# The Chaotic Pendulum

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## Abstract

The abstract should be approximately 50 to 200 words long. It should consist of a clear and precise description of the experiment and the key findings. If there are a few key numerical results then these should be stated with their uncertainty. Try to avoid symbols or equations as these take time to define and are rarely beneficial. Do not use tables or graphics. Try to avoid material requiring referencing, if it is essential, then the reference should appear at the end of the abstract rather than the end of the report. If the same reference is used in the report proper, then it should also be referenced at the end of the report.

The purpose of the abstract is to allow someone to decide whether to read the complete report, and as such an abstract should always be independent of the report; nothing should be in the abstract that is not in the report, and all major elements of the report should be represented in the abstract.

# 1 Introduction

The introduction should introduce the reader to the report and the experiment. To do this it should provide any necessary background or context to the experiment, this may include brief historical information or notable previous work. As in all sections you should cite references to support factual claims other than your own results. We will be more impressed by citations of the original historic papers than by citations of textbooks, and more impressed by textbooks than by web pages. This section should also describe the main desired outcomes of the experiment, any practical applications, and any other notable elements of the experiment not sufficiently technical for the main body of the report. It should not just be a summary of the experiment.

# 2 Theory

This section should explain the physics behind the experiment that you are doing, including diagrams where appropriate. This should be at the level of a non-specialist peer, for example a fellow university undergraduate who has not yet done this experiment. Most theory sections will include equations, these should be centred on the page, numbered with the number aligned to the right of the page, as part of a grammatically correct sentence, and with all terms defined. For example:

The electric field, $\mathbf{E}$, of a monochromatic wave travelling in the $z$ direction and polarized in the $x$ direction is given by

$$\mathbf{E} = \hat{\mathbf{i}}\, E_0 \sin(kz - \omega t), \tag{1}$$

where $k$ is the wavenumber, $\omega$ is the angular frequency, and $t$ is time [1].

## 2.1 Theory subsection

Sometimes it can be useful to subdivide sections. Don't overdo this: if you have more than two titles on a page you are probably subdividing too finely. If you have subsections it may be useful to have an introductory paragraph between the title and the first subsection, but in other cases it makes more sense to have, say, the 'Theory' header, followed immediately by the 'Theory subsection' header. There is no point in having just one subsection in a section! [2] is an example of another citation.

# 3 Experimental approach

This section should describe any finer details of your experiment and should be given a title appropriate to the experiment. It is generally useful to have a schematic diagram of the key parts of your experimental setup; an example is given in Fig. 1.

Figure 1: Schematic diagram of the Michelson interferometer, consisting of two mirrors, labelled A and B, and a coherent laser source targeted at a 50:50 beamsplitter. Mirror A is mounted to a translation stage parallel to the incident radiation, and both A and B have fine adjustments for alignment in two dimensions.

In some cases it might be useful for one of the figures to be a photo of the apparatus, but these are often confusing, and a clear schematic diagram is usually better. However, you will not get much credit for simply copying diagrams from the lab script. Diagrams should contain readable labels for all pieces of equipment shown and should have a caption that describes what is in the image. Remember, when talking about parts of your experiment, you cannot say 'the laser was aligned with the target', until you have told the reader that there is a laser and a target; this can be done via a figure, but the "telling" is then the point where the figure is referred to in the text. This section should also include details of the uncertainties associated with your measurements. Other things you may like to include at this stage are details of any experimental calibration, or actions undertaken to reduce uncertainty in your results. Often, the overall accuracy hangs on such measurements, so they should be clearly described.

## 4 Results

This section should typically be the largest in the report. It should include all the data that you have used to draw results and conclusions from, and a critical analysis of those results and conclusions. The data should typically be presented in either tabular or graphical form, with the graphical form always being preferable where appropriate. You should never include both a table and graph of the same data. Tables and graphs should be placed across the full width of the page. LaTeX automatically sizes a table to fit the text. Table 1 shows an example. For graphs, a scaling factor must be used to ensure that the image fits the page. All figures and tables should be referred to explicitly by number, and explained in the text. Figures should not rely on use of colour, as for marking your report will be printed in black and white. Graphs should contain axis titles, units, error bars and a key as appropriate. This section should not just be sequential graphs, each should have associated text discussing the results from that particular section of experiment. This section should also contain a discussion of your error analysis, and should identify the main contributor(s) to the uncertainty of each value.

## 5 Conclusions

All reports should contain a 'Conclusions' section. This should describe any conclusions that can be drawn from the experiment. Unlike the abstract, it is not a summary of the entire report, so it does not need to re-describe the experiment. This section should contain no new information.

Table 1: Height of the meniscus for different magnetic fields.

| Current (A) | Magnetic field (T) | Height of meniscus (mm)[a] |
|---|---|---|
| 0.1 | 0.23 | 3.24 |
| 0.2 | 0.46 | 3.41 |
| 0.3 | 0.46 | 3.60 |
| 0.4 | 0.87 | 3.97 |
| 0.5 | 1.06 | 4.32 |
| 0.6 | 1.27 | 4.81 |

[a] The heights, measured with a microscope, are accurate to 0.02 mm.

To reiterate that last point, everything discussed in this section should be mentioned somewhere else in the report. However, extensions or improvements to the experiment can be suggested, so long as the limitation that is being overcome has been discussed elsewhere.

## References


[1] D. Morin, *Introduction to Classical Mechanics: With Problems and Solutions*. Cambridge University Press, second ed., 2008.

[2] A. Einstein, "Zur Elektrodynamik bewegter Körper," *Annalen der Physik*, vol. 322, pp. 891–921, 1905.