Chapter 2 Problems

1. A drag racer, starting from rest, speeds up for 402 m with an acceleration of +17.0 m/s^2. A parachute then opens, slowing the car down with an acceleration of -6.10 m/s^2. How fast is the racer moving 3.5×10^2 m after the parachute opens?

Answer: We must break the problem up into two parts: the acceleration phase and the deceleration phase. Starting from rest, $v_{01} = 0$ m/s, the velocity of the racer after the acceleration phase can be found from

$$\begin{aligned} v_1^2 &= v_{01}^2 + 2a_1 x_1, \\ v_1 &= \sqrt{2(17.0\,\mathrm{m/s^2})(402\,\mathrm{m})}, \\ v_1 &= 117\,\mathrm{m/s}. \end{aligned}$$

This is the velocity with which the racer enters the deceleration phase. Therefore, the final velocity from phase 1, v_1, becomes the initial velocity for phase 2, $v_1 = v_{02}$. Using an identical argument, the velocity of the racer after the deceleration phase is

$$\begin{aligned} v_2^2 &= v_{02}^2 + 2a_2 x_2 \\ v_2^2 &= v_1^2 + 2a_2 x_2 \\ v_2 &= \sqrt{v_1^2 + 2(-6.10\,\mathrm{m/s^2})(3.50 \times 10^2\,\mathrm{m})} \\ v_1 &= 96.9\,\mathrm{m/s} \end{aligned}$$

2. A log is floating on swiftly moving water. A stone is dropped from rest from a 75-m-high bridge and lands on the log as it passes under the bridge. If the log moves with a constant speed of 5.0 m/s, what is the horizontal distance between the log and the bridge when the stone is released?

Answer: Since we know the velocity of the log, we need to know the time interval in order to determine how far it has travelled. The time interval is determined by how long it takes for the stone to fall 75 m.

If we take $y_0 = 75$ m, then the surface of the water corresponds to $y = 0$ m. The stone falls from rest, and so $v_{0y} = 0$ m/s. From the expression

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

and using the fact that the acceleration is that due to gravity, $a_y = -9.80\,\mathrm{m/s}^2$, we obtain

$$t = \sqrt{\frac{2y_0}{a_y}} = \sqrt{\frac{2(75\,\mathrm{m})}{9.80\,\mathrm{m/s}^2}} = 3.9\,s. \tag{2}$$

During this time, the log has been moving horizontally with velocity $v_x = 5.0\,\mathrm{m/s}$. The log's displacement is therefore

$$\Delta x = v_x t = (5.0\,\mathrm{m/s})(3.9s) = 2.0 \times 10^1\ \mathrm{m}. \tag{3}$$