Simple Pendulum

Goal: To determine the value of the gravitational acceleration by using a simple pendulum.

- **Theory:** A simple pendulum consists of an object with negligible size hanging on a string. When the object is deflected from its equilibrium, it oscillates back and forth. The time for one complete oscillation is called the period of oscillations, T. For small angles of deflection, the period of the simple pendulum is given by the following formula:

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

  By re-arranging the above equation,

  $$T^2 = \frac{4\pi^2}{g}L$$

  ,

  we see that the graph T^2 vs. L should be a straight line with a slope:

  $$slope = \frac{4\pi^2}{g}$$

  Thus, the gravitational acceleration can be determined by the slope of the T^2 vs. L graph. In order to increase the accuracy of the final result, for any given length, L, the period T must be measured several times. The average of these value will be T for that particular L. We repeat the procedure for several different lengths and plot the T^2 vs. L graph.

- **Preliminary Setup:**
  - You need:
    - A bead and a long string
    - A measuring tape (or ruler) and a watch. If you don't have a watch, you can use this Java Applet Stopwatch.
    - Scissors, a pencil and a scotch tape
  - Experimental setting:
    - Cut approximately 1 meter long string.
    - Tie one end of the string to the bead and the other to the pencil.
    - Tape the pencil onto a table or any other surface, so that the bead is hanging freely. This is your simple pendulum.

- **Activity 1: Determine the value of the gravitational acceleration.**
  - Determine the period of oscillations for a given length.
    - Measure the length of the string from the pencil end to the bead. Write down the length in your lab notebook.
    - Pull the bead approximately 5 cm to the side from its equilibrium position and let it go.
    - Measure the time for 20 oscillations, t, and write it down
    - Repeat the procedure seven times and record your data in your lab notebook
    - Average the seven values and determine the period of oscillations by dividing the time t by 20.
  - Measure the period for different lengths.
    - Decrease the length of the string by approximately 10 cm. Measure the new length, L, and write it down.
    - Measure the period for the new length following the outlined procedure above.
    - Repeat the steps until you have determined the period of oscillations for 5 different lengths.
  - Record the data in the following format:

L (m)	t_1 (s)	t_2 (s)	t_3 (s)	t_4 (s)	t_5 (s)	t_6 (s)	t_7 (s)	t_{av} (s)	T_{av} (s)	T_{av}^2 $(s)^2$

- Results:
  - Plot T^2 vs. L. You can directly plot the graph on a Graphing Paper or you can use a spreadsheet or any other program.
  - Find the slope of the graph. You can use your calculator, a spreadsheet, or you can go to this website for a quick calculation of the slop using the linear regression methods. If you choose the latter, clear the data and type in your own data. The slope of the line is given by "m" in the box below the graph.
  - Determine the gravitational acceleration g from the slope. Calculate the percent error, $100\% \cdot |g_{measured} - 9.8|/(9.8)$

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