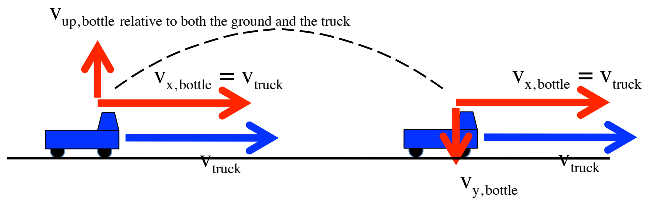
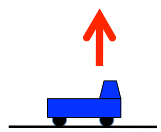
Problem 4.42

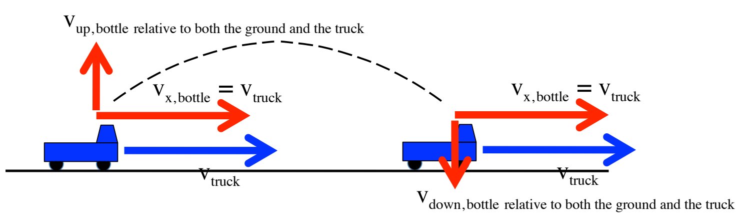


The coke bottle's path is shown above, relative to the ground. The problem assumes no wind and/or air friction.



a.) The bottle and truck have the same ground velocity, so relative to one another, neither is moving horizontally. That means that relative to the truck, the bottle goes straight up and straight down and the throwing angle, relative to the vertical, is zero.

b.) As the velocity of the bottle, relative to the truck, is straight up, it's initial velocity is simply its initial velocity in the y-direction. To determine this, we need to know how long it takes for the bottle to make it's round trip.



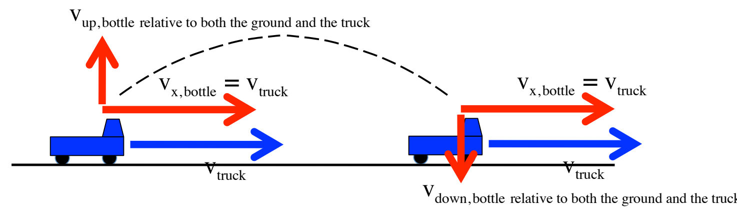
During the round trip, relative to the ground, both the truck and bottle's horizontal displacement is 16 meters. With that and the appropriate kinematic equation, we can write:

$$x_2 = \cancelto{0}{x_1} + v_{1,x}\Delta t + \frac{1}{2}\cancelto{0}{a_x}\Delta t^2$$

$$\Rightarrow \quad x_2 = v_{x,\text{bottle}}\Delta t$$

$$\Rightarrow \quad \Delta t = \frac{(16.0\text{ m})}{(9.50\text{ m/s})} = v_{x,\text{bottle}}$$

$$\Rightarrow \quad \Delta t = 1.68\text{ s}$$



Looking at the y-direction while the bottle makes its round trip, we can write:

$$\cancelto{0}{y_2} = \cancelto{0}{y_1} + v_{1,y}\Delta t + \frac{1}{2}a_y\Delta t^2$$

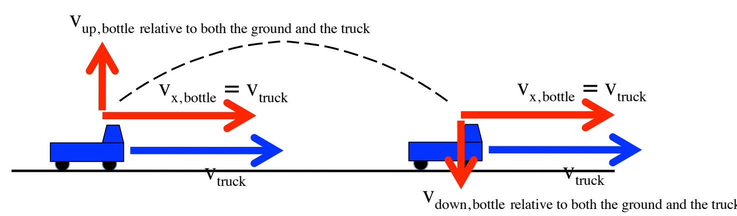
$$\Rightarrow \quad 0 = v_{y,\text{bottle}}(\cancel{\Delta t}) + \frac{1}{2}(-g)(\Delta t)^{\cancel{2}}$$

$$\Rightarrow \quad v_{y,\text{bottle}} = \frac{g\Delta t}{2}$$

$$= \frac{(9.80\text{ m/s}^2)(1.68\text{ s})}{2}$$

$$= 8.23\text{ m/s}$$

Due to symmetry, *minus* that value yields the y-component of the final velocity.



c.) To the kid riding in the truck, the bottle seems to go straight up, then straight back down. That is a one-dimensional kinematic problem.

d.) For an observer on the street, the can follows a parabolic path (as any object would follow if gravity was the only force acting and the motion was two-dimensional). Its net initial velocity, relative to the ground, would have to be:

$$(\vec{v})_{\text{bottle relative to ground}} = (v_{\text{truck}})\hat{i} + (v_{y,\text{bottle}})\hat{j}$$

$$= (9.50\text{ m/s})\hat{i} + (8.23\text{ m/s})\hat{j}$$

$$\Rightarrow \quad (\vec{v})_{\text{bottle relative to ground}} = \left((9.50\text{ m/s})^2 + (8.23\text{ m/s})^2\right)^{1/2} \measuredangle \tan^{-1}\left(\frac{8.23}{9.50}\right)$$

$$= (12.6\text{ m/s}) \measuredangle \tan^{-1} 41.0^\circ$$