Mathematical Pendulum

Galileo Galilei was the first to thoroughly investigate the mathematical pendulum. Since his time, this has been regarded as a model example for how physical laws can be derived from systematic measurements.

Goal

Dealing with a rather simple example, learn how to verify a physical law experimentally and how to disprove a wrong hypothesis.

You learn how to use a spreadsheet program (e.g. Microsoft Excel) to analyse the data, draw diagrams and fit curves.

Devices

- Stand with attached protractor
- several pendulum bobs
- stopwatch and measuring stick
- notebook computer running Excel

Preparation

i Run a series of twenty measurements for the time of five periods of the oscillating pendulum at small amplitude. Record the measurements in a table in Excel.

Calculate the average time. A good estimate for the absolute error of your time measurements is the maximum deviation of a measured time from the average time.

ii Discuss the pros and cons of choosing "nice" string lengths for your measurements.

Procedure

a Choose a pendulum bob and determine the pendulum's period at constant, small amplitude for ten different lengths. The number of periods per measurement has to be taken such that the relative error of the measurement does not exceed 1 %.

b Determine the period at constant, small amplitude and constant length for three different pendulum bobs.

c For one pendulum bob, determine the period at constant length for ten different amplitudes between 0 ° and 60 °.

Analysis

1. Choose an adequate graphical representation (including error bars), which clearly shows that the period varies as the square root of the length.
2. Determine the parameters of the best fitting function in the former diagram (with error estimate) and write them down with correct units. Use them to calculate the magnitude of the acceleration of free fall in the lab room (including error bounds). Compare your result to the accepted value (see "Formeln, Tabellen, Begriffe").
3. Show that the period of the pendulum is (within the error bounds) independent of the pendulum bob's mass.
4. Using the formula for the period at small amplitude, calculate the period for the length used in step c. Find the smallest amplitude for which the measured value deviates significantly (i.e. more than the absolute error) from the calculated value.

Requirements

If you do not write a report on this experiment, work at least on steps 1 and 2 of the analysis. The complete interpretation is required for a report.

Hand in your report or interpretation and the lab journal by Tuesday, 22 March 2011.