

Free Response: Step 2 of 6

Experimental Design Explained



1. If a plumb bob of mass, M , is attached to any length of string, the result is a pendulum that oscillates in simple harmonic motion. Using a stopwatch and other common physics laboratory equipment, determine the acceleration due to gravity.

- Articulate the experimental procedure, explaining what measurements will be recorded and how.
- Explain how the measurements recorded will be used to calculate the acceleration due to gravity.
- Another student overestimated the acceleration of gravity to be 14 m/s^2 . Identify and explain one way in which this may have occurred.

Sample Response

a) In order to calculate the acceleration due to gravity using a pendulum, we first need to measure the period of oscillation for different lengths of string. Taking one length of string at a time, attach the plumb bob to it, and then let it swing. Use the stopwatch to measure how long each pendulum takes to complete a full rotation, and verify the length of each piece of string using a meter stick. Repeat this process for each different lengths of string, noting down the period in s and the length of string in m.

b) Using the measurements for period and length, plug them into the equation for the period of a pendulum.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

The only unknown variable is g , the speed of gravity, so solve for g .

$$T = 2\pi\sqrt{\frac{L}{g}}$$
$$T^2 = 4\pi^2 \left(\frac{L}{g}\right)$$
$$= L \left(\frac{4\pi^2}{g}\right)$$

This now takes the form of a linear equation in slope-intercept form where the dependent variable is T^2 and the independent variable is L . Slope is $\frac{4\pi^2}{g}$.

By squaring the T values from the first part of the experiment and then plotting the corresponding L values, we get a linear graph. Find the slope of this graph by using the LSRL function on a calculator or by using pre-algebra. Set this slope value equal to $\frac{4\pi^2}{g}$ and solve for g to find a value for the acceleration due to gravity.

c) If a student incorrectly calculates that the acceleration due to gravity is much higher than it actually is, either the period was estimated to be too small or the length was estimated to be too large. If the period were smaller or the length were larger, it would have resulted in a smaller value for $\frac{4\pi^2}{g}$, which would have increased the value of g . The student may have thought that the period only accounted for the time that it took for the pendulum to swing across one way or may have incorrectly measured the lengths of string.

Breakdown (9 points)

a) 3 points

- For identifying the need to measure the period of oscillation for different lengths of string (1 point)
- For indicating all the measurements needed to determine acceleration due to gravity (1 point)
- For having no obviously extraneous equipment or measurements (1 point)

b) 3 points

- For work that shows an understanding of how to determine the period of oscillation for a simple pendulum (1 point)
- For work that shows an understanding of how to obtain an expression for which a linear graph can be drawn (1 point)
- For correctly determining the slope of the graph (1 point)

c) 3 points

- For recognizing that the period is either estimated to be too small or the length is estimated to be too large (2 points)
- For indicating the way those errors in measurement could have occurred (1 point)

What Good Responses Will Include

Accuracy

- Explanations of what tools are being used to measure the physical quantities
- How different trials are to be conducted
- Explanation of which scientific theories are being used
- Explanation of any math being used

- Identification of why a value is incorrect
- Analysis of where the incorrect step can be found

Clarity

- A clearly written and easy-to-follow flow of reasoning
- Clear statements as to what quantities are being measured
- Which equation is being used in the problem (if applicable)
- Which units are being used
- Clear articulation of the steps taken during data analysis

Bonus

- Good grammar (always a plus)
- Neat handwriting (another big plus)