CHAPTER OVERVIEW

3: Describing Motion in One Dimension

Learning Objectives

- Describe motion in 1D using functions and defining an axis.
- Define position, velocity, speed, and acceleration.
- Use calculus to describe motion
- Define the meaning of an inertial frame of reference.
- Use Galilean and Lorentz transformations to convert the description of an object's position from one inertial frame to another.

In this chapter, we will introduce the tools required to describe motion in one dimension. In later chapters, we will use the theories of physics to model the motion of objects, but first, we need to make sure that we have the tools to describe the motion. We generally use the word "kinematics" to label the tools for describing motion (e.g. speed, acceleration, position, etc), whereas we refer to "dynamics" when we use the laws of physics to predict motion (e.g. what motion will occur if a force is applied to an object).

prelude

You throw a ball upwards with an initial speed v. Assume there is no air resistance. When you catch the ball, its speed will be...

A. greater than v.
B. equal to v.
C. less than v.
D. in the opposite direction.

The most simple type of motion to describe is that of a particle that is constrained to move along a straight line (one-dimensional motion); much like a train along a straight piece of track. When we say that we want to describe the motion of the particle (or train), what we mean is that we want to be able to say where it is at what time. Formally, we want to know the particle's **position as a function of time**, which we will label as $x(t)$. The function will only be meaningful if:

- we specify an x-axis and the direction that corresponds to increasing values of x
- we specify an origin where $x=0$
- we specify the units for the quantity, x.

That is, unless all of these are specified, you would have a hard time describing the motion of an object to one of your friends over the phone.

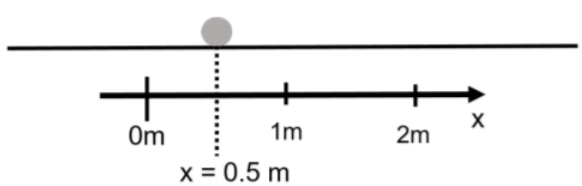

Figure 3.1: *In order to describe the motion of the grey ball along a straight line, we introduce the x-axis, represented by an arrow to indicate the direction of increasing x, and the location of the origin, where $x=0\text{m}$. Given our choice of origin, the ball is currently at a position of $x=0.5\text{m}$.*

Consider Figure 3.1 where we would like to describe the motion of the grey ball as it moves along a straight line. In order to quantify where the ball is, we introduce the "x-axis", illustrated by the black arrow. The direction of the arrow corresponds to the direction where x increases (i.e. becomes more positive). We have also chosen a point where $x=0$, and by convention, we choose to express x in units of meters (the S.I. unit for the dimension of length).

Note that we are completely free to choose both the direction of the x-axis and the location of the origin. The x-axis is a mathematical construct that we introduce in order to describe the physical world; we could just as easily have chosen for it to point in the opposite direction with a different origin. Since we are completely free to choose where we define the x-axis, we should choose the option that is most convenient to us.
