2019 EXPERIMENTAL PROJECT

(STUDENTS MAY WORK SINGLY OR IN TWOS OR THREES)

BIFILAR 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 bifilar pendulum is comprised of a horizontal beam and two supporting threads. Whilst this is a relatively simple setup it is incredibly versatile for a number of engineering and physics based applications. In 1897 an earthquake centred on Kolkata (then "Calcutta"), India was detected in Edinburgh Royal Observatory, Scotland via measurements made from a bifilar pendulum. A similar setup can be used to measure irregularities in the rotation of the Earth, testing stability properties of a UAV and even using the oscillation to determine magnetic field strength when the setup incorporates a permanent magnet as the horizontal beam.

In this experimental project you are asked to accurately construct a bifilar pendulum to investigate how changing some parameters of the setup affects the time period, T, of the oscillation. Throughout the project you should pay attention to employing good experimental technique to increase accuracy and precision.

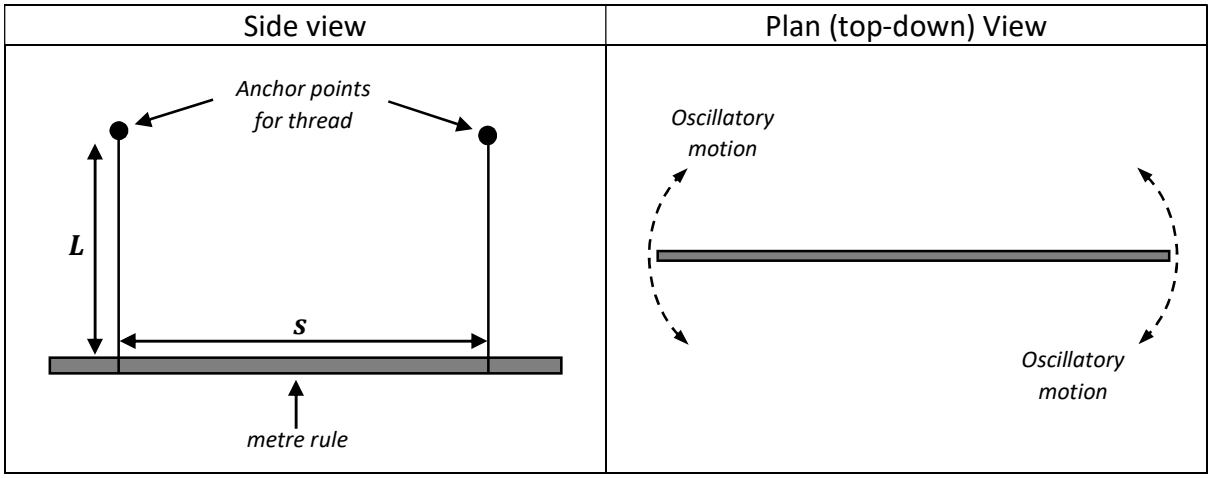
A successful experimental project is not just about the end results – it is about illustrating how the project developed, what challenges you met and how you overcame them.

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 bifilar pendulum, you will need a metre rule, some thread and a suitable means to suspend the beam horizontally in the air. The length, L, of the two supporting threads should be identical and you should take steps to ensure this is the case. The supporting threads are then separated by a distance, s, such that the setup is symmetrical (i.e. the threads are the same distance away from the centre of the metre rule).

Basic Diagram:



First Experiment

IMPORTANT: Keep the distance, s, constant throughout the first experiment.

By varying the length, L, investigate the relationship between the time period, T, and the length, L. 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 and also conclude what you think the underlying relationship is between these two variables, along with a consideration of how confident you are in your findings.

Second Experiment

IMPORTANT: Keep length, L, constant throughout the second experiment.

By varying the distance, s, investigate the relationship between the time period, T, and the distance, s. Again, you should take steps to ensure accurate and precise timing of the oscillation, and you should indicate how this was achieved. You should display your findings graphically and also conclude what you think the underlying relationship is between these two variables, along with a consideration of how confident you are in your findings.

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.

In what way do you think it would be best to set up the arrangement to detect earthquakes?

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 maybe a photograph.

(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.

D. 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, along with 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 preferably shorter), 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, Group G or A (GCSE or A level), your own name and the 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 get muddled.

- Write-ups can be by hand, in Word, or in Latex (if you have someone to help you get started). Hand written reports often score well as such a report tends to be brief and to the point, although a word-processed report would score equally well if suitably concise.

- 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 (bullet points) 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

CHECKLIST ☑

1. Does the front page contain a Title, date, your name(s), Group G or A, the school name? ☐
2. Is your name and school on each page of the report, and year group? ☐
3. Is the report dated? ☐
4. Are the pages numbered? ☐
5. Short introduction to your report, including key findings. ☐
6. Discussion of any relevant safety hazards, with measures to reduce risks. ☐
7. Outline of experimental procedure, including any problems and adjustments. ☐
8. Qualitative description of key observations from experiment. ☐
9. Data recorded appropriately ☐
10. Graphical analysis of data and 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 done by the students themselves **must** contain the school information.

TEACHERS

13. The written report should be **submitted by post**, but a scan of the project should be kept. ☐
14. **Teachers** should fill in an **online form** from the link below, so that we can keep track of the projects. This form should also be printed and should be attached to each project as an additional School cover sheet. ☐

https://www2.physics.ox.ac.uk/bpho-experimental-project-2019-20-entry-form

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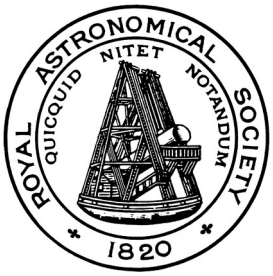

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