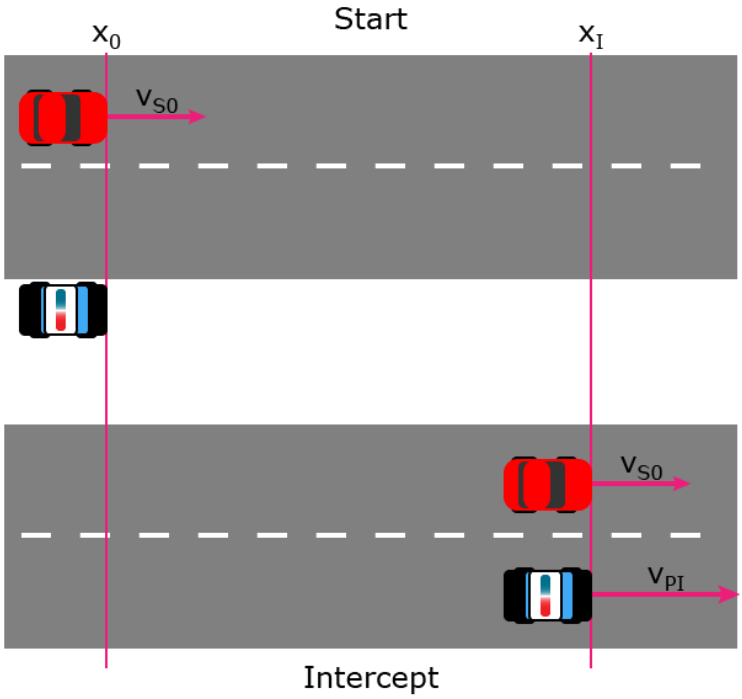
Answer on Question #69599, Physics / Other

a car is travelling on the highway at a constant speed of 90 km/h. The absent-minded driver misses the posted speed limit sign for a small town she is passing through. A police car that is stopped next to the sign accelerates immediately from rest at 3.5 m/s^2. From the time that the speeder passes the police car,

(a) how long will it take the police car to catch up the speeder?
(b) what distance will the cars travel in that time?

Solution:

This illustration shows the conditions of the vehicles at the beginning of the problem and the time when the police car intercepts the speeder.



a)

First, let's look at the police car's equations of motion.

$$x_{PI} = x_{0P} + V_{0P}t + ½at^2$$

since the police car starts at 0 and at rest, v_{0P}=0 then

$$x_P = ½at^2$$

$$v_{PI} = v_{0P} + at$$

$$v_{PI} = at$$

Now for the speeder's car's equations of motion.

$$x_S = x_{0S} + V_{0S}t + ½at^2$$

x_0 = 0 and the speeder is not accelerating, a = 0, therefore

$$x_S = v_{0S}\,t$$
$$v_S = v_{0S} + at$$
$$v_S = 90\ km/hr$$

Convert to m/s since our acceleration is in m/s^2 and it probably won't take hours for the police car to catch up.

$$v_S = 90\frac{km}{hr} = \frac{90\ km}{1\ hr} \times \frac{1000\ m}{1\ km} \times \frac{1\ hr}{3600\ s} = 25\ m/s$$

The two vehicles were in the same position at the very beginning of the chase at x = 0. We need to find where that happens again. This will happen when $x_{PI} = x_S$.

From above:

$$x_{PI} = ½at^2$$
$$x_S = v_{0S}\,t$$

Set them equal to each other.

$$½at^2 = v_{0S}\,t$$

This quadratic equation has two solutions. The first is at x = 0 m. Divide both sides by t to get the other.

$$½at = v_{0S}$$

Solve for t

$$t = \frac{2v_{0S}}{a}$$

using $a = 3.5\ m/s^2$ and $v_{0S} = 25$ m/s

$$t = \frac{2 \times 25}{3.5} = 14.28\ s$$

It takes 14.28 seconds for the police car to catch up and intercept the speeder.

b)

Now that we know the time, we can find the distance. From the speeder car's position equation above:

$$x_S = v_{0S}\,t = 25 \times 14.28 = 357.14\ m$$

Answer: a) $14.28\ s$; b) $357.14\ m$

Source: https://sciencenotes.org/equations-motion-constant-acceleration-intercept-example-problem/