2021 EXPERIMENTAL PROJECT

(STUDENTS MAY WORK SINGLY OR IN TWO's OR THREE's)

COMPOUND PENDULUM

A. Introduction

Practical work is about technique and ideas. It is a skill that needs to be developed. You need to know where you are heading: real practical work is not about following instructions line by line, but about endeavouring to make things work. That is what this Experimental Project is concerned with.

A pendulum is a device that consists of a suspended mass that oscillates with a particular time period.

For a simple pendulum the mass is considered to be concentrated at a point and the method of suspension is considered to be massless. In experiments involving simple pendula the mass is often a dense object e.g. a lead ball and the method of suspension is commonly a light inextensible string.

The expression for the time period, T, of such a pendulum is given by

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

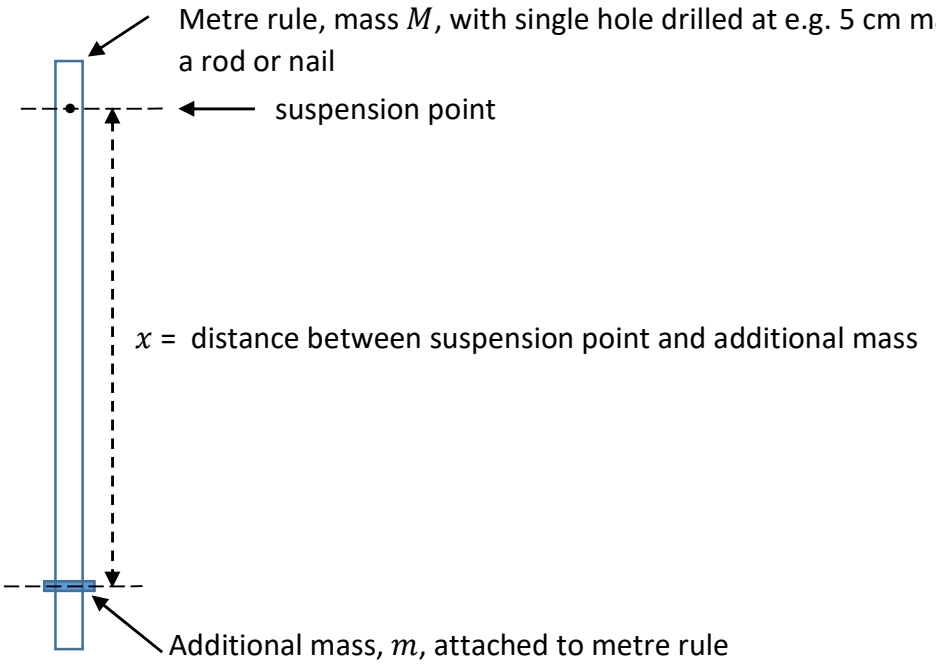
where ℓ is the length of the pendulum (from point of suspension to centre of the 'bob') and g is the acceleration due to gravity at the point on the Earth's surface. T is the time taken to swing out and back.

In reality, pendula for practical uses, such as clocks or metronomes, aren't simple pendula; the mass is usually an extended object such as a rigid bar and these are referred to as compound pendula.

In this experimental project you are asked to construct a compound pendulum to investigate how changing some parameters of the setup affects the time period of the oscillation, T. Throughout the project you should pay attention to employing good experimental technique to increase accuracy and precision. A successful experimental project is not just about the end results – it is about illustrating how the project developed, what challenges you met and how you overcame them. Throughout this project you should always be thinking about how you can increase experimental accuracy – and make it clear what measures you took to do this.

B. Experimental Arrangement

In order to construct a compound pendulum, you will need a metre rule (or a wooden slat about a meter long and similar in cross section to a meter rule, a screw or nail to support the metre rule and some additional mass (and a means to attach it to the metre rule).



IMPORTANT

Great care must be taken when safely drilling through the metre rule.

Some non-wooden rulers may not be suitable for drilling.

Ask a teacher/technician to do this for you.

You could investigate a number of variables with this setup;

- the size of the mass, m
- the distance, x, between the additional mass and the suspension point
- the position at which the rule is suspended
- any other variable you think may affect the time period.

For each experiment you carry out you should vary your chosen variable and ensure you keep all other factors constant.

You should take steps to ensure accurate and precise timing of the oscillation and should indicate how this was achieved.

You should display your findings graphically, obeying standard conventions, and also conclude what you think the underlying relationship is between these any variables investigated, along with some comments about how confident you are in your findings.

You are NOT expected to do a theoretical analysis of the pendulum. Equations to justify or to fit the graphs are not wanted. This is about developing experimental skills not testing a theory, although a quantitative analysis of your results and findings is expected.

C Final Analysis

From the investigation, what can you conclude about the underlying relationship between the variables for the setup?

Review your data and give a consideration of the uncertainty in your measurements and overall experimental accuracy.

Suggest what might you investigate next to further the experimental project (you don't actually need to do this) and explain why.

(a) Experimental Report

The report should describe the experimental work and include data, tables, graphs, diagrams (and/or photographs), plus a discussion of measurement uncertainty and experimental accuracy.

This report should contain:

(i) A concise description of the experimental procedure, including diagrams and photographs.

(ii) A brief description of what you observe happening.

(iii) An outline of any experimental techniques used to improve accuracy or reduce uncertainty, and modifications to the procedure from any trial experiments.

(iv) Precautions taken to consider safety.

(v) Uncertainty and accuracy estimates and brief comments about them.

(b) Report Guidelines

There is no single correct way to write up a report. It depends on how you conducted the investigation. One critical feature is that it must be detailed and concise. If overlong, then it is too much to read through whilst trying to remember the detail; if too short then the reader cannot grasp the essence of the investigation.

The page limit for your report is 12 pages including diagrams/photographs/tables/graphs.

(c) Advice

Keep a log book; an A4 notebook from which pages cannot be ripped out, so that you can write and paste in comments and ideas, stick in graphs from a computer, along with keeping a record of your progress. Learn to be organised. It helps you keep track of your progress and keeps the information in one place. You can refer to it and it makes writing up so much easier. All experimental physicists (and theoreticians) keep such a notebook.

You should give a full (but concise) description of the experimental procedure. Highlight any particular ideas you had to make the results more reliable, with results, tables, units, uncertainties, graphs, diagrams and images. This is elaborated below.

We do not want you to write a long report (12 pages maximum), but one which describes your progress and results in a way that would explain clearly to the reader what happens in the experiment, what you did, and what your results were, in such a clear way that they are persuaded that you knew pretty much what you were doing. Keep it simple and **BRIEF**. You are trying to remove elements of doubt in the reader's mind that you might just be making random measurements.

- Put **a title on the front, the date, your own name and school name**, and ensure your name is on every page by putting it in the footer, along with page numbers. It then appears automatically on each page. If you don't do this the projects can get muddled.
- Write-ups ideally should be word processed, but hand-written reports are also welcome. Regardless, the report should be brief and to the point.
- You should comment briefly on precautions you took and good ideas you had about reducing the uncertainties of your measurements and what were the difficult measurements to make and why. Do not write an essay but just a short comment about each good idea.
- If you feel that the results are not right, then don't scribble them out or delete them; keep them and just point out what might be wrong with them or why you have no confidence in them. The purpose is to show that **you have investigated the apparatus** and given it a good try out so that you can convince the reader that **you know and understand the science behind the investigation**. Things can go wrong and you need to show how you can overcome setbacks. If you delete everything that does not seem right to you, the reader might see a nice final table of results, but they do not know how much investigative effort you have put in to get that set of results. The reader might indeed wonder whether they are that good. Do **not** write an essay, just a few bullet point comments.

  Good luck with the experiment!

  The BPhO Team

(PTO: Checklist and submission details)

CHECKLIST

	☑
1. Is your name and school on each page of the report, and year group?	☐
2. Is the reported dated?	☐
3. Are the pages numbered?	☐
4. Short introduction to your report, including key findings.	☐
5. Discussion of any relevant safety hazards, with measures to reduce risks.	☐
6. Outline of experimental method, including any controlled variables.	☐
7. Discussion of any approaches/adaptions to increase accuracy of measurements.	☐
8. Qualitative description of key observations from experiment.	☐
9. All data recorded appropriately.	☐
10. Graphical analysis of data and detailed conclusions drawn from this	☐
11. Uncertainties considered in some form, either discussed, calculated or both.	☐
12. Evaluation of project, considering validity of conclusions and improvements.	☐

The cover page must contain the school information.

The written report should be submitted by post or email through your teacher.

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