Simple Harmonic Motion

Purpose

The purpose of this lab is to measure the force constant of a spring, commonly called the spring constant, using simple harmonic oscillations.

Introduction and Theory

When an object attached to the end of a spring is displaced from its equilibrium position, the spring will apply a force to the object. The force is called a restoring force because it is opposite to the direction of the displacement and tries to restore the spring to the equilibrium position. If the magnitude of the restoring force is proportional to the magnitude of the displacement, we say that the spring obeys Hooke's Law. Hooke's Law is:

$$F_x = k\Delta x$$

where F_x is the restoring force, k is the force constant, and Δx is the displacement of the object from its equilibrium position. These quantities are magnitudes only – the restoring force is really in the opposite direction to the extension. A real spring obeys this law only for a limited range of deformation.

When the object is displaced from the equilibrium position, the net force on it is no longer zero and acceleration occurs. If Hooke's law applies, the acceleration is proportional to the displacement and opposite in direction, and therefore the object exhibits simple harmonic motion: it oscillates sinusoidally about the equilibrium position with constant amplitude and a period T of

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where m is the mass of the object attached to the spring, and k is the spring constant of the spring.

Apparatus Draw a labelled diagram of the apparatus (see Figure 1). For the spring, record its identifying number and the reference value for k. List all other apparatus required.

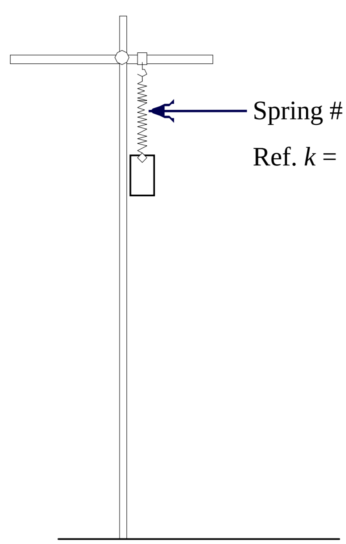

Figure 1

Data

The period T, or the time of one oscillation is short. To get better accuracy, we will measure the time for 20 oscillations t_{20}. Choose 5 or 6 different mass values between 500 g and 1500 g. For each value, pull the mass or masses about 2 cm down from the equilibrium position and then let it go. Use the stopwatch to measure the time for 20 oscillations t_{20} and record it in a data table. Your data table should include the mass m in grams and the time t_{20} in seconds, together with their uncertainties. For the uncertainty of t_{20}, a realistic assumption is that you are limited by your reaction time with the stopwatch, therefore δt_{20} can be estimated as your reaction time (ask your lab demonstrator if you are unsure how to measure your reaction time).

Calculations / Uncertainty Analysis (write them separately in your report!)

First, explain what quantities you will plot and how you will calculate the spring constant k and its uncertainty from the slopes (refer to Introduction and Theory). Then calculate the values and the uncertainties for the quantities that will be plotted, and list them in a "graphing data table". Remember to convert gram to kilogram before calculations. The uncertainties in one period δT should be much smaller than δt_{20} but still visible on the graph. The uncertainties for the other axis, however, are too small to show on the graph – still, you should list them in the table, but note on the graph that they are too small to be plotted.

Plot the graph with slope calculations on the graph. Then calculate the force constant of the spring and its uncertainty in your report.

Conclusions / Discussion (write them separately in your report!)

State your result of the spring constant, compare it to the reference value. Complete the discussion as usual.