In what follows, we will consider the motion of an object that is moving along a vertical line. (Imagine an elevator in a very tall building that also have lots of underground floors.) We will describe the vertical position of the object by $L(t)$, a location function. t will denote time, measured in seconds, and L will denote the vertical position, measured in meters. So, $L(5) = -3$ means that 5 seconds after we start monitoring the object, it is 3 meters below ground level. $L(10) = 2$.

1. Suppose the location function of an object is given by $L(t) = -3t + 20$.
   a) Where is the object at the start (i.e. when we start monitoring its motion)?
   b) Where is the object 4 seconds after we start monitoring its motion?
   c) Where is the object 7 seconds after we start monitoring its motion?
2. Suppose the location function of an object is given by $L(t) = -t^2 + 4t + 8$.
   a) Where is the object at the start (i.e. when we start monitoring its motion)?
   b) Where is the object 3 seconds after we start monitoring its motion?
   c) Where is the object 7 seconds after we start monitoring its motion?

The **displacement** of an object is expressing the change in its location. If $L(t_1) = 13$ and later, $L(t_2) = 21$, then between t_1 and t_2, the object moved from a height of 13 meters to a height of 21 meters. The displacement (often denoted by s) is the change that has occured:

$$s = L(t_2) - L(t_1) = 21\,\text{m} - 13\,\text{m} = 8\,\text{m}$$

Another notation for displacement is using the capital Greek letter Δ to express change. Since displacement is the change in location, it can also be denoted by ΔL.

The displacement can easily be negative. Imagine if an object is moving downward. If $L(t_1) = 13$ and later, $L(t_2) = 2$, then the displacement is

$$s = L(t_2) - L(t_1) = 2\,\text{m} - 13\,\text{m} = -11\,\text{m}$$

A negative displacement indicates that the object has moved downward between t_1 and t_2.

3. Suppose the location function of an object is given by $L(t) = -3t + 20$.
   a) Find the displacement that occurs during the first 5 seconds.
   b) Find the displacement between $t_1 = 3\,\text{s}$ and $t_2 = 7\,\text{s}$. (s denotes seconds)
4. Suppose the location function of an object is given by $L(t) = -t^2 + 4t + 8$.
   a) Find the displacement that occurs during the first 3 seconds.
   b) Find the displacement that occurs during the first 4 seconds
   c) Find the displacement between $t_1 = 1\,\text{s}$ and $t_2 = 5\,\text{s}$.
   d) Find the displacement between $t_1 = 2\,\text{s}$ and $t_2 = 6\,\text{s}$.
   e) Find the displacement between $t_1 = 3\,\text{s}$ and $t_2 = 7\,\text{s}$.

The **average velocity** of an object is defined as the displacement divided by the time it took to travel that much.

5. Suppose the location function of an object is given by $L(t) = -3t + 20$, where t is measured in seconds and L in meters.

   a) Compute the average velocity of the object between $t_1 = 4\,\text{s}$ and $t_2 = 10\,\text{s}$.

   b) Compute the average velocity between $t_1 = 5\,\text{s}$ and $t_2 = 8\,\text{s}$.

6. Suppose the location function of an object is given by $L(t) = -t^2 + 4t + 8$, where t is measured in seconds and L in meters.

   a) Compute the average velocity between $t_1 = 0\,\text{s}$ and $t_2 = 3\,\text{s}$.

   b) Compute the average velocity between $t_1 = 0\,\text{s}$ and $t_2 = 4\,\text{s}$.

   c) Compute the average velocity between $t_1 = 5\,\text{s}$ and $t_2 = 9\,\text{s}$.

7. Suppose that a small object is moving up and down along a vertical line. We monitor the location of the object as a function of time. We set ground level to represent a height (or vertical location) to be zero. In each case, graph the location function given the data on the height.

   t is time, measured by seconds and h is the height, measured in meters.

t	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
h	7	5.25	4	3.25	3	3.25	4	5.25	7	9.25	12	15.25	19	23.25	28

   a) Create a coordinate system to graph this data. Label both axis and set up a consistent scale on both of them. Then graph the data given.

   b) When is the object moving upward?

   c) What is the average velocity of the object between $t = 0$ and $t = 3$ seconds?

   d) What is the average velocity of the object between $t = 5$ seconds and $t = 10$ seconds?

Answers

1. a) $L(0) = 20$ b) $L(4) = 8$ c) $L(7) = -1$
2. a) $L(0) = 8$ b) $L(3) = 11$ c) $L(7) = -13$
3. a) $-15\,\text{m}$ b) $-12\,\text{m}$
4. a) 3 b) 0 c) -8 d) -16 e) -24
5. a) $-3\frac{\text{m}}{\text{s}}$ b) $-3\frac{\text{m}}{\text{s}}$
6. a) $1\frac{\text{m}}{\text{s}}$ b) $0\frac{\text{m}}{\text{s}}$ c) $-10\frac{\text{m}}{\text{s}}$
7. a) see below b) after $t = 4$ c) $-\frac{5}{4}\frac{\text{ft}}{\text{s}}$ d) d) $\frac{7}{4}\frac{\text{ft}}{\text{s}}$