Experiment 2
Gravity

SAFETY

Make sure that you have read the **General Safety Notes**, in the Introductory section of this book, before you begin.

Do not, **under any circumstances,** attempt to repair or dismantle any of the equipment. If you suspect equipment to be faulty, turn it off at the power point and talk to your demonstrator.

Outline of Experiment

Last week you investigated gravity through the motion of a pendulum and were hopefully able to determine accurately the value of 'g' through the motion of the mass. This week you will be employing the equations of motion learnt in your high school education and using some data analysis techniques to find the value for g. It is important as scientists that we have multiple ways to determine our fundamental constants and environmental properties of note. Just as in any experiment we make more than one trial to arrive at a consistent result, we need to test the values of these properties in different ways to prove their validity.

At the address http://www.physicsclassroom.com/class/circles/Lesson-3/The-Value-of-g you will be able to find an applet to tell you the value of g in Melbourne.

The data results to this experiment should all be recorded and plotted in Excel. Please review Appendix B or ask your demonstrator how to use Excel if you're unsure.

✓***Pre-lab exercises:*** *Read the laboratory exercise, complete the questions below, then submit the pre-lab task online (LMS or http://fyl.ph.unimelb.edu.au/prelabs) for this experiment. [Your marks for the pre-lab will be based on the answers to the online questions, which are taken from the pre-lab work in the manual]*

Learning Goals

- To understand mathematical models for a linear relationship in order to determine the most accurate results.
- To relate data and the mathematical model to the physical aspects of the experiment.
- To estimate the overall uncertainty of the results and compare to the accepted value.
- To identify possible sources of uncertainty in the experimental method and offer reasonable ways to improve or minimise these.
- To obtain an experimental value for the acceleration of gravity through analysing the time of flight of a magnet falling under gravity.

✓ Pre-lab question 1

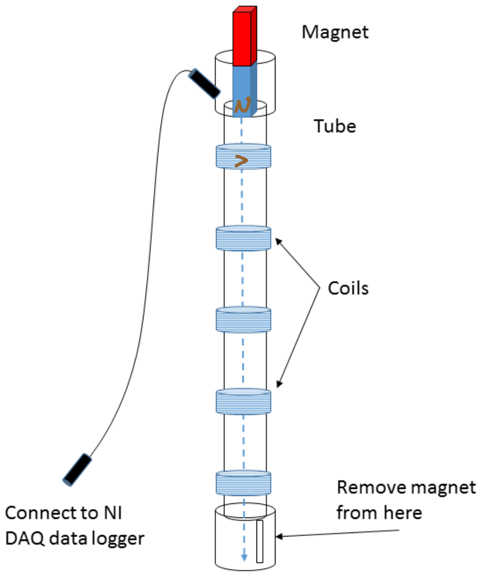
Derive $s = u\,t + \frac{1}{2}\,g\,t^2$ using integration for a body falling with constant acceleration a = g, with an initial velocity, u. (Knowing the equations of motion gives us a way of measuring the acceleration constant, g.)

Introduction

In this experiment, you will use "time-of-flight" techniques to measure the acceleration due to gravity, g. Time-of-flight techniques are very useful and are indispensable in the field of particle detection, where the energy of a particle can be determined by timing the particle's flight over a known flight path. Fast and accurate timing is required to measure the particle's energy.

Experimental Set-up

The "Gravitation System" apparatus consists of a Perspex pipe with several coils connected in series. A magnet is released at the top, and allowed to free-fall. As it does, it passes through each coil, inducing a voltage which is observed on the oscilloscope.



In the course of this experiment you will measure (distance, s; time, t) data as the magnet falls through the coils.

✓ Can you see how you might use the equation from Pre-lab question 1 to obtain g? As it has two unknowns (u and g) it may seem to be impossible. (note that u cannot be made to be zero as the timer starts when the magnet passes the first sensor, implying u≠0)

However, if you rearrange the equation by dividing through by t, you get: ${}^{s}/_{t} = \frac{1}{2}gt + u$

It should then be noted that the two 'unknowns' in this expression influence the structure of a graph of (s/t) vs t in very different, but well understood ways.

✓ If you were to graph s/t vs t for your data, how would you find a value for g? What else could you obtain from your graph?

Data

- ✓ Using the system, record 5 drops taking down the important parameters for your analysis. Think about what these may be and record this in your logbook.

- ✓ Is your data consistent with a linear interpolation or is there a distinct curve in it?

- ✓ If your line is not linear, use the information above to reconsider your data and re-plot your results (include your old data and plot in your lab book, these thoughts about the analysis of the experiment are an integral part of the experimental process).

① the time we first measure is not the starting point

②. ✓ Does the graph of s/t versus t pass through the origin? If not, why not? Determine g with uncertainties (these uncertainties come from the limits of your measuring apparatus) and compare it with the 'known' value of g = 9.800ms^{-2} for Melbourne. Use Appendix A to help you here.

Analysis

✓ Recalling your work from last week. You have now calculated g using 2 different methods. Which method gave you a better value of g? Why would this method be better?

✓ Where would the errors (systematic and random) come from in this experiment? Justify your answer. Could they be removed? If so, how?

systematic ① air friction

random ② manually cause the magnet don't fall vertically

③ length of the coils.

Next Week

Your next experiment will look at the concept of Friction. The first part of the experiment will be directed, but you will have the opportunity to design a small experiment to explore another aspect of friction using the same equipment. So you are prepared, you may like to discuss some ideas with your partners and demonstrator when you have finished this lab.

Write some notes in your logbook for your demonstrator to review.

Summary :