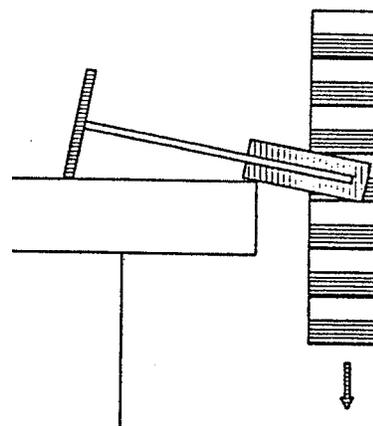


Computer-Assisted Measurement of g

The purpose of this experiment is to introduce you to computer assisted measurements, which you will use in several future experiments. This experiment should also reinforce concepts of velocity-time graphs and objects in free fall.

Getting Set Up

Your measurements will make use of a computer timer that detects when the infrared beam of a photogate is broken. Attach the photogate to its stand in such a way that, with the stand upright, the open side (the gap) points up. Lay the photogate stand on the table so that the photogate gap is nearly horizontal and hanging over the edge of the table as far as possible. Plug the photogate cable into digital input # 1 of the Pasco interface. Double click on the “Data Studio” icon on your desktop. In the main menu click on “Create Experiment”. This should take you to a setup window that has a list of sensors to choose from. Scroll down this list and double click on “Photogate and Picket Fence”. This should place a picture of a photogate and picket fence in digital input #1 of your interface. In the bottom left corner of your screen there is a “Displays” window. Double click on “Table” from this window and choose “Position”. The times recorded on this table will be a list of the time-in, “ t_{in} ”, values (the time that each new black stripe enters the photogate). You can compute the average speed during one of these intervals by dividing the distance moved (the distance between leading edges of two stripes) by the time interval.



Collecting Data and Calculating $|g|$

Now we'll have the computer time a freely falling picket fence. Place a cushion on the floor below the photogate to catch the fence. Gently hold the fence by one end and let it hang vertically just above the photogate gap. The idea is to have it fall through the gap without touching anything. This may take several tries. When you are ready, click on the “Start” button to start the timer. Drop the fence. Then click “Stop” to stop the timer. If you are not satisfied with this data, then do it again. When you are satisfied with the data, you are to create a data table of Δt , t_{in} , t_{mid} , and v values (similar to the sample table provided on the next page). You will enter in your t_{in} values just as they appear from your picket fence-drop data. Each Δt value will be the difference between the corresponding t_{in} values. You will compute average speed, v , as distance traveled (from the start of one stripe to the start of the next stripe) divided by Δt . To the extent that the acceleration is constant this average speed will be the instantaneous speed halfway through the time interval. These halfway-through times go in the column t_{mid} . The third t_{mid} , for example, will be the average of the second and third values of t_{in} . You may have figured out by now that there can be no values for Δt , t_{mid} , and v on the first row of your table.

Sample Table for Picket Fence:

Δt	t_{in}	t_{mid}	v
(sec)	(sec)	(sec)	(m/s)
----	.0030	----	----
.0590	.0620	.0325	.847
.0512	.1132	.0876	.976
.0442	.1574	.1353	1.13
.0398	.1972	.1773	1.26

After completing the table, neatly graph v vs. t_{mid} . Compute the slope of the graph to obtain the acceleration. Is this a reasonable value for g ?

Computer Analysis of the Data

Now let's see that the computer can do all of this work for us. Your data should still be on the screen. In the bottom left "Displays" window double click on "Graph". Choose the "Velocity" vs. time graph. You should now see a very similar looking graph to the one you just drew by hand. At the top of your graph click on the tab that says "Fit". Choose "Linear Fit". This is the computer's attempt to fit your data to a linear equation. In the box that now appears on your graph you should see a value for "m". This is the slope of the fit-curve.

Does this computer-calculated result agree with the one obtained from your hand-plotted graph? If not, try to decide why. Also comment on possible causes of differences between your measured values and the accepted value of 9.8 m/s^2 .

Also in the box of linear fit results on your graph you should see a value for "R". The R-value gives a measure of how well your data fit a straight line, that is, how nearly constant the acceleration was. A perfect fit would give exactly $R=1$. If you have R very near 1, you should see that all data points are on or very near the straight line. Record this R-value.

Next, let's analyze free fall further. In the Data window (top left corner window) click and drag the word "Position" into the white area of your velocity-time graph. This should give you two graphs (position-time and velocity-time). Comment on the shape of this position-time graph. What type of graphical relationship is this? From your Physics I class, what theoretical equation explains this graph?

A Challenge:

Now get rid of the position-time graph (only display the velocity-time graph). Can you produce as nearly constant acceleration as gravity does? Hit the "Start" button again and see if you can use your hand to move the picket fence through the photogate with constant acceleration. What acceleration did you produce? How close do your data points come to the best-fit straight line? Does the R-value indicate as nearly constant acceleration as that due to gravity? If not, see if you can do better. Good luck with this one!