6 Constant Acceleration
Computerized Gravity

Purpose

To use the computer to measure free-fall acceleration.

Required Equipmentand Supplies

Apple II Series computer
interface box
photogate (light probe)
LabTools software
Data Plotter graphing program
2 ring stands
2 clamps
cardboard or metal figure "g"
plexiglass "picket fence"

Part A: The Figure "g" Method

Discussion

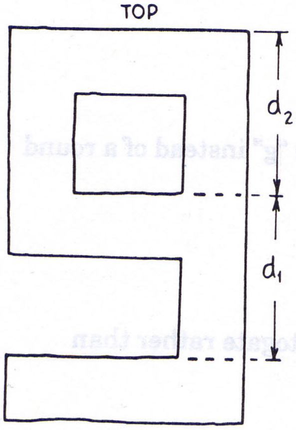


Figure 6.1

If you know the initial and final speeds of a freely-falling object, and the time interval between them, you can compute the acceleration. In this experiment you will exploit the computer's ability to time events accurately to compute the free-fall acceleration. A square figure "g" cut out of stiff cardboard, plastic, or sheet metal (see Figure 6.1) will serve as the falling object. The *LabTools* software enables the computer to clock the time, t_1, taken when the figure falls the first distance, d_1, and the time, t_2, taken when it falls the second distance, d_2. The measurement of the time it takes to fall each distance can be used to compute the average speed for each interval, and from these speeds, the acceleration. Acceleration is defined as the change in velocity per second. The acceleration, g, of a freely falling object is

$$a = g = \frac{v_{2avg} - v_{1avg}}{t_{avg}}$$

In this experiment,

$$v_{1avg} = \frac{d_1}{t_1}$$

$$v_{2avg} = \frac{d_2}{t_2}$$

$$t_{avg} = \frac{t_1 + t_2}{2}$$

The value of this lab is not in finding the well-known value of 9.8 m/s^2, but in the activity of making measurements with the computer and its ancillaries.

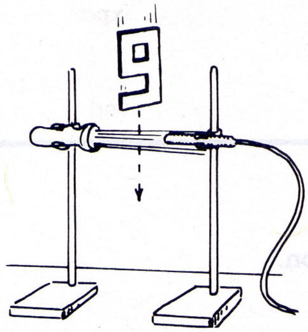


Figure 6.2

Procedure

Step 1. Select the "Acceleration of Gravity" program from the main menu on the *LabTools* disk. Follow the directions given by the program.

Step 2. Measure the distances d_1 and d_2 of the figure "g" with a meter-stick to the nearest thousandth of a meter (millimeter). Enter the measured values in millimeters directly into the computer.

Step 3. Hook up the light probe to the interface box. Check to make sure the connections are made properly. Drop the figure "g" through the light beam, as in Figure 6.2. Compute the value of g using your experimental results. If your computed values for g are not within 5% of the accepted value of 9.8 m/s^2, repeat the experiment.

Analysis

1. List possible sources of error in this experiment. (Assume that the computer has been programmed with 100% accuracy!)

2. Why would a figure "g" made of sheet metal probably be better than one made of cardboard?

3. What are the advantages of using a square figure "g" instead of a round one?

4. If the figure "g" falls at an angle through the photogate rather than straight down, how is the calculation of g affected?

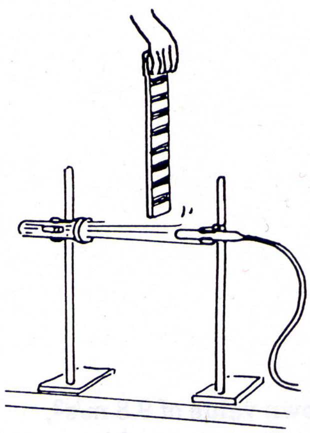


Figure 6.3

Part B: The Picket Fence Method

Discussion

This method of measuring g is an extension of the method used in Part A. A long plexiglass strip serves in place of the figure "g." The plexiglass strip has eight black stripes spaced 5 cm apart from one edge to the next to create a "picket fence," as shown in Figure 6.3. The stripes create alternating opaque and transparent regions as the picket fence falls past the light probe. The same light probe arrangement as in Part A is used here.

The computer has been programmed to measure the time it takes for the fence to fall from the top of one dark stripe to the top of the next. If the distances between the stripes are all the same (equidistant), this experiment simulates the "undiluted" incline of the lab "Merrily We Roll Along." In that lab you rolled a ball down an incline. In this one, you simply drop the picket fence through the light beam. Wouldn't Galileo have loved to see you do this experiment!

Procedure

Step 4. Follow the directions on the "Acceleration of Gravity" program on the *LabTools* disk. Enter the number of pickets on your fence (commonly eight).

Step 5. Measure the distance from the top of one dark stripe to the top of the next dark stripe (commonly 50 mm). Enter this distance in millimeters into the program.

Step 6. Position some form of padding to protect the picket fence after it passes past the light probe and hits the table. Carefully drop the picket fence through the light beam. For best results and to minimize false readings, keep the distance between the light probe and the light source to a minimum (i.e., a few centimeters).

Step 7. After you successfully acquire data, plot distance vs. time. Use *Data Plotter*, if available.

5. Describe your graph.

Save your data and make a printout of your graph.

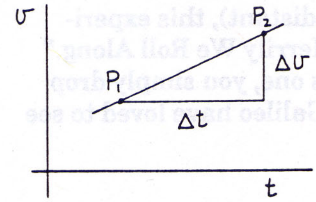
Step 8. Plot velocity vs. time. Use *Data Plotter*, if available.

6. Describe your graph.

Save your data and make a printout of your graph to be included with your report.

Analysis

7. Are either of your graphs straight lines? If so, what is the significance of the slope of your graph?



8. **If the slope of your velocity vs. time graph is constant (or nearly so), pick two points that represent a good average of your data. Label these two points as P_1 and P_2 and make a right triangle of the velocity graph and the horizontal and vertical lines passing through P_1 and P_2. Compute the slope of the graph and label the axes of your graph with the appropriate units.**

How does the slope of your velocity vs. time graph compare to 9.8 m/s^2? To the value on the "Analyze Data" option of *Data Plotter*? Calculate the percentage error.