Lab 2: Acceleration Due to Gravity

Staple your papers together in the upper left-hand corner.

Include the lab number and title.

Don’t forget your name, lab partners, date, class, and section

John Smith, with Steve Jones and Rob Brown
June 21, 2013

General Physics Lab I
Section 3
Title: “Lab 2: Acceleration of Gravity”

Purpose:
Measure the acceleration due to gravity of a freely falling body near the Earth’s surface (g) using a Picket Fence and a Photogate.

Data and Calculations:
Below is a diagram of the apparatus for this experiment:

The distance vs. time graphs are parabolic (see attached graph), and the velocity vs. time graphs are linear.

The purpose of the following data is to determine the acceleration due to gravity at the Earth’s surface.

<table>
<thead>
<tr>
<th>Trial</th>
<th>C (m/s²)</th>
<th>g (m/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.907</td>
<td>9.814</td>
</tr>
<tr>
<td>2</td>
<td>4.899</td>
<td>9.798</td>
</tr>
<tr>
<td>3</td>
<td>4.796</td>
<td>9.592</td>
</tr>
<tr>
<td>4</td>
<td>4.905</td>
<td>9.810</td>
</tr>
<tr>
<td>5</td>
<td>4.905</td>
<td>9.810</td>
</tr>
<tr>
<td>6</td>
<td>4.910</td>
<td>9.820</td>
</tr>
</tbody>
</table>

*This is the data taken from the plot of distance vs. time. See attached graph for Trial 1.
**This column was calculated from the data taken in the lab from the equation $g = -2 \cdot C$.

Inspecting the data shows that Trial 3 is significantly lower than the other five trials. We expect that the Picket Fence was tilted and fell through the Photogate at an angle, resulting in a lower value of $g$ (see the Conclusion section for more information). Since that value is probably from an incorrectly performed trial, it has been rejected and the rest of the calculations ignore it.
Therefore, the minimum, average, and maximum values for the trials are:

<table>
<thead>
<tr>
<th>Acceleration (m/s²)</th>
<th>Minimum</th>
<th>Average*</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.798 m/s²</td>
<td>9.810 m/s²</td>
<td>9.820 m/s²</td>
</tr>
</tbody>
</table>

*The average was calculated from:

\[ \bar{g} = \left( \frac{9.814 \text{ m/s}^2}{5} \right) + \left( \frac{9.798 \text{ m/s}^2}{5} \right) + \left( \frac{9.810 \text{ m/s}^2}{5} \right) + \left( \frac{9.810 \text{ m/s}^2}{5} \right) + \left( \frac{9.820 \text{ m/s}^2}{5} \right) \]

\[ \bar{g} = 9.810 \text{ m/s}^2 \]

From the maximum, minimum and average values, we get our best answer and uncertainty for the acceleration due to gravity:

<table>
<thead>
<tr>
<th>Acceleration due to gravity (g)</th>
<th>((9.81 \pm 0.01)\text{ m/s}^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision</td>
<td>0.1%</td>
</tr>
<tr>
<td>Percent Error</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

*The precision was calculated as follows:

\[ \text{Precision} = \frac{0.01 \text{ m/s}^2}{9.81 \text{ m/s}^2} \times 100\% = 0.1\% \]

**The percent error was calculated as follows:

\[ \% \text{ error} = \left| \frac{(9.81 \text{ m/s}^2) - (9.81 \text{ m/s}^2)}{9.81 \text{ m/s}^2} \right| \times 100\% = 0.0\% \]

**Results:**

From the data taken for this experiment, we determined that the acceleration due to gravity at the Earth’s surface is \((9.81 \pm 0.01)\text{ m/s}^2\). The value was measured to a precision of 0.1% and a percent error with the accepted value of 9.81 m/s² of 0.0%. Additionally, the accepted value lies within the uncertainty \pm 0.01 m/s² of the experiment.

**Conclusion:**

The acceleration of gravity measured in this lab verified that the accepted value of \(g\) is 9.81 m/s² to within the uncertainty of the experiment. Additionally, our measurement was precise, with a small uncertainty of 0.01 m/s².

In performing our calculations, it was noted the value of \(g\) in Trial 3 was unusually low compared to the other values. This is probably because the Picket Fence was dropped at an angle that increased the distance, and therefore the measured time, between dark and transparent bands. This results in a lower calculated value of \(g\) for this trial. Since Trial 3 was done incorrectly, we rejected the data from this trial and calculated our final result from the other five trials.
There are two main sources of error in this experiment. First, there is air resistance present in the measurement. Secondly, it is difficult to make certain the Picket fence is dropped perfectly vertically every time. Both of these could contribute to the uncertainty of the experiment. However, since the uncertainty was small, they cannot have contributed much, except as explained for Trial 3.

The distance vs. time graphs are parabolic because the motion is uniformly accelerated. Additionally, the velocity vs. time graphs are linear for the same reason.

For Trial 6, the Picket Fence was thrown downward, but let go before it entered the Photogate. This does not change the acceleration, because the Picket Fence was still only under the influence of gravity as it fell through the Photogate. Graphically, this is because the slope of the velocity vs. time graph does not change, only the values on the graph change.

The Conclusion, and the lab as a whole, is short and to the point, but still manages to be complete. The phrase “Economy of Words” should come to mind.
Distance vs. Time for Picket Fence

Graphs should be a full page and should be clearly labeled. Labels should include a title, x-variable and y-variable with units in parenthesis, and scales on each axis.

Equation of best fit line is displayed.

\[ y = 4.9070 \cdot x^2 + 0.7776 \cdot x + 0.0002 \]