Chapter N2: Acceleration

The main goal of this chapter is to learn how to describe motion. We aren't interested in asking what causes motion—that will be the topic of chapter 3. Here, we develop a mathematical vocabulary that will let us describe the motion we observe.

N2.2: The Definition of Acceleration

Acceleration is defined as the rate of change of velocity:

$$\vec{a} \equiv \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} \equiv \lim_{\Delta t \to 0} \frac{\vec{v}(t + \Delta t) - \vec{v}(t)}{\Delta t} \ . \tag{1}$$

Thus, the acceleration is derivative of the velocity

$$\vec{a} = \frac{d\vec{v}}{dt} \ . \tag{2}$$

N2.3: Average Acceleration

The average acceleration $\vec{a}_{\Delta t}$ during a time interval Δt is defined as:

$$\vec{a}_{\Delta t} \equiv \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}(t + \Delta t) - \vec{v}(t)}{\Delta t} \ . \tag{3}$$

Example: A car goes from zero to 60 miles per hour in 12 seconds. What is its average acceleration during these 12 seconds?

N2.4: Motion Diagrams

For both of the motion diagrams, assume that the time between dots is 0.1 seconds.

Figure 1: A motion diagram

1. For the motion diagram in Fig. 1:
   (a) What is the average velocity between 1 and 2?
   (b) What is the average velocity between 2 and 3?
   (c) What is the approximate acceleration at 2?
2. For the motion diagram in Fig. 2:
   (a) What is the magnitiude of the average velocity between 1 and 2?
   (b) What is the magnitiude of the average velocity between 2 and 3?
   (c) What is the magnitude of the acceleration at point 2?

Motion diagrams in two dimensions:

Figure 2: Another motion diagram

N2.6: Uniform Circular Motion

The main equation:

$$a = \frac{v^2}{r} , \tag{4}$$

where the direction of $\vec{a}$ is directly toward the center of the circle. This formula only applies if the object is moving in a circle at a constant speed!