1.5: Acceleration

Calculate the acceleration of an object by analyzing its velocity.

The motion of objects can be described in terms of position, displacement, velocity, and acceleration. We have learned about the first three—now it is time to learn about acceleration. Acceleration is a measure of how the velocity of an object changes over time. One way in which velocity can change is to change your speed. Speeding up and slowing down are both examples of acceleration. The other way for an object to accelerate is to change its direction. Remember that velocity is speed with direction, so changing direction would be changing the velocity. In this course we will focus primarily on the kind of acceleration where an object's speed changes.

You found velocity by finding the change in position of an object (displacement) divided by time. Similarly, you can calculate acceleration by finding the change in velocity of an object divided by time! So to find acceleration, take the final velocity minus the initial velocity, then divide that by the time it took for the change to happen. This will give you the acceleration of the object. The units of measure for acceleration are the units of velocity divided by the units of time. The metric units would be meters per second divided by seconds. This is sometimes abbreviated as m/s². This unit means a change in velocity of so many meters per second for each second. It is the rate at which the velocity changes.

$$acceleration = \frac{\text{change in velocity}}{\text{time}} = \frac{\text{(final velocity - initial velocity)}}{\text{time}}$$

Fig. 1.7: Formula for finding acceleration

Example 1.2:

Suppose you were riding your bicycle at 10 m/s and had to stop at a stop sign. If you hit the brakes and came to a stop in 5 seconds, what was your acceleration?

First, let's look at what we know:

- The initial velocity was 10 m/s.
- The final velocity was 0 m/s (because you stopped).
- The time it took to do this was 5 seconds.

Now, let's plug these values into the formula:

$$a = \frac{(0\ \frac{m}{s} - 10\ \frac{m}{s})}{5s} = -2\ \frac{\frac{m}{s}}{s} = -2\ \frac{m}{s^2}$$

Another way to find the acceleration of an object is by analyzing a velocity vs. time graph. The slope of a velocity vs. time graph represents the acceleration of an object. Remember that the slope is the vertical change divided by the horizontal change. On a velocity vs. time graph, the vertical change is the change in velocity and the horizontal change is the amount of time that the velocity changes. So finding the slope of a velocity vs. time graph will give you the acceleration.

Example 1.3:

Use the following velocity vs. time graph to find the acceleration:

Remember how to find the slope: Pick two points. Find the rise (vertical change). Find the run (horizontal change). Take the rise divided by the run.

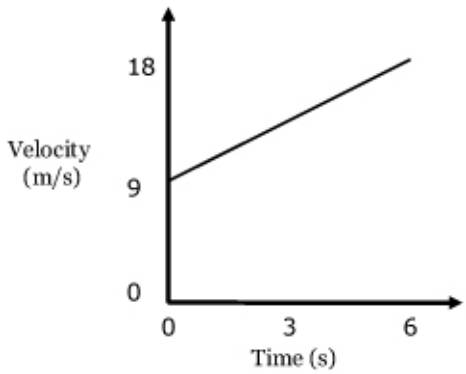

Fig. 1.8: Velocity vs. time graph

- Let's pick the beginning and ending points: (0 s, 9 m/s) and (6 s, 18 m/s)
- You rise from 9 m/s to 18 m/s: that's a rise of 9 m/s.
- You run from 0 s to 6 s: that's a run of 6 s.
- Now divide rise by run: 9 m/s divided by 6 s = 1.5 m/s/s or 1.5 m/s²