A sports car accelerates from rest to 98 km/h in 6.4 s. What is its average acceleration? (in m/s²).

\[ V_0 = 0 \text{ m/s} \quad V_f = 98 \text{ km/h} = 27.2 \text{ m/s} \]

\[
\begin{align*}
X_0 &= 0 \\
T_0 &= 0 \\
X_f &= ? \\
T_f &= 6.4 \text{ s}
\end{align*}
\]

We assign specifics that the answer should be in m/s² — so let's convert everything to meters and seconds.

\[
(98 \text{ km/h}) \left( \frac{1000 \text{ m}}{1 \text{ km}} \right) \left( \frac{1 \text{ h}}{3600 \text{ s}} \right) = 27.2 \text{ m/s}
\]

The equation for average velocity is:

\[ a_{\text{ave}} = \frac{V_f - V_0}{T_f - T_0} \]

So,

\[ a_{\text{ave}} = \frac{27.2 \text{ m/s} - 0 \text{ m/s}}{6.4 \text{ s} - 0 \text{ s}} \]

\[ a_{\text{ave}} = 4.25 \text{ m/s}^2 \]
At highway speeds, a particular automobile is capable of an acceleration of about 1.6 m/s². At this rate, how long does it take to accelerate from 83 km/h to 109 km/h? (Answer is 's'.)

\[
\begin{align*}
V_0 &= 83 \text{ km/h} \\
X_0 &= 0 \\
t_0 &= 0 \\
\frac{d}{dt} &= ? \\
V_f &= 109 \text{ km/h} \\
X_f &= ? \\
t_f &= ? \\
a &= 1.6 \text{ m/s}^2
\end{align*}
\]

First let's convert the km/h into m/s:

\[
\begin{align*}
(83 \text{ km/h}) & \left( \frac{1000 \text{ m}}{1 \text{ km}} \right) \left( \frac{1 \text{ h}}{3600 \text{ s}} \right) = 23.1 \text{ m/s} \\
(109 \text{ km/h}) & \left( \frac{1000 \text{ m}}{1 \text{ km}} \right) \left( \frac{1 \text{ h}}{3600 \text{ s}} \right) = 30.3 \text{ m/s}
\end{align*}
\]

Next we use the equation for average acceleration:

\[
\alpha_{ave} = \frac{V_f - V_0}{t_f - t_0}
\]

Filling what we know:

\[
\begin{align*}
1.6 \text{ m/s}^2 &= \frac{30.3 \text{ m/s} - 23.1 \text{ m/s}}{t_f - 0} \\
\end{align*}
\]

Solving for \(t_f\):

\[
t_f = 4.50 \text{ s}
\]
A sports car moving at constant speed travels 15m in 5.0s. If it then brakes and comes to a stop in 4.0s, what is its acceleration? Express the answer in terms of a different unit for acceleration called a "g" where 1g = 9.8 m/s² (Take the direction of travel to be the positive direction).

\[
\begin{align*}
X_0 &= 0 \text{ m} \\
X_1 &= 15 \text{ m} \\
V_0 &= ? \\
V_1 &= V_0 \\
\alpha &= ? \text{ m/s}^2 \\
\end{align*}
\]

Let's go ahead and try to use the equation for average acceleration:

\[
\alpha_{ave} = \frac{V_f - V_i}{t_f - t_i}
\]

Let's think about the fact that the initial and final positions refer to the beginning and end times of when it is slowing down. So \( V_f = V_2 \) and \( V_i = V_1 \).
So filling in what we know into the equation for average acceleration gives:

\[ a_{ave} = \frac{V_2 - V_1}{t_2 - t_3} \]

\[ a_{ave} = \frac{0 \text{ m/s} - V_1}{9.05 - 5.05} \]

And we see have a problem: we have two things we don't know in the same equation. We can't solve for both. We need to figure out some way to find \( V_1 \), then we can solve for \( a_{ave} \).

We need to look at the first part of this problem and figure out \( V_1 \). We know that the speed was constant between \( t_0 \) and \( t_1 \), so \( V_0 = V_1 \). We'll get a number for \( V_1 \) (and \( V_0 \)) by calculating \( V_{ave} \) in this interval:

\[ V_{ave} = \frac{X_1 - X_0}{t_1 - t_0} \]

\[ V_{ave} = \frac{115 \text{ m} - 0 \text{ m}}{5.05 - 0.5} \]

\[ V_{ave} = 23.0 \text{ m/s} \] \( (= V_1 = V_0) \)

Using this in acceleration equation we get:

\[ a_{ave} = \frac{0 \text{ m/s} - 23.0 \text{ m/s}}{9.05 - 5.05} \]

\[ a_{ave} = -5.75 \text{ m/s}^2 \left( \frac{4.9}{9.8 \text{ m/s}^2} \right) = -0.587 \]
A car accelerates from 17.0 m/s to 30.0 m/s in 8.0 s. Assume constant acceleration.

a) What was its acceleration?

b) How far did it travel in this time?

\[ X_0 = 0 \quad X_1 = ? \]
\[ V_0 = 17.0 \text{ m/s} \quad V_1 = 30.0 \text{ m/s} \]
\[ t_0 = 0 \quad t_1 = 8.0 \text{ s} \]
\[ a = ? \]

a) What was its acceleration? We need to choose one out of the four constant acceleration equations that includes only quantities that we know and the one we want to know. This is a good choice:

\[ V_1 = V_0 + a t_1 \]

Filling in what we know we get:

\[ 30.0 \text{ m/s} = 17.0 \text{ m/s} + a (8.0 \text{ s}) \]

Solving for "a" we get:

\[ a = 1.63 \text{ m/s}^2 \]

b) How far does it travel in this time? We choose another constant acceleration equation:

\[ x_1 = x_0 + v_0 t_1 + \frac{1}{2} a t_1^2 \]

\[ x_1 = 0 + (17.0 \text{ m/s}) (8.0 \text{ s}) + \frac{1}{2} (1.63 \text{ m/s}^2) (8.0 \text{ s})^2 \]

\[ x_1 = 188 \text{ m} \]
A car slows down from 24.0 m/s to rest in a distance of 85.0 m. What was its acceleration? (Assume constant)

\[ a = ? \]

They didn't ask us anything about time, and we don't know how long it took — so let's use the one of the four Constant Acceleration Equations that doesn't use time.

\[ V_f^2 = V_i^2 + 2a(X_f-X_i) \]

\[ (0 m/s)^2 = (24.0 m/s)^2 + 2a(85.0 m - 0 m) \]

Solving for \( a \) we find

\[ a = 3.39 m/s^2 \]
A car slows down uniformly from a speed of 270 m/s to rest in 4.50 s. How far did it travel in that time?

\[ X_0 = 0 \text{ m} \]
\[ V_0 = 270 \text{ m/s} \]
\[ t_0 = 0 \text{ s} \]
\[ V_1 = 0 \text{ m/s} \]
\[ t_1 = 4.50 \text{ s} \]
\[ a = ? \]

They didn't tell us anything about acceleration, and they aren't asking us anything about acceleration — so let's use the one of the four Constant Acceleration Equations that doesn't use \( a \):

\[ X_t = X_0 + \left( \frac{V_1 + V_0}{2} \right) t_1 \]
\[ X_1 = 0 \text{ m} + \left( \frac{0 \text{ m/s} + 270 \text{ m/s}}{2} \right) (4.50 \text{ s}) \]
\[ X_1 = 60.8 \text{ m} \]
In coming to a stop, a car leaves skid marks 92.0 m long on the highway. Assuming a deceleration of 6.50 m/s\(^2\), estimate the speed of the car just before braking.

\[ x_0 = 0 \text{ m} \]
\[ v_0 = ? \text{ m/s} \]
\[ t_0 = 0 \text{ s} \]
\[ x_f = 92.0 \text{ m} \]
\[ v_f = 0 \text{ m/s} \]
\[ t_f = ? \text{ s} \]
\[ a = -6.50 \text{ m/s}^2 \]

They didn't tell us anything about time, and they are not asking us anything about time—so let's use the one of the four Constant Acceleration Equations that doesn't include time.

\[ v_f^2 = v_0^2 + 2a(x_f - x_0) \]
\[ (0 \text{ m/s})^2 = v_0^2 + 2(-6.50 \text{ m/s}^2)(92.0 \text{ m} - 0 \text{ m}) \]

Notice that deceleration means that we need a minus sign for the acceleration.

Solving for \( v_0 \):

\[ v_0 = 34.6 \text{ m/s} \]