

# Formal Lab Report Instructions

The following eight pages of instructions are formatted like your formal lab report. The format is deliberately plain to the point of being ugly. Reports generally undergo substantial revision after submission and before approval no matter where you work. The double spaced text allows room for edits. A uniform, plain look encourages the editor to focus on the presented information and logic. It is also designed to fit smoothly into the institution's publishing workflow.

If you intend to include your report in your Junior Writing Portfolio, please follow the instructions with care. Avoid copying fragments of text from the lab manual or other sources—especially material from the goals and introduction sections. Those who evaluate the physics submissions often have experience as physics teaching assistants, and are likely to identify the material as plagiarized.

## **Formal Lab Report Instructions—Title of Lab Here**

Authors names here. You will be the first author, with your lab partner's name following.

Author address(es) here. Write your Course and Lab Section Numbers here in lieu of an address.

Put your abstract on the first page. Do not label it "Abstract." It will be obvious that it is an abstract. The abstract is a brief summary of your report, including your results and conclusions. Normally, the length of your abstract should be about 5% the length of your report. Your abstract should make it implicitly clear what your report includes and what it omits. By implicit, I mean that you don't say, "This report includes  $x$  and omits  $y$ ." You don't even say that it is a report. A good summary of your results and conclusions will do the job implicitly. Readers use these summaries to decide whether to read your report. If they notice discrepancies between your abstract and what actually appears in your report, they feel cheated.

## 1. Introduction

**What to include in the introduction.** Like the abstract, your introduction should describe the subject of your paper. An introduction is longer than an abstract, so the subject is described in more detail. One includes the purpose of the experiment and describes its scope. For instance, you will often specify which parameters were explored and how much they were varied. Any background information that the reader needs to understand the rest of your introduction is also included. For the purposes of this exercise, assume that your reader is an introductory physics student like yourself who has not performed this particular experiment.

The introduction is usually written after the main body of your report is complete. Paradoxically, it is seldom clear exactly what you are going to write until you actually write it.

**Characteristics of good technical writing.**<sup>1</sup> Good technical English is unified, coherent, clear and concise. Unity is achieved by enforcing a theme to the paper as a whole. Subjects that are not encompassed by the theme should be left out. The *choice* of theme is critical to the success of the writing operation. The theme is not stated explicitly. (Don't write, "The theme of this paper is...") The abstract of the work should make it clear what belongs in the report and what does not. A good abstract helps the author maintain unity. Ideally, your theme should include everything you intend to write and exclude everything else. After writing the abstract, you may decide to add or delete material as appropriate to make the report a unified whole.

Coherence is achieved by providing logical transitions between the parts of your paper. The order of topics in your paper has a major effect on coherence. If you find yourself repeating ideas in different parts of the paper, you may have failed to order your topics appropriately. Cause and effect is a major part of technical writing. Be sure you state cause and effect relationships clearly.

Clarity is achieved by removing potential sources of ambiguity. Avoid text that can be interpreted inappropriately. In general, your statements should be as specific as possible. The

goal is to communicate as much information as possible. Do not hide information that should be available to the reader.

Conciseness is generally achieved by good editing. All other things being equal, you should use as few words as necessary to communicate what you have to say. Sentences that start with “There are” or “It is” can often be shortened by making an appropriate noun the subject of the sentence. This often resolves unintended ambiguities as to what “it” refers to. Verbs and adjectives with more specific meanings can shorten sentences and improve readability. Active verbs are better than passive verbs unless they shift your focus inappropriately. Your report is not about you. Similarly, do not write about your report in your report. Focus on your subject.

Formatting technical reports is mostly a matter of achieving conformity. Creative formats are not rewarded. (The nail that sticks up gets beaten down.) Your reader must focus on the content of your work, not the details of presentation. Any deviation from standard formatting must be well justified as an improvement (more clear, more concise, etc.). Although these standards are to a large degree arbitrary, many are related to the need for good-looking copy when reproduced. For the purposes of this assignment, the formatting requirements will follow those of the American Institute of Physics.<sup>2</sup>

With the exception of figures and equations, this assignment must be printed from a word processor. Use a 12 point serif font, preferably Times. (A point is about 1/72 of an inch. In this context, the font size refers to the intended spacing between single-spaced lines, not the size of the letters themselves.) Set the line spacing to exactly 24 points (not double-spaced), with no extra space before or after paragraphs. (Exceptions include lines with equations or figures, which often need more room. These usually need to be single-spaced, that is, with a line space of “at least 12 points”. Lines with equations and figures should be the only lines in your paper that are single-spaced.) Use one-inch margins on all four sides of the paper. For regular paragraphs, justify the text along both left and right margins. The first line of every paragraph should be indented 0.5 inches. Disable automatic formatting options like “format the next paragraph like

the one before it.” They often cause formatting faults and complicate inserting equations and figures.

Use a spell checker, but keep a dictionary at hand for unusual words.

## **2. Experiment**

Title this section Experiment, not Experimental. Titles normally function as nouns, and “Experimental” is not appropriate in this role. Put an extra line break (24 point) before and after numbered headings (as well as figures and equations).

**What to include in the experiment section.** The experiment section should not include all the procedures that appear in your lab notes. Assume that your reader is familiar with the equipment. Omit most of the information that would normally be found in equipment manuals. Do include the manufacturer’s name and model numbers of any equipment with special features that might not be easily duplicated. Also include any details that might be necessary to the replication of the experiment but would not be clear from reading the manuals. For instance, it is often important to include sample rates for data collection, but not important to specify the units employed when acquiring data.

The experiment section is not the best place to describe some experimental details. Details that apply to only one section of the results can (and usually should) be included in the appropriate part of the results section. This reduces the strain on the reader’s memory and eliminates the temptation to repeat these details unnecessarily. Details that apply to more than one section of the results are generally included in an experiment section. The goal is to avoid repetition, not to collect all the experimental details in one place.

**Equations and math.** Any equations in your paper should be numbered in sequence on the right hand margin. The number should be in parentheses. Position the equation itself near the middle of the page (left and right). In a word processor, this is achieved by right-justifying the line to position the equation number [(1), (2), etc.] on the right hand margin, then inserting tabs

to center the equation. Equations are normally type-set using an equation editor. If necessary, hand-write your equations. Computer type-set equations must generally be inserted into lines that are single-spaced. For instance, the magnitude of the gravitational force of the earth on the moon,  $|F_{EonM}|$ , can be calculated using the equation:<sup>3</sup>

$$|F_{EonM}| = \frac{Gm_E m_M}{R_{EM}^2} \quad , \quad (1)$$

where  $G$  is the Universal Gravitational Constant ( $6.67 \times 10^{-11}$  N-m<sup>2</sup>/kg<sup>2</sup>),  $m_E$  is the mass of the earth ( $5.97 \times 10^{24}$  kg),  $m_M$  is the mass of the moon ( $7.35 \times 10^{22}$  kg), and  $R_{EM}$  is the distance between the earth and the moon (average  $3.84 \times 10^8$  m).<sup>4</sup> In text, symbols for variables and constants are italicized. If experimental uncertainties are available, specify them as well (for example,  $1.01 \pm 0.01$  g).

All mathematical variables must be defined in the text immediately before or after the first time they are used, except for numbers like  $\pi$  and  $e$ . (Similarly, acronyms must be defined the first time they are used.) If you define a variable in Equation (1), and the same variable is used in Equation (2), use the same symbol in both equations and define this variable only once, with Equation (1). In the text that follows an equation, refer to it as Equation (1) or Equation (2), etc. Equation can be abbreviated “Eq.,” except at the beginning of a sentence. Do not abbreviate the first word of a sentence. The first word of each sentence should be completely spelled out.

### **3. Results and Discussion**

**Descriptive titles.** Papers of modest length do not need numbered subsections. Subheadings are useful. Mark a new subsection by placing a bold title at the beginning of the first paragraph of that section. Do not include the exercise number. Readers quickly loose count.

Short *descriptive* titles are a great help. When sections become longer than a few double-spaced pages, numbered subsections are appropriate.

For emphasis, use *italic*, not **bold** or underlined characters.

**What to include in the Results and Discussion section.** The general principle is to include all the data needed to support your conclusions, with enough discussion to convince the reader of the truth of your conclusions. If some of your data can be interpreted in more than one way, for instance, you will want to present data and/or explanations that support your interpretation. Although we must structure the labs so that they make maximum use of your data to teach physics, your report should be more focused. Everything needed to support your conclusions must be included, and everything that is not related to those conclusions must be excluded. A great deal depends upon what you choose to conclude. Conclusions that are overly broad or too narrow can ruin your entire report. Consider your conclusions carefully.

Unless each data point is of special interest to the reader, tables of data are generally inappropriate. (Data tables are important in your lab notes.) If you need to display your data, use a format that communicates not only the data, but any important relationships. In most cases, figures are the best way to display data. If a table is necessary, they should be numbered with Roman numerals (Table I, Table II, etc.) and provided with descriptive titles. Double lines run across the top and bottom, and a single line separates the column headings from the data. No other lines should appear. A properly formatted example appears below as Table I.

Table I. Power loss versus frequency.

Frequency (Hz)	Power Loss (W)
10	0.24
100	1.75
1000	0.68

**Figure formats.** In your lab notes, your figures generally should be as large as possible. You may, for instance, want to add handwritten notes or slope calculations. In a formal report, you want them to fit comfortably with the text. Figures are normally less than 3.2 inches across, including all labels. If a figure has many parts that can be arranged in two columns, you can double the width. Large figures must fit on a single page with their captions while maintaining the normal one-inch margins. In reports, titles are optional, but captions are mandatory. Figure labels should normally use the same font as the text or a sans serif font like Arial. The figure and caption must contain sufficient information so that the reader does not need to refer to the text to understand what is being presented. Figure captions start with a phrase that serves as a title. This introductory phrase is not a complete sentence. The text that follows consists of complete sentences. Captions should not normally include a discussion of the data. The implications of your data should appear in the text.

All figures must be described in the text. Figures must appear as soon as possible *after* they are mentioned in the text. The word Figure may be abbreviated (Fig.) in the middle of a sentence, but never at the beginning.

If possible, embed your figures as high resolution bitmap files—at least 300 dots per inch (dpi). TIF files (Tagged Image Files) are compatible with many word processes. To ensure that your graphics files are readable, all lines should be at least 1 point (about 0.014 inch) thick. The smallest letter (including superscripts and subscripts) should be at least 1 mm high. This rules out most superscript and subscript fonts unless you can manually control the size. Do not use open symbols (○) for data points; always use closed symbols (●). Remove all grids and backgrounds. (The background should be transparent.) Center your figure left and right on the page on a single-spaced line. Not long ago, figures were traced by hand for publication. You may trace your figures and label them neatly by hand, if the size requirements are met.



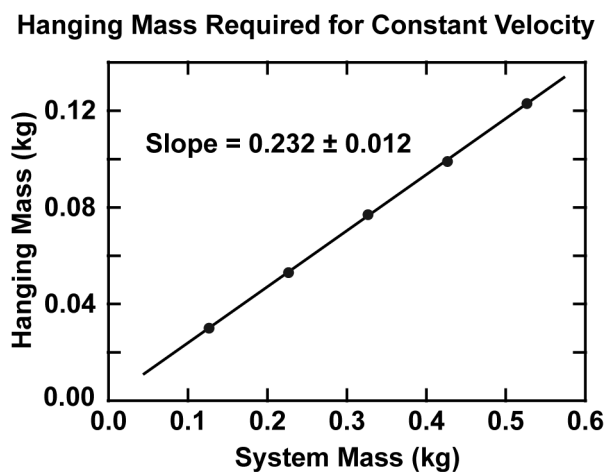


Fig. 1. Hanging mass required to move a pine block across a clean aluminum surface at a constant velocity of 0.2–0.3 m/s as a function system mass (the sum of the mass of the block and any added masses). The slope of the graph corresponds to the kinetic coefficient of friction.<sup>5</sup>

**Discussion Section.** Relatively short papers do not need a separate discussion section. (Section 3 is then a “Results and Discussion” section, as above.) Otherwise, the third section is titled “**3. Results**” and the fourth section is titled “**4. Discussion.**” In your report, a separate discussion section is probably not warranted. Discuss your results as they are presented in the results section.

Generally, it is inappropriate to answer questions for further discussion in a formal lab report. Although these questions are designed to help you learn, your report must be more focused. You should include everything necessary to support your conclusions and nothing more. If the answers form a logical part of your report, and you have data to back them up, they are probably appropriate. If this is true, it would be superfluous to have a subsection entitled, “Questions for further discussion.” You would need to provide other, more descriptive, titles.

**Traceability.** As a rule, formal reports do not contain the details needed to fully verify whether your conclusions are valid. The reader will assume a reasonable level of competence on

the part of the authors. If questions arise, the reader will need access to your lab notes. Do not put anything in your report that is not supported in your lab notes. Your lab notes must in general be recorded at the same time the work was performed. That is, notes about experiment details must be made during the course of the experiment. Notes about data analysis must be made when you analyze the data. Notes about conclusions should be made when you are prepared to conclude. Notes made after the fact are not reliable records. Turn in your lab notes along with your lab report. Your teaching assistant should be able to support your conclusions from your report's Results and Discussion section, which in turn must be supported by the data in your lab notes. This is called traceability.

#### **4. Conclusion**

Never conclude anything you don't discuss. Do not discuss anything that does not relate to your results. Raising new issues in the conclusion is a bad idea. Conclusions must be supported by your work, not merely be related to it. Medical misinformation, for instance, is often presented in conclusions that are not supported in the rest of the report.<sup>6</sup> As noted above, your conclusions determine what you choose to put in the rest of your report.

#### **Acknowledgments**

Acknowledgments are optional. If someone or some organization has supported your work financially or provided significant assistance, say so here. Example:

We thank Mario Iona, University of Denver, for helpful discussions. This work was supported by the Schweitzer Engineering Laboratories and the Department of Energy under Contract FG02-04ER-15618.

## References<sup>7</sup>

<sup>1</sup> Michael Alley, *The Craft of Scientific Writing*, Third Edition (Springer, New York, 1996).

<sup>2</sup> *AIP Style Manual*, Fourth Edition (American Institute of Physics, New York, 1990).

<sup>3</sup> Randall D. Knight, “Newton’s Theory of Gravity,” Chapter 13 in *Physics for Scientists and Engineers—A Strategic Approach*, Second Edition (Addison Wesley, San Francisco, 2008).

<sup>4</sup> Jay M. Pasachoff, “Astronomy,” in *AIP Physics Desk Reference*, Third Edition, edited by E. Richard Cohen, David R. Lide, and George L. Trigg (Springer, New York, 2003), pp. 93-118.

<sup>5</sup> Charles A. Maney, “Experimental study of sliding friction,” *Am. J. Phys.* **20**(4), 203-210 (1952).

<sup>6</sup> J. P. A. Ioannidis, “Why most published research findings are false,” *PLoS Med* **2**(8), e124. (2005) doi:10.1371/journal.pmed.0020124.

<sup>7</sup> Some publications permit paragraph-length notes in the references section. Few publications require article titles in their citation lists, but they help the reader. Please include them. If you do not know the official abbreviation of a journal title, write out the entire journal title. Article and section titles are enclosed in quotes. Book titles are italic. Journal volume numbers are bold. Journal issue numbers, if provided, should be in parentheses. Page numbers follow, with the year of publication in parentheses. Normally one does not cite URL’s (Uniform Resource Locators for web-based material) unless the links are permanent. To address this problem, many publishers provide each article with a Digital Object Identifier (DOI). One can often locate an article on the web by searching on its DOI at <http://www.doi.org>. If you know the DOI, provide it. Do not cite unpublished work unless absolutely necessary.