In the previous chapter, we have analyzed objects with constant velocity. When the velocity of an object changes, the object is said to be accelerated. In this chapter, we will further analyze the motion and think about how fast an object moves, how far it moves and for how long.

Section 1. What is acceleration?

When an object's velocity changes, it accelerates. **Acceleration** shows the change in velocity in a unit time. Velocity is measured in meters per second, m/s, so acceleration is measured in (m/s)/s, or m/s^2, which can be both positive and negative.

Section 2. Average Acceleration and Instantaneous Acceleration

The **average acceleration** is the ratio between the change in velocity and the time interval.

$$a = \frac{\Delta v}{\Delta t} = \frac{Velocity\ \ Change}{Ellapsed\ \ Time}$$

For example, if a car moves from the rest to 5 m/s in 5 seconds, its average acceleration is

$$a = \frac{5m/s}{5s} = 1m/s^2$$

An **instantaneous acceleration** is the change in velocity at one moment. We will study instantaneous acceleration more in depth later in the chapter.

QUESTION: If a car accelerates from 5 m/s to 15 m/s in 2 seconds, what is the car's average acceleration?

m/s/s Check

QUESTION: How long does it take to accelerate an object from rest to 10 m/s if the acceleration was 2 m/s^2?

s Check

QUESTION: Carl started to run at 10 km/h when he left his house. He arrived at school 30 minutes later. How fast was he running when he arrived there? Assume that his average acceleration was 30 km/h^2.

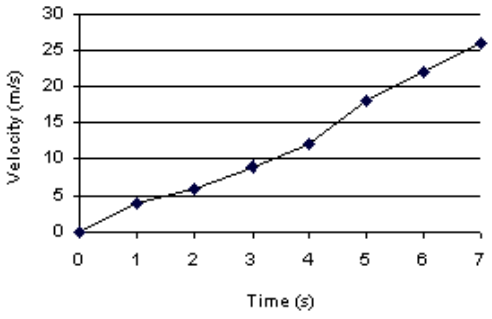
km/h Check

Section 3. More Velocity-time Graph

Let's examine more about a velocity-time graph. We can say that the **tangent of a velocity-time graph represents instantaneous acceleration** since

$$m = \frac{\Delta y}{\Delta x} = \frac{\Delta V}{\Delta t} = a$$

For example, the instantaneous acceleration when t = 3 at the below graph is 3 m/s^2, since the graph has a slope of 3 when t = 3.



QUESTION: What is the instantaneous acceleration of the above object when t = 0?

m/s Check

QUESTION: What is the average acceleration of the whole trip? (When t = 7, velocity = 26 m/s)

m/s/s Check

QUESTION: Does above object has a constant acceleration?

(Yes/No) Check

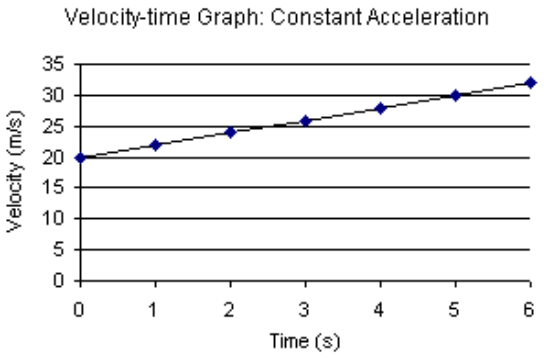
Section 4. Displacement and Constant Acceleration

In this section, we will assume that acceleration is always constant.

We know that the area under the line of a velocity-time graph represents the displacement. Therefore, the equation

$$d = \frac{1}{2}(V_f + V_i)t$$

is true, where V_i is the initial velocity and V_f is the final velocity, since the area of a triangle is 1/2 * width * height.



QUESTION: If a car accelerated from 5 m/s to 25 m/s in 10 seconds, how far will it travel?

m Check