EXPERIMENT 2: ACCELERATION OF GRAVITY

An important constant which we use repeatedly is the value of g, the acceleration of gravity. The value we usually use is 9.80 m/s^2. In this experiment we will determine this constant by two methods, one by timing and calculating directly, and second by using a built in program of the interface. The timing and calculating will be done by a spark timer and by use of an Excel spreadsheet. Directions for use of the spreadsheet are included below.

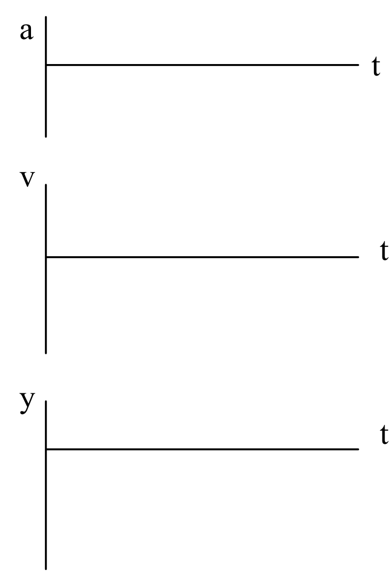
BACKGROUND

In the direct calculation method, an object is made to fall between two wires while a high voltage is applied between the wires at a frequency of 60 Hz, or 60 cycles per second. The high voltage causes a spark to jump between the two wires and the falling object, and makes a spot on the strip of paper between one of the wires and the falling object. The series of spots indicates the location of the falling object each sixtieth of a second. Care should be taken while the spark timer is turned on not to touch either wire or the wires leading to the apparatus. Also be careful not to crowd the students doing the experiment while you are waiting for your turn. In using the built-in program of the interface, an object will be dropped between the parts of a photogate, and the program will calculate the value of g.

ADVANCE STUDY ASSIGNMENT

1. On the graphs at right, sketch the expected acceleration, velocity and position graphs for a dropped object with initial position of y = 0. Pay attention to the algebraic signs of points on all graphs, using the usual convention of up being positive.

2. In words, describe what would change in each graph if the object were thrown down, rather than simply dropped, again starting from the y = 0 position.



PROCEDURE A

If the equipment is in use, you may start Procedure B while you are waiting your turn for use of the equipment in Procedure A.

1. Retrieve the object from the bottom of the apparatus, make sure the low voltage power supply which operates the electromagnet is turned on and place the object hanging from

the electromagnet. Touch the object to stop it from swaying, and make sure the paper tape is centered in front of the back wire.

2. Test the high voltage power supply switch. One partner operates the high voltage supply, and one the electromagnet power supply. When both are ready, the high voltage is turned on, and the switch is held on. Then the other partner turns off the electromagnet. The high voltage switch is kept on until the falling object has fallen and is caught at the bottom. The partner operating the high voltage switch should be careful only to turn the voltage on when there is no one touching or near to the apparatus, in order to avoid shocking experiences.
3. Look at the tape and count how many dots are visible down the center. There must be at least 11, although you may use a tape if only one dot is missing. It is best to use 16 dots, but 11 will do. If you have at least 11, make a mark on the bottom of the tape (your fingernail will do to make a mark) and remove the clamp on the end of the tape hanging behind the apparatus, while holding the free end of the tape. Gently pull the tape until the mark you made is at the top where the falling body hangs from the electromagnet. Tear the tape and replace the clamp.
4. Return to your table. Turn on the computer interface, and then turn on the computer.
5. Open a new Excel spreadsheet. In cell A2 type the word "time". In positions A3 through A18 type "0", "=1/60", "=2/60", "=3/60", etc. (Of course, when you type, do not type the quotation marks " ".)
6. Tape the paper strip to the table and use a 1-meter stick to measure the positions of the dots, starting at the 10.00 cm mark. Enter the positions you record onto the Excel spreadsheet, in cells B3 through B18 (or as many data points as you have). In cell B2 type the word "position".
7. Copy cells A2 through A18 to C2 through C18, by highlighting the A cells, clicking on the Edit button on the menu bar, and then clicking on "Copy". Then highlight the same number of cells in Column C, and click on "Paste" in the Edit area of the menu bar.
8. Next, you will enter a formula to calculate the average velocity for each adjacent pair of dots. In cell D2 type the word "velocity". Leave cell D3 blank. In cell D4 type "=(B4-B3)/(A4-A3)". What you are doing is calculating the average velocity:

   $$\bar{v}_i = \frac{y_i - y_{i-1}}{t_i - t_{i-1}};\ \text{for example:}\quad \bar{v}_3 = \frac{y_3 - y_2}{t_3 - t_2}$$

9. Copy this formula into cells D5 to D18 by first clicking on cell D4, then using the mouse, move the pointer to the lower right hand corner of D4. When the pointer changes to a plus sign push and hold the left mouse button while you drag the mouse down to D18. The formula should be "relatively copied" into each cell D5 to D18. DO ONE OR TWO CALCULATIONS YOURSELF TO VERIFY THAT THE FORMULA IS WORKING AS EXPECTED. SHOW YOUR CALCULATION IN THE DATA AND CALCULATION SECTION, AND INDICATE WHICH CELL YOU ARE CHECKING.
10. Now use the Excel Spreadsheet Program to plot a velocity vs time graph and a position vs time graph, using the directions. You will find the directions in the physics file folder on the desktop of the computer, under the name "Graph directions exp 2". Make the MSWord window a small window, and adjust the size so you can see the spreadsheet in Excel and follow the directions on the Word window at the same time.)
11. Follow the directions to determine the slope of the velocity vs time graph. This slope is your experimental value of g. Compare it with the accepted value of 9.80 m/s^2.

Calculate percent error in the Data and Calculation section and enter values in Data Table B.

12. Enter an identifying name or word in cell A1. Move graphs next to Data Table, and adjust sizes so all will fit on one page. Before you print, always do a print preview to see if your work will fit on one page, and that you will print the page you want. Print a copy of Data Table and graph for each partner.

PROCEDURE B

13. Now you are to use the photogate or photocell on the computer to determine a second experimental value of g. Open Data Studio by double clicking on the icon.
14. Then, click on "Create Experiment." On Experiment Setup, scroll down and double-click "Photogate and Picket Fence".
15. Click & drag "Acceleration Ch1 (m/s/s) from Data icon onto Table in Displays window (to show an Acceleration table).
16. Position the photogate over the edge of the table, attached by a rod to a ring stand clamped to the table with a C-clamp.
17. Click "Start" and drop the picketfence through the photogate, either catching if after it falls through, or allowing it to fall into a padded catcher. After it has fallen through, click "stop".
18. Look at the table. If you have any very large values of a (such as 200 m/s/s) omit them, because they are probably due to scratches on the plastic giving false readings to the photocell. Highlight data near the center of the table (omitting the first and last data entries) and select mean (for average) by clicking on the statistics button (Σ).
19. Enter the average value (mean) on Data Table B. Calculate percent errors (|EXP – ACC|/ACC) for the two experimental values from the accepted value, 9.80 m/s^2.

DATA TABLE B

g from graph	% error
g from photogate	% error

* Show calculation of % error under Data + Calculation section of each report

QUESTIONS

1. How would your graph change if you associated a lower dot on the spark paper with time t = 0? Discuss in particular what would change and what would not change in the graph of v vs t produced from the data recorded.
2. How do the two values of g from the two methods compare? Which is more accurate?
3. Write the polynomial fit equation from the position vs time graph, replacing "x" with "t". Show how you can get g from this equation. (It may be useful to look at one of the 5 equations for falling objects with constant acceleration g).