Homework 3 Solutions **PHYS 211** **Dr. Amir**

Chap.2

51. Choose upward to be the positive direction, and take $y_0 = 0$ to be at the height where the ball was hit. For the upward path, $v_0 = 20\,\text{m/s}$, $v = 0$ at the top of the path, and $a = -9.80\,\text{m/s}^2$.

(*a*) The displacement can be found from Eq. 2-12c, with *x* replaced by *y*.

$$v^2 = v_0^2 + 2a\left(y - y_0\right) \quad \rightarrow \quad y = y_0 + \frac{v^2 - v_0^2}{2a} = 0 + \frac{0 - \left(20\,\text{m/s}\right)^2}{2\left(-9.80\,\text{m/s}^2\right)} = \boxed{20\,\text{m}}$$

(*b*) The time of flight can be found from Eq. 2-12b, with *x* replaced by *y*, using a displacement of 0 for the displacement of the ball returning to the height from which it was hit.

$$y = y_0 + v_0 t + \tfrac{1}{2}at^2 = 0 \quad \rightarrow \quad t\left(v_0 + \tfrac{1}{2}at\right) = 0 \quad \rightarrow \quad t = 0\ ,\ t = \frac{2v_0}{-a} = \frac{2\left(20\,\text{m/s}\right)}{9.80\,\text{m/s}^2} = \boxed{4\,\text{s}}$$

The result of t = 0 s is the time for the original displacement of zero (when the ball was hit), and the result of t = 4 s is the time to return to the original displacement. Thus the answer is t = 4 s.

63. Choose up to be the positive direction, so $a = -g$. Let the ground be the $y = 0$ location. As an intermediate result, the velocity at the bottom of the window can be found from the data given. Assume the rocket is at the bottom of the window at t = 0, and use Eq. 2-12b.

$$y_{\substack{\text{top of}\\\text{window}}} = y_{\substack{\text{bottom of}\\\text{window}}} + v_{\substack{\text{bottom of}\\\text{window}}} t_{\substack{\text{pass}\\\text{window}}} + \tfrac{1}{2}at^2_{\substack{\text{pass}\\\text{window}}} \quad \rightarrow$$

$$10.0\,\text{m} = 8.0\,\text{m} + v_{\substack{\text{bottom of}\\\text{window}}}\left(0.15\,\text{s}\right) + \tfrac{1}{2}\left(-9.80\,\text{m/s}^2\right)\left(0.15\,\text{s}\right)^2 \quad \rightarrow \quad v_{\substack{\text{bottom of}\\\text{window}}} = 14.07\,\text{m/s}$$

Now use the velocity at the bottom of the window with Eq. 2-12c to find the launch velocity, assuming the launch velocity was achieved at the ground level.

$$v^2_{\substack{\text{bottom of}\\\text{window}}} = v^2_{\text{launch}} + 2a\left(y - y_0\right) \quad \rightarrow$$

$$v_{\text{launch}} = \sqrt{v^2_{\substack{\text{bottom of}\\\text{window}}} - 2a\left(y - y_0\right)} = \sqrt{\left(14.07\,\text{m/s}\right)^2 + 2\left(9.80\,\text{m/s}^2\right)\left(8.0\,\text{m}\right)} = 18.84\,\text{m/s}$$

$$\approx \boxed{18.8\,\text{m/s}}$$

The maximum height can also be found from Eq. 2-12c, using the launch velocity and a velocity of 0 at the maximum height.

$$v^2_{\substack{\text{maximum}\\ \text{height}}} = v^2_{\text{launch}} + 2a\left(y_{\max} - y_0\right) \quad \rightarrow$$

$$y_{\max} = y_0 + \frac{v^2_{\substack{\text{maximum}\\ \text{height}}} - v^2_{\text{launch}}}{2a} = \frac{-(18.84\,\text{m/s})^2}{2\left(-9.80\,\text{m/s}^2\right)} = \boxed{18.1\,\text{m}}$$

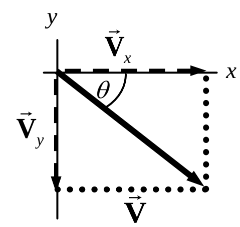
67. The displacement is found from the integral of the velocity, over the given time interval.

$$\Delta x = \int_{t_1}^{t_2} v\,dt = \int_{t=1.5\text{s}}^{t=3.1\text{s}} (25+18t)\,dt = \left(25t+9t^2\right)\Big|_{t=1.5\text{s}}^{t=3.1\text{s}} = \left[25(3.1)+9(3.1)^2\right]-\left[25(1.5)+9(1.5)^2\right]$$

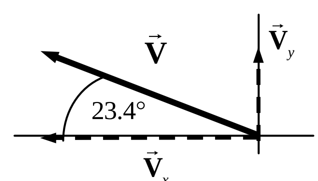
$$= \boxed{106\,\text{m}}$$

Chap.3

3. 3. Given that $V_x = 7.80$ units and $V_y = -6.40$ units, the magnitude of $\vec{\mathbf{V}}$ is given by $V = \sqrt{V_x^2 + V_y^2} = \sqrt{7.80^2 + (-6.40)^2} = \boxed{10.1\,\text{units}}$. The direction is given by $\theta = \tan^{-1}\frac{-6.40}{7.80} = \boxed{-39.4^\circ}$, 39.4° below the positive *x*-axis.



5. (*a*) See the accompanying diagram



(*b*) $V_x = -24.8\cos 23.4^\circ = \boxed{-22.8\text{ units}}$ $\quad V_y = 24.8\sin 23.4^\circ = \boxed{9.85\text{ units}}$

(*c*) $V = \sqrt{V_x^2 + V_y^2} = \sqrt{(-22.8)^2 + (9.85)^2} = \boxed{24.8\text{ units}}$

$\theta = \tan^{-1}\frac{9.85}{22.8} = \boxed{23.4^\circ\text{above the } -x \text{ axis}}$

10. $A_x = 44.0\cos 28.0^\circ = 38.85$ $\quad A_y = 44.0\sin 28.0^\circ = 20.66$

$B_x = -26.5\cos 56.0^\circ = -14.82$ $\quad B_y = 26.5\sin 56.0^\circ = 21.97$

$C_x = 31.0\cos 270^\circ = 0.0$ $\quad C_y = 31.0\sin 270^\circ = -31.0$

(*a*) $\left(\vec{\mathbf{A}}+\vec{\mathbf{B}}+\vec{\mathbf{C}}\right)_x = 38.85 + (-14.82) + 0.0 = 24.03 = \boxed{24.0}$

$\left(\vec{\mathbf{A}}+\vec{\mathbf{B}}+\vec{\mathbf{C}}\right)_y = 20.66 + 21.97 + (-31.0) = 11.63 = \boxed{11.6}$

(*b*) $\left|\vec{\mathbf{A}}+\vec{\mathbf{B}}+\vec{\mathbf{C}}\right| = \sqrt{(24.03)^2 + (11.63)^2} = \boxed{26.7}$ $\qquad \theta = \tan^{-1}\frac{11.63}{24.03} = \boxed{25.8^\circ}$

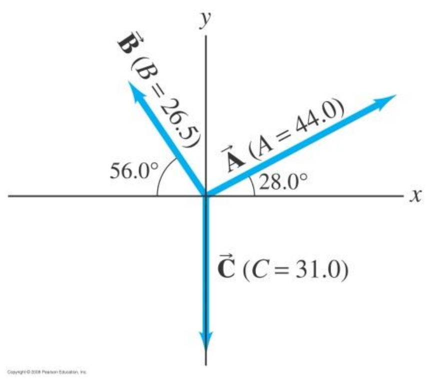


Fig. 3–38

38. Choose the origin to be the point on the ground directly below the point where the baseball was hit. Choose upward to be the positive *y* direction. Then $y_0 = 1.0\,\text{m}$, $y = 13.0\,\text{m}$ at the end of the motion, $v_{y0} = (27.0 \sin 45.0°)\,\text{m/s} = 19.09\,\text{m/s}$, and $a_y = -9.80\,\text{m/s}^2$. Use Eq. 2-12b to find the time of flight.

$$y = y_0 + v_{y0}t + \tfrac{1}{2}a_y t^2 \quad \rightarrow \quad \tfrac{1}{2}a_y t^2 + v_{y0}t + (y_0 - y) = 0 \quad \rightarrow$$

$$t = \frac{-v_{y0} \pm \sqrt{v_{y0}^2 - 4\left(\tfrac{1}{2}a_y\right)(y_0 - y)}}{2\,\tfrac{1}{2}a_y} = \frac{-19.09 \pm \sqrt{(19.09)^2 - 2(-9.80)(-12.0)}}{-9.80}$$

$$= 0.788\,\text{s},\ 3.108\,\text{s}$$

The smaller time is the time the baseball reached the building's height on the way up, and the larger time is the time the baseball reached the building's height on the way down. We must choose the larger result, because the baseball cannot land on the roof on the way up. Now calculate the horizontal distance traveled using the horizontal motion at constant velocity.

$$\Delta x = v_x t = \left[(27.0 \cos 45.0°)\,\text{m/s}\right](3.108\,\text{s}) = \boxed{59.3\,\text{m}}$$

46. Choose the origin to be at ground level, under the place where the projectile is launched, and upwards to be the positive *y* direction. For the projectile, $v_0 = 65.0\,\text{m/s}$, $\theta_0 = 35.0°$, $a_y = -g$, $y_0 = 115\,\text{m}$, and $v_{y0} = v_0 \sin\theta_0$.

(*a*) The time taken to reach the ground is found from Eq. 2-12b, with a final height of 0.

$$y = y_0 + v_{y0}t + \tfrac{1}{2}a_y t^2 \quad \rightarrow \quad 0 = y_0 + v_0 \sin\theta_0 t - \tfrac{1}{2}gt^2 \quad \rightarrow$$

$$t = \frac{-v_0 \sin\theta_0 \pm \sqrt{v_0^2 \sin^2\theta_0 - 4\left(-\tfrac{1}{2}g\right)y_0}}{2\left(-\tfrac{1}{2}g\right)} = 9.964\,\text{s},\ -2.3655\,\text{s} = \boxed{9.96\,\text{s}}$$

Choose the positive time since the projectile was launched at time *t* = 0.

(*b*) The horizontal range is found from the horizontal motion at constant velocity.

$$\Delta x = v_x t = (v_0 \cos\theta_0)t = (65.0\,\text{m/s})(\cos 35.0°)(9.964\,\text{s}) = \boxed{531\,\text{m}}$$

(*c*) At the instant just before the particle reaches the ground, the horizontal component of its velocity is the constant $v_x = v_0 \cos\theta_0 = (65.0\,\text{m/s})\cos 35.0° = \boxed{53.2\,\text{m/s}}$. The vertical component is found from Eq. 2-12a.

$$v_y = v_{y0} + at = v_0 \sin\theta_0 - gt = (65.0\,\text{m/s})\sin 35.0° - (9.80\,\text{m/s}^2)(9.964\,\text{s})$$
$$= \boxed{-60.4\,\text{m/s}}$$

(*d*) The magnitude of the velocity is found from the *x* and *y* components calculated in part (*c*) above.

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(53.2\,\text{m/s})^2 + (-60.4\,\text{m/s})^2} = \boxed{80.5\,\text{m/s}}$$

(*e*) The direction of the velocity is $\theta = \tan^{-1}\frac{v_y}{v_x} = \tan^{-1}\frac{-60.4}{53.2} = -48.6°$, and so the object is moving $\boxed{48.6° \text{ below the horizon}}$.

(*f*) The maximum height above the cliff top reached by the projectile will occur when the *y*-velocity is 0, and is found from Eq. 2-12c.

$$v_y^2 = v_{y0}^2 + 2a_y(y - y_0) \quad \rightarrow \quad 0 = v_0^2 \sin^2\theta_0 - 2gy_{\text{max}}$$

$$y_{\text{max}} = \frac{v_0^2 \sin^2\theta_0}{2g} = \frac{(65.0\,\text{m/s})^2 \sin^2 35.0°}{2(9.80\,\text{m/s}^2)} = \boxed{70.9\,\text{m}}$$