PHY 2053, Spring 2009, Quiz 3 — Whiting

1. The absolute world record for a javelin throw is 104.80 m. Assume that an object launched from ground level at an angle of 45° travels the same distance, and neglect air resistance.

a) What is the initial speed of the object?

In this problem there are two unknowns, v_0 and t. We will need two relations between them. Horizontally, we have $v_x = v_0 \times \cos\theta_0$, where $\theta_0 = 45°$, so the time of flight will be given by $t = \Delta x/v_x$. Vertically, we have $v_{y0} = v_0 \times \sin\theta_0$, while the vertical displacement will be given by $\Delta y = v_{y0} \times t + a \times t^2/2$. When the object returns to earth, $\Delta y = 0$, so we must have $t = -2 \times v_{y0}/a$, where $a = -g$. This must be the same as the t we have computed above, so:

$$t = \frac{\Delta x}{v_x} = \frac{2 \times v_{y0}}{g} \Rightarrow v_0^2 = \frac{\Delta x \times g}{2\sin\theta_0 \cos\theta_0} \Rightarrow v_0 = 32.0 \text{ m/s}.$$

b) How long is the object in the air?

$$\text{Solve}: \quad t = \frac{\Delta x}{v_x} = \frac{\Delta x}{v_0 \times \cos\theta_0} \Rightarrow t = 4.62\,\text{sec}\,.$$

$$\text{Check}: \quad t = \frac{2 \times v_{y0}}{g} = \frac{2 \times v_0 \times \sin\theta_0}{g} = 4.62\,\text{sec}\,.$$

2. A river has a steady speed of 0.800 m/s. A student swims upstream a distance of 1.600 km and then swims back to the starting point. The student can swim at a speed of 1.20 m/s in still water.

a) How long does the trip take in the moving river?

Upriver, we have $v_{SB} = v_{SR} + v_{RB}$, so the velocity of the swimmer relative to the bank is $-1.20 + 0.80 = -0.40$ m/s. The time taken is given by $t = \Delta x/v_{SB}$, so we find $t_{\text{up}} = (-1600)/(-0.40) = 4000\,\text{sec}$. Down-river, we have $v_{SB} = v_{SR} + v_{RB}$, so the velocity of the swimmer relative to the bank is $1.20 + 0.80 = 2.00$ m/s. The time taken is again given by $t = \Delta x/v_{SB}$, so $t_{\text{down}} = (1600)/(2.00) = 800\,\text{sec}$. Thus, the total time is 4800 s (or 80 min).

b) How long would a trip of the same length take in still water?

In still water we would have the total time as twice the one-way time given by $\Delta x/v_{SR}$, so $t = 2 \times 1600/1.20 = 2667\,\text{sec}\,.$