

Division of Physics & Applied Physics
PH2198/2198—Physics Laboratory IIA/IIB

Writing a Good Lab Report

1 What is—and isn’t—a proper lab report

The lab reports that you will prepare in this course are shorter and simpler versions of the reports that working scientists use to communicate their findings. Such reports are expected to be accurate, complete, concise, and readable.

- *Accurate*—The contents must be unambiguous and correct. “Correct”, in this context, means that the contents match what happened during the experiment; it does not mean “getting the right answer”. It is OK to have results that are uncertain or that do not match expectations, provided these uncertainties and deviations are pointed out and/or explained.
- *Complete*—The report must include all information a reader would reasonably want. For example, if you use a symbol in an equation, figure, or text, that symbol should be defined (in a caption or in the text). If you show a plot of experimental results, the text should describe how the data were obtained, and what conclusions the reader should draw from it.
- *Concise*—Do not clutter the report with useless information. Assume that the reader is scientifically literate (at the level of a fellow physics undergraduate). For instance, you need not explain classical mechanics before talking about forces. Omit details that most readers would consider trivial (e.g., the fact that the voltage on a power supply increases when turning a dial clockwise).
- *Readable*—The text in the lab report must form a coherent, readable narrative. The main text should form proper paragraphs. Do not write your report in Q&A (question-and-answer) form, and do not organize your report as a mere collection of bullet-point lists. Your descriptions of experimental procedures shouldn’t be a list of steps lifted from the lab manual; that information should be converted into proper paragraphs, and interwoven with explanations about the intention of the procedures, what happened during the experiment, etc.

The best way to internalize these criteria is to always bear in mind the goal of a lab report, which is to communicate a set of scientific findings to interested parties. Readers will be happy if the information is presented clearly and accurately, and contains all the details that they need to understand the results. They will be annoyed if you write about irrelevancies, or format the report in an inscrutable way.

2 Sections of the report

Your lab report should be divided into distinct sections. There is no standard set or sequence of sections. Here is a typical and acceptable outline:

1. *Introduction*—A description of the goals of the experiment. Do not lift the text from the lab manual; use your own words. The introduction need not be long; in many cases, one or two paragraphs is enough.
2. *Methods*—Descriptions of the experimental set-up and procedures. When writing about the set-up, do not follow the lab manual in listing out individual pieces of equipment and assembly instructions; that’s not relevant information in a lab report! Instead, describe the apparatus as a whole (preferably with a diagram), and explain how it works.

Likewise, when describing the experimental procedure, do not simply lift instructions from the lab manual. Your description should take the form of a narrative, and include information not present in the manual, such as descriptions of what happened during intermediate steps of the experiment.

3. *Results*—This section should contain *both* complete paragraphs of text *and* figures/tables. It should be possible to understand what’s going on by just reading through the text paragraphs, without looking at the figures. Every figure/table must be referenced and discussed somewhere in the text (e.g., “*The dependence of the sample temperature on applied voltage is plotted in Fig. 3. From the data, we observe an approximately linear relationship...*”).

The report should contain all necessary details about how the data were analyzed, including error analysis (i.e., derivations for the uncertainty estimates). If an analysis is too long, relegate it to an appendix.

4. *Conclusions*—Summary of what was learnt from the experiment. If the results seem unexpected or unreliable, discuss them and give possible explanations. This section need not be long; one or two paragraphs is OK.
5. *Appendix A, Appendix B, etc.*—You can use appendices for detailed derivations, tables of raw data, etc., to avoid cluttering up the main text.
6. *References*—If you referred to any other works in the text of the report, list them here. References should be numbered, and appear in the same order they are mentioned in the text. The text should cite references by number.

You don’t need to stick religiously to this outline. For example, in some cases, instead of *Methods* and *Results* sections, it might be better to divide the experiment into several conceptually distinct parts, and describe the methods and results for each part within a single section.

Some lab manuals provide an explicit list of issues/questions to be addressed in your report. Do not create a Question-and-Answer section for this. Instead, deal with these issues at appropriate places in your report; it is up to you to decide where. For example, if there is a question about safety hazards and how to mitigate them, it might be appropriate to have one or two paragraphs discussing this in the *Methods* section, during your description of experimental procedures.

3 Figures

You are free to choose the software for preparing the figures in your lab report. The software must be able to produce plots of professional scientific quality, including horizontal and vertical error bars, text labels, multiple curve and data point types, and logarithmically-scaled axes. We specifically recommend Python’s [Matplotlib](#) module, [GNU Octave](#), [Matlab](#), or [Origin](#) (the first two are free).

Here are some issues to watch out for when making plots:

- All data points must have error bars—preferably both vertical and horizontal error bars—unless there’s a good reason otherwise.
- Axes must be clearly titled, including units. If space permits, axis titles should have descriptive text, not just symbols; e.g., “Applied force F (mN)” is better than “ F (mN)”.
- If a graph has multiple sets of curves/data points, they must be distinguishable (e.g., solid versus dashed curves, or circular versus triangular data points). The different sets should be labeled in the figure and/or described in the caption.
- The figure must have a caption describing its contents. Never worry about putting “too much” in the captions; in particular, it is OK to have overlap between the contents of the caption and the main text.
- All text in the figure (including the legends, axis labels, and axis titles) must be big enough to read. As a rule of thumb, figure text should be 60–100% the size of the regular text in the manuscript, and no smaller. If your plotting program produces text that’s too small by default, adjust it yourself.

An example of a good figure is shown in Fig. 1. Note the error bars, the axis titles and labels (which are in legible sizes, with units), and the description of the best-fit line in the caption. Some examples of bad figures are given in Appendix A.

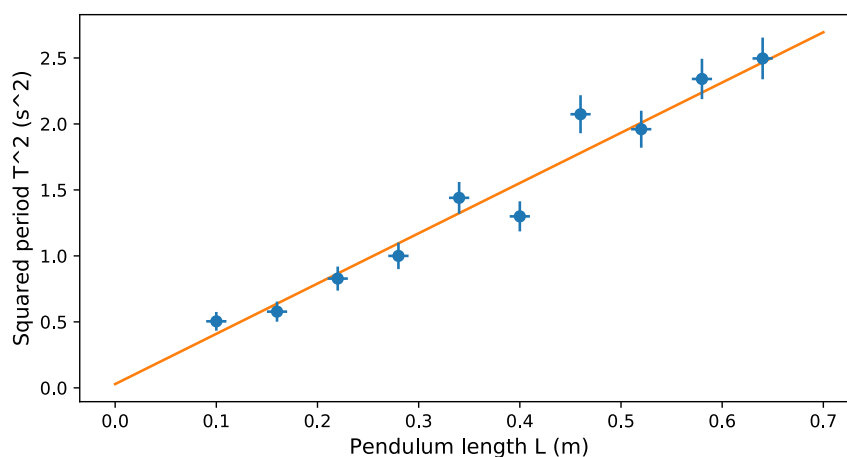


Figure 1: [Example of a good figure.] Plot of squared pendulum period T^2 versus pendulum arm length L . The solid orange line shows the linear least-squares fit, which yields an estimated gravitational constant of $g \approx 10.4 \pm 0.8 \text{ ms}^{-2}$.

4 Miscellaneous Issues

- *Figures from the lab manual*—You may excerpt figures from the lab manual, where appropriate. However, the figure caption must note that the figure is from the lab manual, with an appropriate citation/reference.
- *Page and figure/table/equation/section numbering*—All pages should be numbered, and so should figures, tables, equations, and sections. Refer to these numbers whenever possible; e.g., “*as described in Section 2...*” instead of “*as described above...*”
- *Curve fits must make sense*—When fitting data, you should be able to justify the type of curve you are using (e.g., based on theory). It is a mistake to simply fit to a high-order polynomial, like in Fig. 2, without any idea whether the “actual” curve ought to have such a form. Such a fit might look nice, but it supplies no actual information!

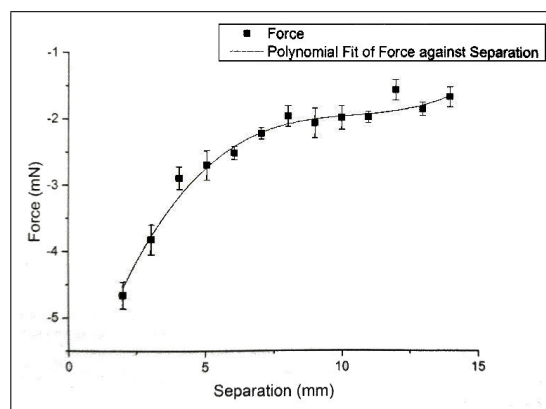


Figure 2: An example of a curve fit that makes no sense.

- *Raw data*—Include your raw experimental data in table form, with proper captions and column headings (including units and uncertainties). If the table is quite large, put it in an appendix. If there is truly too much raw data to put into the report, you may omit it, but in that case you must bring the raw data (in hardcopy or electronic form) to the viva. You must be able to provide the raw data on request anytime during the semester, so do not dispose of it until after the semester, when you have received a grade for the course.
- *Length*—Lab reports in this course typically need not exceed 7 pages. Use ≈ 11 point fonts, with normal (*not* double) line spacing.

Appendix

A Bad Examples

Here are some examples showing what *not* to do in lab reports.

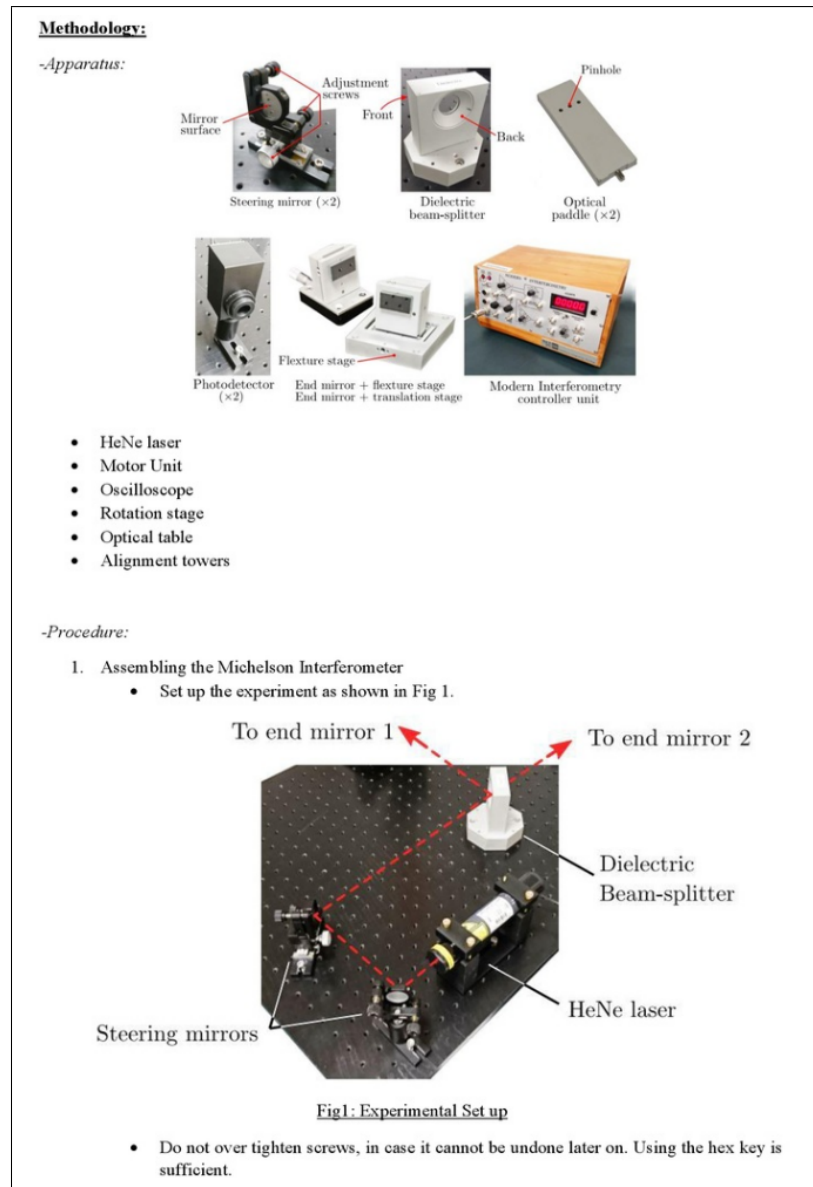


Figure 3: Here, the “Apparatus” and “Procedure” sections are lifted from the lab manual. The pictures are from the lab manual, which should be cited. The equipment list and assembly instructions are irrelevant; only the assembled apparatus ought to be described. The text should consist of complete paragraphs, not bullet-point lists.

3.4 Answers to lab questions

1. Force between the balls increases at an increasing rate as ΔV increases. In contrast, force between the balls decreases at a decreasing rate as δr increases and relatively quite compatible with the estimate of equation (3).
2. ΔV increases linearly with an increase in δr . Experimental breakdown field differs from the

Figure 4: This student has set aside a separate section for answering the lab manual's question list. Instead, the questions should be addressed at relevant points in the lab report.

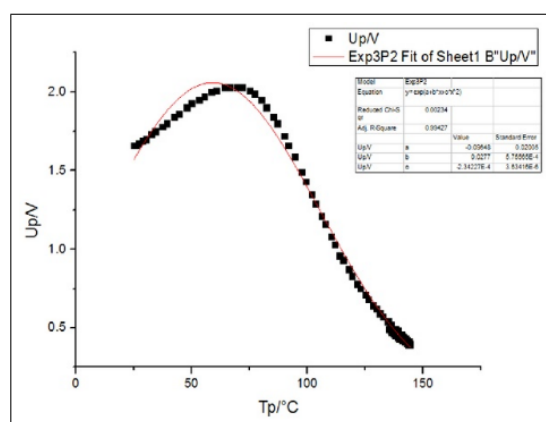


Figure 5: Here, the text in the lower box is too small to read. Any text appearing in a figure is assumed to be relevant, and should thus be legible; if the text is irrelevant, omit it. Also, the data points should have error bars.

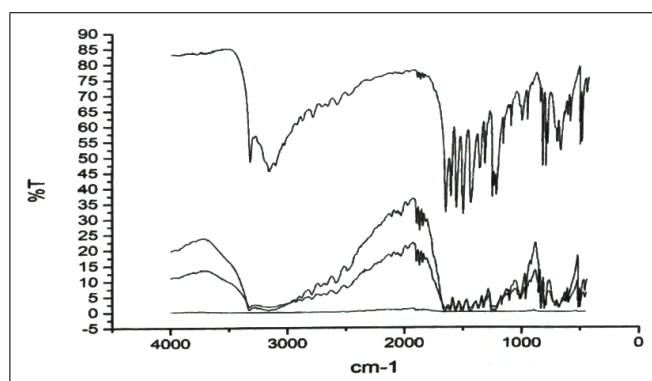


Figure 6: Here, three different data sets are plotted with indistinguishable lines; instead, different line types should be used, and clearly labelled. Also, the horizontal axis should have a proper title (text description and symbol, not just a unit). The vertical axis should have a text description, not just a symbol.