Calculating change in velocity and time

The equation $\vec{a} = \frac{\triangle \vec{v}}{\triangle t}$ can be used to calculate both the change in velocity and the time interval. Mathematically, $\vec{a} = \frac{\triangle \vec{v}}{\triangle t}$ can be rewritten as:

$$\triangle \vec{v} = \vec{a} \triangle t$$

Or

$$\triangle t = \frac{\triangle \vec{v}}{\vec{a}}$$

Suppose the bullet train in Japan accelerates from rest at 2.0 m/s^2 forward for 37 s. What is the velocity of the bullet train at the end of 37 s? Remember that the forward motion is positive (+).

$$\begin{aligned} \triangle \vec{v} &= \vec{a} \triangle t \\ &= (2.0 \text{ m/s}^2)(37 \text{ s}) \\ &= 74 \text{ m/s} \end{aligned}$$

The train's change in velocity is 74 m/s forward. Since the train started from rest, $\vec{v}_i = 0$, therefore

$$\begin{aligned} \triangle \vec{v} &= \vec{v}_f - \vec{v}_i \\ 74 \text{ m/s} &= \vec{v}_f - 0 \\ \vec{v}_f &= 74 \text{ m/s} \end{aligned}$$

The velocity of the train after 37 s is 74 m/s forward.

Suppose a car is travelling north at 22 m/s. How long would it take to slow this car to 12 m/s north if it accelerates at 2.5 m/s^2 south? Remember that the north direction is positive (+). First, find the value of $\triangle \vec{v}$:

$$\triangle \vec{v} = \vec{v}_f - \vec{v}_i = (12 \text{ m/s}) - (22 \text{ m/s}) = -10 \text{ m/s}$$

Then find the value of $\triangle t$:

$$\begin{aligned} \triangle t &= \frac{\triangle \vec{v}}{\vec{a}} \\ &= \frac{-10 \text{ m/s}}{-2.5 \text{ m/s}^2} \\ &= 4.0 \text{ s} \end{aligned}$$

Note: acceleration is (−) since it is south.

It would take 4.0 s to slow the car.

Practice Problems

Try the following acceleration problems yourself.

1. A car starting from rest accelerates uniformly to 15 m/s [E] in 5.0 s. What is the car's acceleration?
2. A skier moving 6.0 m/s forward begins to slow down, accelerating at −2.0 m/s^2 for 1.5 s. What is the skier's velocity at the end of the 1.5 s?
3. A motorcycle is travelling north at 11 m/s. How much time would it take for the motorcycle to increase its velocity to 26 m/s [N] if it accelerated at 3.0 m/s^2?

Answers

1. 3.0 m/s^2 [E]
2. 3.0 m/s forward
3. 5.0 s