Physics 131: Physics I: Mechanics
Motion with Constant Acceleration

Problem: A speeding motorist traveling 120 km/h passes a stationary police officer. The officer immediately begins pursuit at a constant acceleration of 10.0 (km/h)/s (note the mixed units). How much time will it take for the police officer to catch the speeder, assuming that the speeder maintains a constant speed?

Problem: A speeding motorist traveling 120 km/h passes a stationary police officer. The officer immediately begins pursuit at a constant acceleration of 10.0 (km/h)/s (note the mixed units). How much time will it take for the police officer to catch the speeder, assuming that the speeder maintains a constant speed?

Set up two sets of constant acceleration equations, one for the motorist, and one for the speeder.

Motorist:

$$\begin{aligned} a_m &= 0 \\ v_{mi} &= 120\,\text{km/hr} \\ x_{mf} &= x_{mi} + v_{mi}t \end{aligned}$$

Police Officer:

$$\begin{aligned} a_p &= 10.0\,(\text{km/h})/\text{s} \\ v_{pi} &= 0 \\ x_{pf} &= x_{pi} + v_{pi}t + \frac{1}{2}a_p t^2 \end{aligned}$$

To "catch" the speeder means that at the same time

$$\begin{aligned} x_{mf} &= x_{pf} \\ x_{mi} + v_{mi}t &= x_{pi} + v_{pi}t + \frac{1}{2}a_p t^2 \end{aligned}$$

Further, since the policeman starts "immediately" when the motorist passes, we should take $x_{mi} = x_{pi}$, so those terms cancel. Also, since $v_{pi} = 0$, that term drops out as well.

$$\begin{aligned} v_{mi}t &= v_{pi}t + \frac{1}{2}a_p t^2 \\ v_{mi}t &= \frac{1}{2}a_p t^2 \\ v_{mi} &= \frac{1}{2}a_p t \\ t &= \frac{v_{mi}}{\frac{1}{2}a_p} = 2\frac{120\,\text{km/hr}}{10.0\,(\text{km/h})/\text{s}} = 24.0\,\text{s} \end{aligned}$$

Then, at that time

$$
\begin{aligned}
x_{mf} - x_{mi} &= v_{mi}t = 120\,\text{km/hr} \times 24.0\,\text{s} = 0.80\,\text{km} \\
x_{pf} - x_{pi} &= v_{pi}t + \frac{1}{2}a_p t^2 \\
&= 0 + \frac{1}{2}10.0\,(\text{km/hr})/\text{s} \times (24.0\,\text{s})^2 = 0.80\,\text{km} \\
v_{mf} &= v_{mi} = 120\,\text{km/hr} \\
v_{pf} &= v_{pi} + a_p t = 0 + 10.0\,(\text{km/hr})/\text{s} \times 24.0\,\text{s} = 240\,\text{km/hr}
\end{aligned}
$$