PhET and Lab Activity: Unit 1, Acceleration and Kinematics

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1 Position, Velocity, and Acceleration

1. Open the OpenStax text for the course, and navigate to Ch. 2.4: `https://openstax.org/details/books/college-physics`.

2. Scroll all the way to the bottom and find the PhET simulation. Click on the link for the Moving Man Simulation, entitled **Click to View Content.**

3. The introduction tab at the top left will help you learn the controls. Using the mouse, you can drag the man left and right in one dimension. His position, velocity, and acceleration will be indicated by the blue, red, and green markers, respectively.

4. Now click on the tab at the top left entitled **Charts.**

5. Slowly drag the man to the right *at a steady pace.* Do you observe the following?

   - A linearly increasing position?
   - A (roughly) constant velocity?
   - An acceleration that is basically zero?

6. Hit reset at the bottom right, and redo the experiment. This time, move the man all the way to the right, then move him all the way to the left. As accurately as you can, with labeled axes and units, draw his position below:

7. From the position versus time graph you've created, identify the region of positive velocity by looking at the slope. Calculate the average velocity from the slope of your graph. Repeat this exercise for the region of negative velocity. When does acceleration deviate from zero?
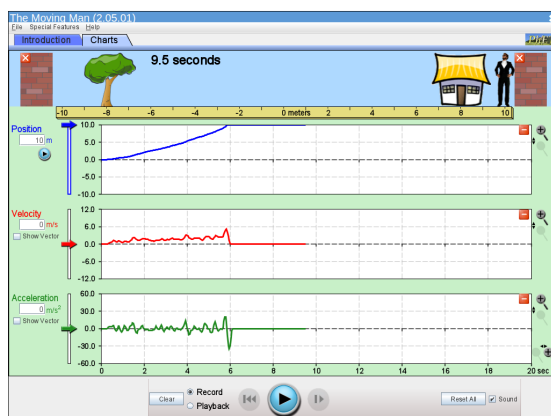

Figure 1: Example of the PhET simulation.

2 The Acceleration of Gravity

This is a simple lab exercise to see if we understand the kinematic equations well enough to predict where an object will land. You will need the stopwatch on your mobile, a small object like a marble, and a ruler or tape measure. Let's assume we are rolling a marble off the edge of a table. According to observations of other systems accelerating constantly, when the marble leaves the table the vertical position versus time will be

$$y(t) = -\frac{1}{2}gt^2 + v_{i,y}t + y_i \tag{1}$$

In Eq. 1, $-g$ is the acceleration. The vector form of acceleration points down, so we give g a minus sign. The time $t = 0$ is when the marble begins to fall, and $v_{i,y}$ is the vertical component of the velocity at $t = 0$. The initial position is y_i. We know that $v_{i,y} = 0$ because we do not *push the marble downwards*, but instead let it fall. Let the change in height be $h = y(t) - y_i$. Show that

$$h = -\frac{1}{2}gt^2 \tag{2}$$

Use this equation to solve for t. The result should be

$$t = \sqrt{\frac{-2h}{g}} \tag{3}$$

Note that h is negative because the marble starts at y and descends.

1. Measure h with the ruler, and predict t, using the accepted value of $-g = -9.81$ m s^{-2} (remember h is a negative number).

2. Roll the marble off the table 15 times, and record 15 measurements of t using a stopwatch. Compute the average measured t value, and compare to your prediction. The percent error will be

$$\Delta t\% = \frac{t_{ave} - t_{predict}}{t_{predict}} \times 100 \tag{4}$$

Write your data, average, prediction, and percent error below. Do the results make sense?