PHSX 221L   Acceleration of a Freely-Falling Body   Name:______________________

Object: (a) To study the distance-versus-time and speed-versus-time relationships for a falling body, and (b) To measure experimentally the acceleration of an object in free fall.

Theory: The law of falling bodies says that all objects in free fall (motion under the influence of gravity only) have the same acceleration; near the surface of the earth, it has a value of a_g (often simply called g). Acceleration is defined as the time rate of change of velocity:

$$a = \frac{dv}{dt}. \tag{1}$$

When the acceleration is constant this expression can be easily integrated to obtain velocity as a function of time:

$$v(t) = v_0 + at. \tag{2}$$

This is a linear first degree equation. Therefore, a plot of v vs. t should be a straight line with slope equal to the acceleration a.

If this equation for velocity is again integrated the result will be displacement as a function of time:

$$y(t) = y_0 + v_0 t + \frac{1}{2}at^2. \tag{3}$$

This is a second degree equation, which means that if y were plotted against t the result would be a parabolic curve.

Your experiment today uses a fast timing mechanism to observe a dense cylinder as it falls freely under the pull of gravity (air resistance is negligible). A high voltage between two vertical wires causes a spark to jump between the wires every 1/30 second. The spark passes through the falling cylinder and then through the special paper tape, making a small dot on the tape, thus marking the position of the falling cylinder at each 1/30 second. The rate at which the spark is produced is controlled by the 60 hertz (or 60 cycles per second) power line, which is a very stable timing source.

Apparatus and Procedure:

1. Include a diagram of the apparatus used. Label the diagram and indicate the principles of operation.
2. Level the apparatus. Verify levelness by dropping the cylinder in a dry run with no sparks.
3. Push the sparker button, release the cylinder, and then release the sparker button after the cylinder has landed, all in quick succession.

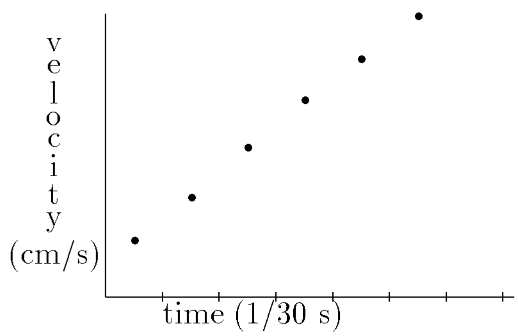
Analysis:

1. Call the first *good* dot time zero and location zero (you may not want to use the very first dot). Then record in a table the displacements for the rest of the dots relative to *that* dot.

2. Subtract successive displacements in pairs to obtain the information for the $\Delta \boldsymbol{y}$ column in your "difference table." Verify the $\Delta \boldsymbol{y}$ by measuring between successive dots with a ruler. Then divide each $\Delta \boldsymbol{y}$ by Δt (which is 1/30 s) to obtain the average velocity for each time interval (*i.e.*, between successive dots).

3. Subtract successive velocities in pairs to obtain the information for the $\Delta \boldsymbol{v}$ column in your table. Then divide each $\Delta \boldsymbol{v}$ by Δt to obtain the acceleration for each interval (*i.e.*, between successive velocities). Compute the average of all of the numbers in the acceleration column and record it at the bottom of your acceleration column.

4. Make a graph of velocity versus time. The value on the vertical axis for each data point is the average velocity (acquired from your table) during that time interval. The value on the horizontal axis is halfway between the tic marks representing the times 1/30 s apart. See example below.



5. Draw a best-fit straight line between the points on the graph and compute its slope and read the intercept off the v axis. The slope of your line will be a and the intercept will be v_0.

6. Also, make a plot of displacement (position) versus time and draw a best-fit curve. Interpret, and compare to the theoretical curve.

7. Compute the percent difference between each of your two measured values of a_g (the slope of the line and the average from your table and the value of $a_g = 979.59$ cm/s^2 predicted by formula for Ephraim.

Conclusions: