Experiment 3

Uniform Acceleration

Preparation

Prepare for this week's quiz by reviewing last week's experiment. Read this week's experiment and the section in your textbook dealing with velocity and acceleration.

Principles

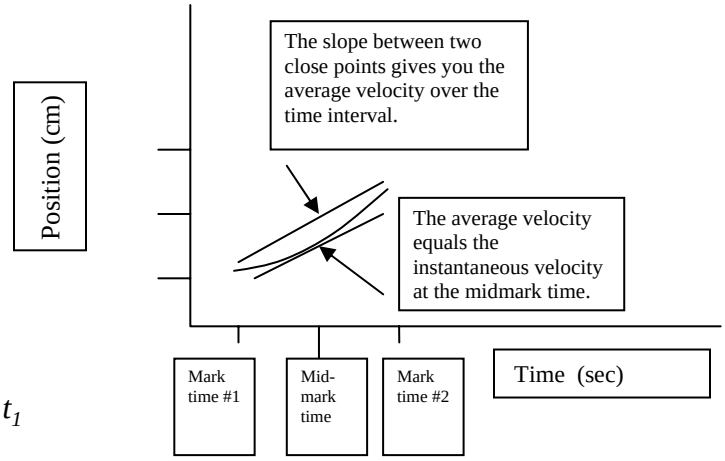
When an object moves through a distance, Δx, in an amount of time, Δt, its average velocity is given by:

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

where x_1 is the object's position at time t_1 and x_2 is its position at t_2 If you have an object's instantaneous velocity at two points in time, you can find its average acceleration with the equation:

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

where v_1 is the object's velocity at mark time t_1 and v_2 is its velocity at mark time t_2.



If the object is moving for some period of time with constant acceleration its actual, or instantaneous, velocity will be less than the average velocity half the time. The other half of the time its average velocity will be greater than the average. At the exact middle of the time period the object's actual and average velocity will be the same.

If you can mark an object's position at different times (called the **mark times**), you will be able to compute its average velocity for each time interval. This gives you the instantaneous velocity at specific times (called the **mid mark times**) and so you can compute the average acceleration for each interval. You could also make a graph of velocity as a function of time. In this experiment you will use both these procedures to compute a value for the acceleration due to gravity.

In this experiment you will study the motion of an object in free fall. The object is a heavy cylinder with a raised metal ring around the center. An electromagnet holds it at the top of the apparatus until an experimenter is ready to begin. When he or she pushes the right button, the electromagnet is turned off and the spark source is turned on. The bob will fall parallel to a strip of thermal paper and between two wires that are attached to a 60 Hz sparking apparatus. The spark will jump from one wire, through the ring, through the paper, to the ground wire, leaving a small mark on the paper. This marks the position of the bob at 1/60 second intervals. The distance between the marks will increase at a constant rate since the object is undergoing constant

acceleration. Acceleration due to gravity is given the symbol g (***g*** when you are talking about the vector). Its value for Atlanta is about 9.795 meters/second^2.
Because the free fall apparatus can be dangerous, you will not be asked to make your own tape. Your instructor will demonstrate how the apparatus works and will give you a prepared tape.

Equipment

1 prepared free fall tape
1 two meter stick
masking tape

Procedure

Small measurement errors will cause a large error in the value you get for g. Measure, as carefully as possible to 0.0001 m (estimate tenths of mm). Remember the rules for dealing with significant digits. Be sure to note the units at the head of each column.

1. Unroll the tape and lay in on the table so that the distance between the dots increases from left to right. Use masking tape to secure it to the table.

2. Skip the first four or five spark marks. Then select a clear mark, circle it and label it zero (0). Circle every third mark until you have six marks and number them. (0-5).

3. Ask your instructor to check your tape to make sure that it has no "misfires" or missing marks and that it is properly labeled.

4. The first mark corresponds to $t = 0$ sec. The second corresponds to $t = 3/60 = 1/20$ sec, or .05sec; the third to $t = 6/60 = 2/20$ sec or .10 sec, etc. Record your mark times in the table.

5. Turn your meter stick on its side and place it against the tape so that the scale is directly against the row of dots. This will eliminate parallax errors in reading your data. Align the 10.00 cm mark on the stick with the 0^{th} mark on the tape. Record the position of mark 0 as 0.1000 m. Then, without moving the tape or the meter stick, record the positions of the rest of the marks. Remember, estimate tenths of mm.

6. Do the calculations necessary to fill in the rest of the table. Find the velocities by dividing the change in position by the change in time. Remember that dividing by 1/20 is the same as multiplying by 20. Calculate each mid mark time by adding the mark times and dividing in half. Calculate the acceleration by dividing the change in velocity by the change in mid mark time. Notice that the change in mid mark time is exactly the same as the change in mark times, 1/20 second. Find the average of the four interval accelerations.

7. Graph mid mark velocities as a function of mid mark times. Draw the best fitting line and find its slope.