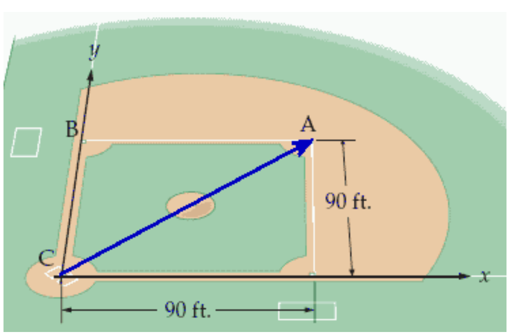
$$\vec{\mathbf{r}} = \boxed{(90\text{ ft})\hat{\mathbf{x}} + (90\text{ ft})\hat{\mathbf{y}}}$$

2. (b) Write the displacement vector from C to B in terms of its *x* and *y* components:

$$\vec{\mathbf{r}} = (0\text{ ft})\hat{\mathbf{x}} + (90\text{ ft})\hat{\mathbf{y}} = \boxed{(90\text{ ft})\hat{\mathbf{y}}}$$

3. (c) For a home run the displacement is zero:

$$\vec{\mathbf{r}} = \boxed{(0\text{ ft})\hat{\mathbf{x}} + (0\text{ ft})\hat{\mathbf{y}}}$$



Q2. Given two vectors, $\vec{A} = 2\vec{\imath} - 3\vec{\jmath}$ and $\vec{B} = 5\vec{\imath} + \vec{\jmath}$, find

(a) Find the magnitude of $|\vec{A}|$ and $|\vec{B}|$

(b) Find the magnitude and direction of the vector sum $(\vec{A} + \vec{B})$

(c) Find the magnitude and direction of the vector difference $(\vec{A} - \vec{B})$

Solution

$|\vec{A}| = \sqrt{x^2 + y^2} = \sqrt{2^2 + (-3)^2}$ =3.6

$|\vec{B}| = \sqrt{x^2 + y^2} = \sqrt{5^2 + 1^2} = 5.1$

$$\begin{aligned}\text{(b) } \vec{\mathbf{A}} + \vec{\mathbf{B}} &= (A_x + B_x)\,\hat{\mathbf{i}} + (A_y + B_y)\,\hat{\mathbf{j}} \\ &= (2+5)\,\hat{\mathbf{i}} + (-3+1)\,\hat{\mathbf{j}} \\ &= 7\,\hat{\mathbf{i}} - 2\,\hat{\mathbf{j}}\end{aligned}$$

$$\begin{aligned}\text{(C) } \vec{\mathbf{A}} - \vec{\mathbf{B}} &= (A_x - B_x)\,\hat{\mathbf{i}} + (A_y - B_y)\,\hat{\mathbf{j}} \\ &= (2-5)\,\hat{\mathbf{i}} + (-3-1)\,\hat{\mathbf{j}} \\ &= -3\,\hat{\mathbf{i}} - 4\,\hat{\mathbf{j}}\end{aligned}$$

Magnitude

$|\vec{A} + \vec{B}| = \sqrt{x^2 + y^2} = \sqrt{7^2 + (-2)^2}$ =7.3

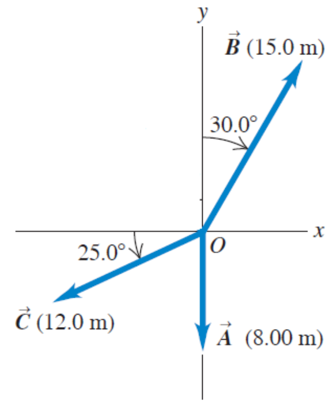
$$\theta_1 = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{-2}{7}\right) = -15.9°$$

$|\vec{A} - \vec{B}| = \sqrt{x^2 + y^2} = \sqrt{(-3)^2 + (-4)^2} = 5.0$

$$\theta_2 = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{-4}{-3}\right) = 36°$$

Q3. **(1.42)** For the vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ in Figure below, find the scalar products (a) $\vec{A}\cdot\vec{B}$; (b) $\vec{B}\cdot\vec{C}$; (c) $\vec{A}\cdot\vec{C}$

.



Solution

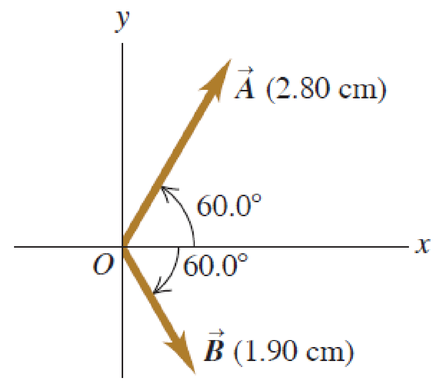
$\vec{\boldsymbol{A}}\cdot\vec{\boldsymbol{B}} = AB\cos\phi$

For $\vec{\boldsymbol{A}}$ and $\vec{\boldsymbol{B}}$, $\phi = 150.0°$. For $\vec{\boldsymbol{B}}$ and $\vec{\boldsymbol{C}}$, $\phi = 145.0°$. For $\vec{\boldsymbol{A}}$ and $\vec{\boldsymbol{C}}$, $\phi = 65.0°$.

(a) $\vec{\boldsymbol{A}}\cdot\vec{\boldsymbol{B}} = (8.00\text{ m})(15.0\text{ m})\cos 150.0° = -104\text{ m}^2$

(b) $\vec{\boldsymbol{B}}\cdot\vec{\boldsymbol{C}} = (15.0\text{ m})(12.0\text{ m})\cos 145.0° = -148\text{ m}^2$

Q4. (1.44) For the two vectors in Figure below, find the magnitude and direction of (a) the vector product $\vec{A}\times\vec{B}$; (b) the vector product $\vec{B}\times\vec{A}$



Solution

The right-hand rule gives the direction and $|\vec{\boldsymbol{A}}\times\vec{\boldsymbol{B}}| = AB\sin\phi$ gives the magnitude.

$\phi = 120.0°$.

(a) The direction of $\vec{\boldsymbol{A}}\times\vec{\boldsymbol{B}}$ is into the page (the $-z$-direction). The magnitude of the vector product is $AB\sin\phi = (2.80\text{ cm})(1.90\text{ cm})\sin 120° = 4.61\text{ cm}^2$.

(b) Rather than repeat the calculations, $\vec{\boldsymbol{B}}\times\vec{\boldsymbol{A}} = -\vec{\boldsymbol{A}}\times\vec{\boldsymbol{B}}$ may be used to see that $\vec{\boldsymbol{B}}\times\vec{\boldsymbol{A}}$ has magnitude 4.61 cm^2 and is in the $+z$-direction (out of the page).

Q7.

EXERCISE 3–1

a. Find A_x and A_y for the vector $\vec{\mathbf{A}}$ with magnitude and direction given by $A = 3.5$ m and $\theta = 66°$, respectively.

b. Find B and θ for the vector $\vec{\mathbf{B}}$ with components $B_x = 75.5$ m and $B_y = 6.20$ m.

SOLUTION

a. $A_x = 1.4$ m, $A_y = 3.2$ m

b. $B = 75.8$ m, $\theta = 4.69°$

Chapter 4

Q1.

16. •• IP A crow is flying horizontally with a constant speed of 2.70 m/s when it releases a clam from its beak (Figure 4–14). The clam lands on the rocky beach 2.10 s later. Just before the clam lands, what is **(a)** its horizontal component of velocity, and **(b)** its vertical component of velocity?

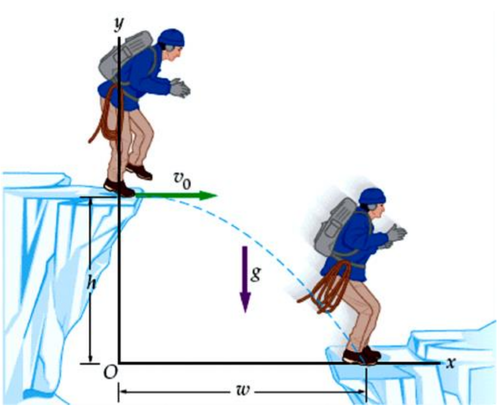
Solution: **1. (a)** The horizontal velocity remains constant at $\boxed{2.70\text{ m/s}}$.

2. (b) The vertical speed increases due to the acceleration of gravity:

$$v_y = -gt = -\left(9.81\text{ m/s}^2\right)\left(2.10\text{ s}\right) = \boxed{-20.6\text{ m/s}}$$

Q5.

A mountain climber encounters a crevasse in an ice field. The opposite side of the crevasse is 2.75 m lower, and is separated horizontally by a distance of 4.10 m. To cross the crevasse, the climber gets a running start and jumps in the horizontal direction. **(a)** What is the minimum speed needed by the climber to safely cross the crevasse? If, instead, the climber's speed is 6.00 m/s, **(b)** where does the climber land, and **(c)** what is the climber's speed on landing?



Part (a)

1. Set $y = h - \frac{1}{2}gt^2$ equal to zero (landing condition) and solve for the corresponding time t:

$$y = h - \tfrac{1}{2}gt^2 = 0$$
$$t = \sqrt{\frac{2h}{g}}$$

2. Substitute this expression for t into the x equation of motion, $x = v_0 t$, and solve for the speed, v_0:

$$x = v_0 t = v_0\sqrt{\frac{2h}{g}} \quad \text{or} \quad v_0 = x\sqrt{\frac{g}{2h}}$$

3. Substitute numerical values in this expression:

$$v_0 = x\sqrt{\frac{g}{2h}} = (4.10\ \text{m})\sqrt{\frac{9.81\ \text{m/s}^2}{2(2.75\ \text{m})}} = 5.48\ \text{m/s}$$

Part (b)

4. Substitute $v_0 = 6.00\ \text{m/s}$ into the expression for x obtained in Step 2, $x = v_0\sqrt{2h/g}$:

$$x = v_0\sqrt{\frac{2h}{g}} = (6.00\ \text{m/s})\sqrt{\frac{2(2.75\ \text{m})}{9.81\ \text{m/s}^2}} = 4.49\ \text{m}$$

Part (c)

5. Use the fact that the x component of velocity does not change to determine v_x, and use $v_y^2 = -2g\Delta y$ to determine v_y. For v_y, note that we choose the minus sign for the square root because the climber is moving downward:

$$v_x = v_0 = 6.00\ \text{m/s}$$
$$v_y = \pm\sqrt{-2g\Delta y}$$
$$= -\sqrt{-2(9.81\ \text{m/s}^2)(-2.75\ \text{m})} = -7.35\ \text{m/s}$$

6. Use the Pythagorean theorem to determine the speed:

$$v = \sqrt{v_x^2 + v_y^2}$$
$$= \sqrt{(6.00\ \text{m/s})^2 + (-7.35\ \text{m/s})^2} = 9.49\ \text{m/s}$$

Q3. A cork shoots out of a Pepsi bottle at an angle of 35.0° above the horizontal. If the cork travels a horizontal distance of 1.30 m in 1.25 s, what was its initial speed.

Solution: 1. Find the horizontal speed of the cork:

$$v_x = \frac{x}{t} = \frac{1.30\ \text{m}}{1.25\ \text{s}} = 1.04\ \text{m/s} = v_{0x}$$

2. Use the cosine function to find the initial speed:

$$v_0 = \frac{v_{0x}}{\cos\theta} = \frac{1.04\ \text{m/s}}{\cos 35.0°} = \boxed{1.27\ \text{m/s}}$$

Insight: Because gravity acts only in the vertical direction, the horizontal component of the cork's velocity remains unchanged throughout the flight.

Q4. John is on top of the building and jack is down. If john throws a ball at an angle of 60° and with initial velocity 20 m/s. At what height will the ball reach after 2 s?

Solution

$$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$$

$$y = 0 + v_0\ sin\theta\ t - \frac{1}{2}gt^2$$

$$y = 0 + (20)(sin60°)(2s) - \frac{1}{2}(9.81)(2)^2 = 15.04\ m$$

Q5. A golfer gives a ball a maximum initial speed of 34 m/s. The ball left the club 45.0˚ above the horizontal.

(a) What is the longest possible hole-in-one for this golfer? Neglect any distance the ball might roll on the green are at the same level.

(b) what is the minimum speed of the ball during this hole-in-shot?

Solution

(a) Find the range of the ball when it is launched at 45° by using equation 4-12

$$R = \left(\frac{v_0^2}{g}\right)\sin 2\theta = \left[\frac{(34.4\text{ m/s})^2}{9.81\text{ m/s}^2}\right]\sin 90° = \boxed{121\text{ m}}$$

(b) Find the *x* component of the ball's velocity, which corresponds to the minimum speed during the flight:

$$v_{0x} = v_0 \cos\theta = (34.4\text{ m/s})\cos 45° = \boxed{24.3\text{ m/s}}$$