Isaac Physics

Conical Pendulum Experiment

1 Aims and Objectives

- To investigate the effect of string length on the period of conical pendula.
- To use graphical methods to find the power law relation between the time for a revolution of a conical pendulum, the diameter of the rod and the number of revolutions from the fully wound position

2 Introduction: Conical pendulum of fixed length

- A pendulum bob is suspended from a fixed point by a string of length l. It is moving on a horizontal circle, of radius r, at a constant speed, v. The string makes a constant angle θ to the vertical. Draw a diagram showing all the forces acting on the bob at any given snapshot in its motion (instantaneously).

  Draw your diagram here:

- By considering the resultant force on the bob and the radial acceleration of a point moving at a constant speed on a circular path, show that the time t for one revolution of this conical pendulum is given by

$$t = 2\pi\sqrt{\frac{l}{g}\cos\theta} \tag{1}$$

  where g is the gravitational field strength.

  Space for calculation / proof over the page:

3 Experiment: Conical pendula of varying length

3.1 Methods

- Attach the free end of a pendulum thread to one of the rods, using a treasury tag through the hole in the rod. Wind the thread around the rod, with the turns packed closely together. Attach a pendulum bob, and continue winding away from the end until the bob touches the rod. Clamp the rod vertically so that the thread unwinds when released and the bob can move freely in a conical motion.
- Record the time t_n taken for the bob to execute n complete revolutions from the fully wound position, for at least five values of n in the range 4 – 12.
- Repeat the experiment, using $n = 8$, for each of the other rods which have different diameters, d. You may assume the rod diameters are 9.0 mm, 12 mm, 15 mm, 18 mm and 25 mm.

3.2 Results

- Enter your results in the excel spreadsheet table that has already been created. There are two worksheets within the file - one for each of the two experiments.
- A log-log graph will be plotted automatically as you enter your data points.

3.3 Analysis

- Assume that t_n is related to d and n by a power law relation such that

$$t_n = kd^a n^b, \tag{2}$$

  where k, a and b are constants. Note that k is not dimensionless: thinking about the units for t and d, can you see why this must be so?
- We have plotted in excel two graphs,

  (i) one of $\ln(t_n)$ (vertical axis) against $\ln(n)$ (horizontal axis) for fixed d,

  (ii) the other $\ln(t_n)$ (vertical axis) against $\ln(d)$ (horizontal axis) for fixed n.

From their gradients, find empirical values for a and b.

Some space for analysis calculations

4 Additional challenge

- Starting from equation (1), derive analytic values for a and b and an expression for k.