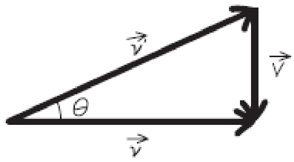
56. The velocity of the boat relative to the ground, $\vec{v}$, is perpendicular to the velocity of the water relative to the ground, the current velocity $\vec{V}$ which form a right triangle with hypotenuse $\vec{v}$ equal to the velocity of the boat relative to the water, as shown in the diagram and as required by Equation 3.7. The heading upstream is $\theta = \sin^{-1}(|\vec{V}|/|\vec{v}'|) = \sin^{-1}(6.3/15) = 24.8°$.



62. The horizontal and vertical distances covered by the stuntman are $x - x_0 = v_0 t$ and $y_0 - y = \frac{1}{2}gt^2$ (since $v_{0x} = v_0$, and $v_{0y} = 0$). Eliminating t, one finds $v_0 = (x - x_0)\sqrt{g/2(y_0 - y)} = (4.5\text{ m})\sqrt{(9.8\text{ m/s}^2)/2(1.9\text{ m})} = 7.23$ m/s. (Note that Equation 3.14 with $\theta_0 = 0$ and $y_0 = 0$ provides an equivalent solution.)

66. The candy bar moves horizontally only at the apex of its trajectory (where $v_x = v_{0x}$ and $v_y = 0$). Thus, $y_{\max} - y_0 = (8.6\text{ m})\sin 39° = 5.41$ m, and $v_{0y} = \sqrt{2g(y_{\max} - y_0)} = \sqrt{2(9.8\text{ m/s}^2)(5.41\text{ m})} = 10.3$ m/s (see Equation 2.11). The time to reach the apex is $t = v_{0y}/g$, so $v_{0x} = (x - x_0)/t = (x - x_0)g/v_{0y}$ (see Equations 3.11 and 3.12). The horizontal distance from apex to origin is $x - x_0 = (8.6\text{ m})\cos 39° = 6.68$ m, so $v_{0x} = (6.68\text{ m})(9.8\text{ m/s}^2)/(10.3\text{ m/s}) = 6.36$ m/s. $\vec{v}_0$ can be expressed in unit vector notation as $(6.36\hat{n} + 10.3\hat{j})$ m/s, or by its magnitude $\sqrt{v_{0x}^2 + v_{0y}^2} = 12.1$ m/s and direction $\theta = \tan^{-1}(v_{0y}/v_{0x}) = 58.3°$ (CCW from the x axis).

69. **INTERPRET** This is a problem involving projectile motion. The physical quantity of interest is the initial speed of the cyclist.

DEVELOP Suppose the projectile is launched at an angle θ_0 with an initial velocity $\vec{v}_0$. The x and y components of the initial velocities are then equal to

$$v_{0x}=v_0\cos\theta_0 \quad v_{0y}=v_0\sin\theta_0$$

From Equation 3.13, we find the total flight time to be

$$0=y-y_0=v_{0y}t_{tot}-\frac{1}{2}gt_{tot}^2 \quad\rightarrow\quad t_{tot}=\frac{2v_{0y}}{g}$$

The range of the projectile is

$$x=v_{0x}t_{tot}=(v_0\cos\theta_0)\left(\frac{2v_0\sin\theta_0}{g}\right)=\frac{2v_0^2\cos\theta_0\sin\theta_0}{g}=\frac{v_0^2\sin 2\theta_0}{g}$$

EVALUATE If the motorcyclist was deflected upward from the road at an angle of 45°, the horizontal range formula found above implies a minimum initial speed of

$$v_0=\sqrt{xg}=\sqrt{(39\text{ m})(9.8\text{ m/s}^2)}=19.5\text{ m/s}=70.4\text{ km/h}.$$

In fact, some speed would be lost during impact with the car, so the cyclist probably was speeding.

ASSESS The greater the range, the larger the initial speed. If the cyclist were traveling at a speed of 60 km/h, or 16.67 m/s, he would have landed at a distance of about 28 m from his bike.

76. We need to find the intersection of the trajectory of the ball (Equation 3.14) with a 15° slope through the same origin, $y=x\tan 15°$. The appearance of the trajectory equation can be simplified by use of the fact that $y=0$ when $x=28$ m and $\theta_0=40°$. Thus, $y=0=x\tan\theta_0-(g/2v_{0x}^2)x^2=(28\text{ m})[\tan 40°-(g/2v_{0x}^2)(28\text{ m})]$, or the coefficient $(g/2v_{0x}^2)$ equals $\tan 40°/28$ m. The trajectory equation simplifies to $y=x\tan 40°-x^2$ $(\tan 40°/28\text{ m})=x(1-x/28\text{ m})\tan 40°$. The intersection of this with the slope occurs when y also equals $x\tan 15°$, or $x\tan 15°=x(1-x/28\text{ m})\tan 40°$. The x coordinates of the two points of intersection are $x=0$ (the origin) and $x=(28\text{ m})(1-\tan 15°/\tan 40°)=19.1$ m (the horizontal distance queried in this problem).