

INTERNATIONAL FOUNDATION YEAR (IFY)

Physics Lab: Hooke's Law Experiments

LABORATORY INSTRUCTIONS

1 INTRODUCTION

1.1 General introduction

The laboratory work for *Physics Lab* is offering practical experience of construction and testing to support the theory. You will undertake the experiments described in this document over two formal 2-hour laboratory sessions.

Organisation

You will be working in the laboratory in pairs, with one set of test equipment for each pair. You are free to choose your partner for the laboratory work. If you are unable to attend your timetabled formal session, it will not be possible for you to attend any other formal session instead.

You must attend the lab on time and if you are late you may not be let in. Attendance registers will be taken.

At the end of each lab session, it is your responsibility to tidy up your workspace.

In the experiment for *Physics Lab*, although it is a joint activity, each member of the pair is expected to contribute, and each must make an individual record of the test results in his/her logbook.

You will need a laboratory logbook, **with alternate pages of graph paper and ruled paper**, to record the results of experimental work. These logbooks are on sale in the bookstore in the Library and the Union shop.

1.2 Using the logbook

The laboratory logbook is a permanent record of your work. It should not be mistaken for a laboratory report, which would contain the findings of your experiments, but is a secondary document. The logbook is a primary document and as an engineer you are likely to be expected to use one properly in your professional career. It is therefore extremely important that you learn how to do this early on in your course.

This module will introduce the concept of a logbook and require you to carefully and methodically record the required results. In subsequent modules and in your final year at the university, you will be expected to keep your own logbook, recording results and plotting graphs without being prompted.

You will need to record results and observations in your laboratory logbook as the experiment proceeds and will be prompted to do so by the use of CAPITAL LETTERS throughout this laboratory instructions sheet. **YOU MUST MAKE CLEAR HEADINGS** for each of the entries in your logbook. In combination with this sheet, your logbook must show a complete record of your experiment and the results you obtained.

It is important to write results straight into the logbook, and not record them in rough first. Direct recording of results is good engineering practice, and there will not be time to copy out rough work. Write in ink, not pencil. The logbook is a permanent record. If you make a mistake, just cross it through; you will not be penalised for doing that. Once you have gained skills in keeping the logbook, the following should always be included:

- Title of the experiments
- The date, which should be entered each day you add information
- Methods and equipment used
- Results and observations, with headings
- Sketches, calculations and graphs as required
- Brief discussions of results
- Brief conclusions when suitable
- Comments about failures and reasons

Avoiding collusion

Although you are doing the practical work for this lab in pairs, your logbook is supposed to be a record of **your own work**. The methods used, and results measured will be the same for each pair, but you must keep your own record as you go along and not copy from your partner.

2 THE SPIRAL SPRING

2.1 Object

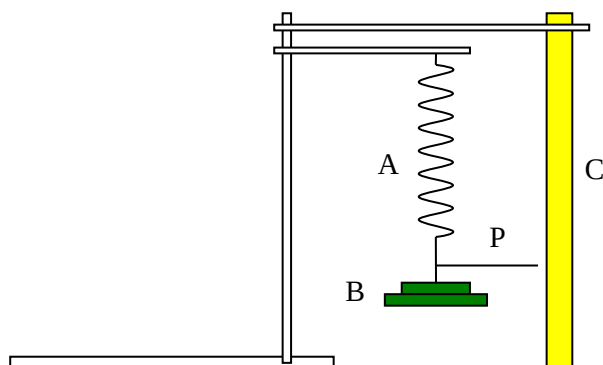
This laboratory session will be used to measure the static and dynamic properties of a spiral spring. This experiment will enable you to understand:

- How soft or firm is your car's suspension?
- How do you actually characterise a spring? We need a number to say how 'spring' it is? How much resistance it gives to being pushed and pulled.

2.2 Constructing

For the construction and testing of this experiment you will need to make entries in your logbook, giving evidence you have undertaken and understood the lab work. CAPITAL LETTERS indicate that you should record results, make graphs or comment on your findings. Do not forget to write clear headings for each entry.

Components



Each pair will be issued with the following:

1. Light spiral spring (A)
2. Scale pan (B)
3. Metre rule (C)
4. Pointer (P)
5. Stopwatch
6. Two boxes of weights
7. Two clamps and stands

Experiments

You will need to complete the following two measurement experiments:

1. Measurement of the Elastic Constant of the Spring: Simply by loading the spring with weights to see how much it stretches.
2. Oscillations of a Spring: Simply by using a slightly more subtle method of letting a weight bounce up and down, and measuring the frequency. The stiffer the spring, the faster the weight bounces up and down.

The two measurements should agree.

2.3 Experiment 1: Measurement of the Elastic Constant of the Spring

Procedure

- 1 Suspend the spring from the clamp.
- 2 Attach the pointer or a piece of wire, for example, to the lower end of the spring.
- 3 Attach the scale pan to the lower end of the spring.
- 4 Set up a metre rule parallel to the spring so that the pointer just touches it.
- 5 **SETUP THE FOLLOWING TABLE IN YOUR LOGBOOK.**

Mass (g)	Ruler Reading (cm)
0.00	

- 6 Load the pan with progressively increasing masses, **NOTING THE POINTER READINGS** each time in your table on your logbook.
- 7 On your computer, using a spreadsheet like Microsoft Office Excel to make a column of the weight in newtons (N) of each of the masses. Remember that under Earth's gravity, a mass of 1,000 g has a weight of 9.81 N (not 10 N).
- 8 Make a column of the ruler reading in metres.
- 9 **PLOT A GRAPH OF THE RULER READING (y-axis) IN cm AGAINST APPLIED WEIGHT (x-axis) IN N. WITH CORRECT UNITS, LABELS AND TITLE.**
- 10 Measure the gradient m of the graph and the error in the gradient.
- 11 The elastic constant k of the spring is the force applied per metre extension of the spring.
$$F = kx$$
$$\text{Where: } k = \frac{dF}{dx} = \frac{1}{m}$$
- 12 Use the gradient of your graph to find k .
- 13 Find the error in k using the error in your gradient.

2.4 Experiment 2: Oscillations of a Spring

Procedure

- 14 Using the same setup as in Experiment 1.
- 15 Load with a suitable mass of 100 g to the scale-pan.
- 16 Pull the scale-pan down slightly and release it so that the pan makes simple harmonic oscillations.
- 17 SET OUT THE FOLLOWING TABLE IN YOUR LOGBOOK.

Load on pan (kg)	Time for 30 oscillations (s)	Period T (s)	T ² (s ²)
0.10			

- 18 You will be measuring the period of oscillation for various loads.
- 19 Apart from gross errors including losing count, the major source of error will be in the timing of the start and finish of the oscillation. Therefore, it is necessary to count over enough periods, 30 in this case, to make such an error acceptably small.
- 20 Repeat the experiment for eight loads between the minimum and maximum values used in Experiment 1, taken in random order.

3 THEORY FOR ANALYSIS

If the spring is extended a distance x from its equilibrium position, there is a restoring force (F)

$$F = -kx$$

Note the minus sign, which is because here we are talking about the restoring force applied by the spring rather than the force that you have to apply to the spring to stretch it.

The period T is given by

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

Where:

- M is the mass
- M_p is the pan mass
- m is a constant, related to the mass of the spring itself. If the spring had negligible mass, m would be zero.

Therefore, squaring the previous equation, we find:

$$T^2 = \frac{4\pi^2}{k}M + \frac{4\pi^2}{k}(M_p + m)$$

Note this is just like a straight-line equation:

$$y = Gx + c$$

If we vary the mass M , then the period squared T^2 varies with it; everything else stays the same. So, if T^2 is y , the mass M is x , then the gradient G of the line will be $\frac{4\pi^2}{k}$

- 21 PLOT A GRAPH OF T^2 IN s^2 ON THE y -axis VERSUS M IN kg ON THE x -axis WITH CORRECT UNITS, LABELS AND TITLE.
- 22 MEASURE THE GRADIENT G AND THE ERROR IN THE GRADIENT.
- 23 CALCULATE k USING THE FOLLOWING EXPRESSION.

$$k = \frac{4\pi^2}{G}$$

- 24 WORK OUT THE VALUE OF k AND ITS ERROR.
- 25 COMPARE k WITH THE VALUE MEASURED IN EXPERIMENT 1 TO SEE IF THE TWO MEASUREMENTS ARE CONSISTENT WITHIN THE MEASURED EXPERIMENTAL ERRORS.
- 26 SUBTRACT ONE VALUE FROM THE OTHER, IS THE ANSWER ZERO TO WITHIN A COUPLE OF ERROR BARS?
- 27 COMMENT ON YOUR RESULTS, SOURCES OF ERRORS, LIMITATIONS IN TAKING MEASUREMENTS AND ANY CONFOUNDING VARIABLES TO GIVE A CONCLUSION ON MEASURING THE STATIC AND DYNAMIC PROPERTIES OF SPIRAL SPRING.