

# Introduction to Displacement, Velocity and Acceleration

## Purpose

We will use computer simulation to become more familiar with the concepts of displacement, velocity and acceleration.

## Introduction

We will study  $x-t$ ,  $v-t$ , and  $a-t$  graphs in this lab. In particular, we will verify the following relations:

$$\begin{aligned}\text{Slope of } x-t \text{ graph} &= \text{velocity} = v \\ \text{Slope of } v-t \text{ graph} &= \text{acceleration} = a \\ \text{Area of } v-t \text{ graph} &= \text{change of displacement} = \Delta s \\ \text{Area of } a-t \text{ graph} &= \text{change of velocity} = \Delta v\end{aligned}$$

## Procedures

1. Google “PhET” and click on the first search result. This should take you to the homepage of the Physics Education Technology. Alternatively you can enter the following address to the web browser directly:  
<http://phet.colorado.edu>
2. Click on “Simulations” and then choose from the tabs on the left “Motion”. Scroll down to the “The Moving Man” simulation, double click it to start the program.
3. Select “Acceleration” under “Vectors” to display the acceleration vector. You can play with the program a little bit to get a sense of what it does. Note that you can either drag the man directly, or you can control him using the three arrows under “Position”, “Velocity” and “Acceleration”.

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## Displacement and Velocity

1. In this section we will focus on studying the relationship between displacement (position) and velocity. First clear any previous graph. Click on the  button of the acceleration chart to hide it. We will not need this chart for now. Click the magnifying glass of the velocity chart until the maximum range becomes  $2\text{m/s}$  as shown in Figure 1.

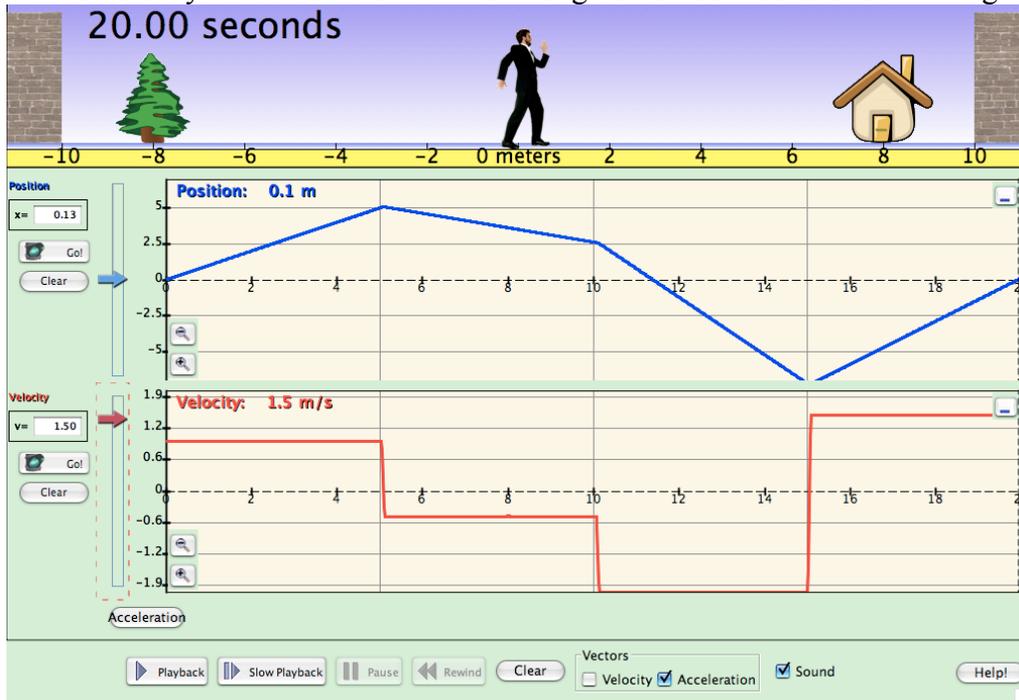


Figure 1

2. We are going to control the man using the velocity arrow. Select a non-zero velocity then click "Go!". The man will start moving.

3. Click "Pause" at  $5\text{s}$ . Change the velocity to a different value, then click "Go!" again.

4. Repeat step 3 at  $10\text{s}$  and at  $15\text{s}$ , each time picking a different velocity. Make sure the man does not hit the wall. Your graph should look somewhat similar to Figure 1 above (no need to make your graph look exactly the same as mine). When the time reaches  $20\text{s}$ , the simulation stops automatically. DO NOT CLEAR THE GRAPH. You will need the graph to do the following analysis. If you like, you can see the replay by clicking the "Playback" or "Slow Playback" buttons. Do not print out the graph.

5. You can drag the playhead (the gray vertical bar in the graphs) to any time you like to get a precise reading of the displacement and the velocity. Move the playhead to  $0\text{s}$ ,  $5\text{s}$ ,  $10\text{s}$ ,  $15\text{s}$ , and  $20\text{s}$  to record the displacements at these times. Record them in Table 1 below.

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**Table 1**

Time (s)	Displacement (m)	Area of $v-t$ curve (m)	Percentage Difference
0			
5			
10			
15			
20			

6. Drag the playhead to the different time periods when the velocity was not changing to record the velocity. Write your result in the second column of Table 2 below.

**Table 2**

Time Period (s)	Velocity (m/s)	Slope of $x-t$ curve (m/s)	Percentage Difference
0 – 5			
5 – 10			
10 – 15			
15 – 20			

7. Calculate the slope of the displacement-time graph using the data in Record your results in the third column in Table 2.

8. Calculate the percentage difference between the velocity and the slope and record them in Table 2.

9. Calculate the area under the velocity-time curve between 0s and 0s, 5s, 10s, 15s, and 20s. Record your results in Table 1. and calculate the percentage difference with the displacement.

## *Velocity and Acceleration (Homework assignment)*

1. Open all three charts (Position, Velocity, and Acceleration). Click on “Special Features” on the menu at the top and select “Free Range”. This will remove the wall.

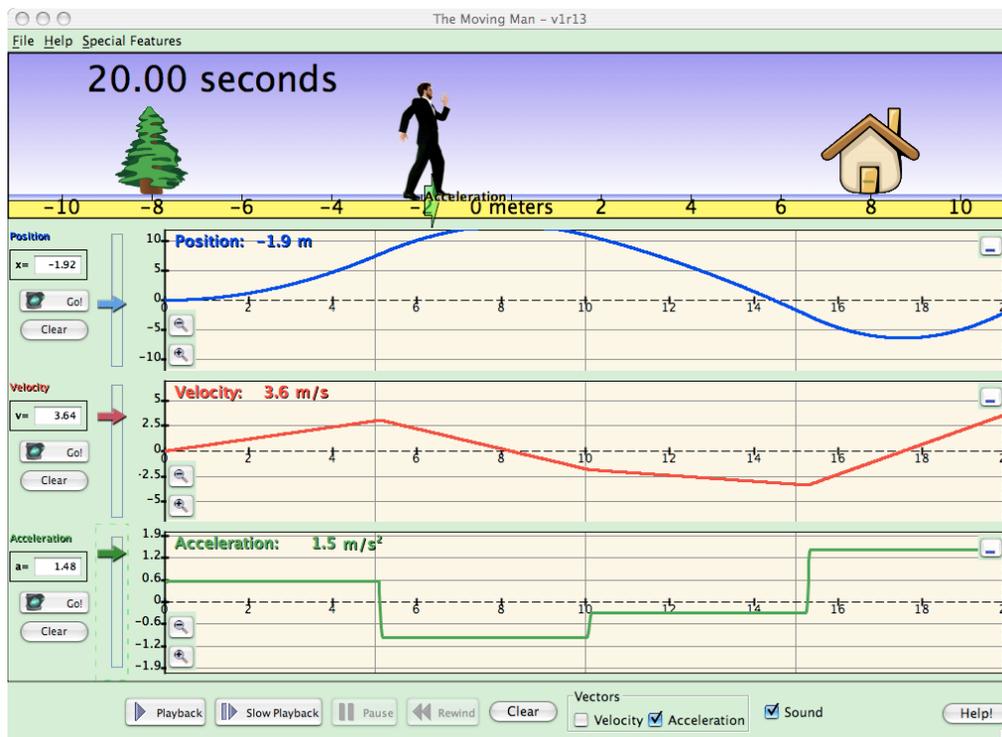
2. Click on the magnifying glass of the acceleration chart until the maximum range becomes  $2m/s^2$  as shown in Figure 2.

3. We are going to control the man using the acceleration arrow. Select a non-zero acceleration then click “Go!”. The man will start moving. *Use very small acceleration (less than  $1.5m/s^2$ ) so that the man would not move too far away.*

4. Click “Pause” at 5s. Change the acceleration to a different value, then click “Go!” again.

5. Repeat step 3 at 10s and at 15s, each time picking a different acceleration. Your graph should look somewhat similar to Figure 2 below (no need to make your graph look exactly the same as mine). When the time reaches 20s, the simulation stops automatically. **DO NOT CLEAR THE GRAPH.** You will need the graph to do the following analysis. If you like, you can see the replay by clicking the “Playback” or “Slow Playback” buttons. Do not print out the graph.

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**Figure 2**

6. Move the playhead to 0s, 5s, 10s, 15s, and 20s to record the displacements and velocity at these times. Record them in Table 3 and Table 4 below.

**Table 3**

Time (s)	Displacement (m)	Area of $v-t$ curve (m)	Percentage Difference
0			
5			
10			
15			
20			

**Table 4**

Time (s)	Velocity (m/s)	Area of $a-t$ curve (m/s)	Percentage Difference
0			
5			
10			
15			
20			

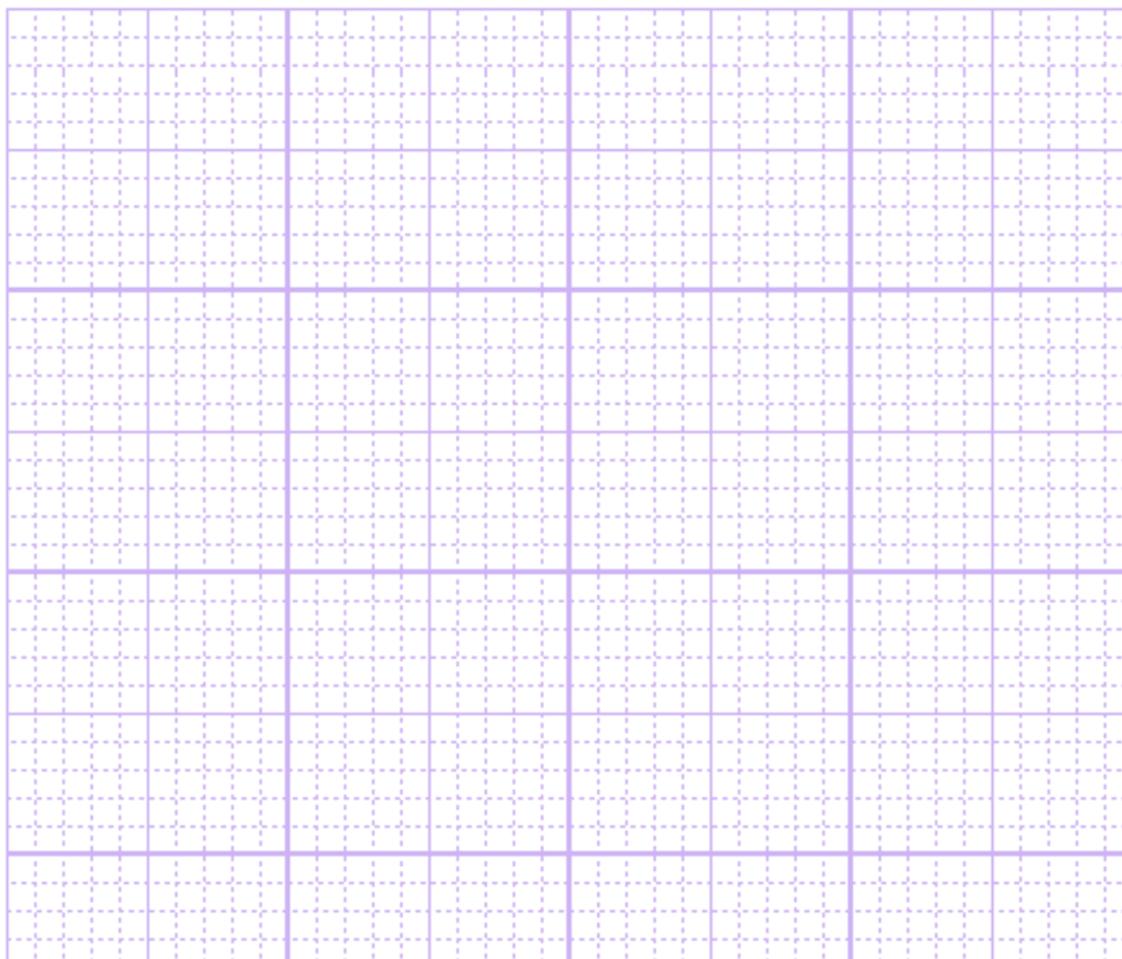
7. Drag the playhead to the different time periods when the acceleration was not changing to record the velocity. Write your result in the second column of Table 5 below.

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**Table 5**

Time Period (s)	Acceleration ( $m/s^2$ )	Slope of $v-t$ curve ( $m/s^2$ )	Percentage Difference
0 – 5			
5 – 10			
10 – 15			
15 – 20			

- Calculate the slope of the velocity-time graph using the data in Table 4. Record your results in the third column in Table 5.
- Calculate the percentage difference between the acceleration and the slope and record them in Table 5.
- Calculate the area under the acceleration-time curve between  $0s$  and  $0s$ ,  $5s$ ,  $10s$ ,  $15s$ , and  $20s$ . Record your results in Table 4 and calculate the percentage difference with the velocity.
- Calculate the area under the velocity-time curve between  $0s$  and  $0s$ ,  $5s$ ,  $10s$ ,  $15s$ , and  $20s$ . Record your results in Table 3 and calculate the percentage difference with the displacement.
- Draw (not print) the three graphs below.



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