Gustavus Physics Department
Writing Style Guide

also available at:

https://gustavus.edu/physics/concertFiles/media/Writing_Style_Guide.pdf

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I. PREFACE

Each discipline (and each specific journal) has a general preferred (required) manner in which to style (and format) their published works. In the Gustavus Physics Department we will follow the general physics (scientific) writing conventions with the specific American Institute of Physics (AIP) style for formatting.

Scientific writing is a style of writing, much like science fiction or romance (novels) or speechwriting or technical writing or blogging or any number of other styles of writing. Each style has its intended goals, audience and its associated writing rules. Although the content of your paper is of paramount importance, the style of the paper is important to present information to the reader in a consistent way. The goal of scientific writing is to convey information to an audience of scientific peers using a common set of conventions (rules) that makes the information as clear and concise as possible. This document covers the general scientific writing style for a certain type of assignment (called an article) that we will use consistently through your time at Gustavus.

The precise formatting for submission to any journal (such as Physics Today or Physical Review) sets clear rules for aspects like the referencing of others' work, equations, and references to figures. As stated, we will use AIP style for formatting. A complete AIP style manual is available online at:

http://publish.aps.org/files/styleguide-pr.pdf

but here we present the summary information needed to start writing and succeed in your assignments at Gustavus.

Finally, the style and format of scientific writing is likely different than anything you have experienced in your past. Thus it is likely you will be uncomfortable as you read and also write scientifically. As with any new experience, as you gain familiarity, your comfort level will increase. Thus, the best way to learn the style of scientific writing is to read and practice writing.

II. SCIENTIFIC WRITING STYLE

Prose

Your ideas will have little impact, no matter how good the research, if they are not communicated well. Thus, your writing should conform to the conventions of all standard well-written English (sentence form, grammar, spelling, etc.). Your writing should be in complete sentences and easily understood. Make sure that every paragraph has a clear topic sentence and that the paragraph content supports the topic. Topics should be properly introduced and the paper should follow a logical progression.

Physics

In scientific writing, it is important that what you say is factually correct. Even though you are a student, the experiments you perform and the assignments you are given are at the student level. It is therefore expected that you will understand your topic and write about it correctly. Don't exaggerate or make misleading claims. Remember: if you do these things, or make errors, your instructor will know immediately!

Content

It can be difficult to know what content to include in your paper. The goal of scientific writing is to present information to your scientific peers, which we consider any student of physics with your level of education or more. Accordingly, your fellow classmates at Gustavus (or similar students at another school) and certainly any physics Ph.D should be able to read your paper and fully understand your goal, methods, analysis, results, etc.

Style

Be clear and concise. Write briefly and to the point. Say what you mean clearly and avoid embellishment with unnecessary words or phrases. Brevity is very important. The previous four sentences say the same thing but the importance cannot be understated.

Precise word use is critical: scientific terminology carries specific meaning - learn to use it appropriately and use it consistently. A critical function of technical terminology is to say a lot with a few words, i.e., economy. This applies as well to appropriate acronyms and abbreviations. Some specific scientific style points:

- Do not try to impress people by using words most people have never heard of.
- Do not use colloquial speech, slang, or "childish" words or phrases.
- Do not use contractions.
- First vs. Third Person: Use first person sparingly, and avoid its use entirely in the results.
- Active vs. Passive: Although passive is generally preferred, use of the active voice shortens sentence length considerably and is much easier to read.

References

References to the research findings of others are an integral component of any research paper. Aside from the obvious fact that references are there to prevent plagiarism, references provide a way for the writer to support their writing. References provide examples of others with similar work, point to introductory or background material, and connect your work to the rest of science.

The usual practice is to summarize the finding or other information in your own words and then cite the source. As a rule, direct quotation and footnoting are not practiced - simply restate the author's ideas or findings in your own words and provide a citation.

The use of others' words, ideas, images, etc. without citation is not to be tolerated and can be easily avoided by adequately referencing any and all information you use from other sources. In the strictest sense, plagiarism is representation of the work of others as being your work. Paraphrasing other's words too closely may be construed as plagiarism in some circumstances. In journal style papers there is virtually no circumstance in which the findings of someone else cannot be expressed in your own words with a proper citation of the source. If you are unclear about what constitutes plagiarism, please confer with your instructor.

III. SECTIONS of the PAPER

The standard format for a paper for most scientific academic writing contains a number of essential elements which are described below. Unless instructed otherwise, your papers should follow, in order, these sections.

Section	Purpose of section:
• Abstract	A synopsis of important ideas and results.
• Introduction	Why did you do the experiment? Why should the reader care?
• Theory	Information validating the method. Vital physics.
• Apparatus	Special or novel setups.
• Experimental Procedure	Original or particular techniques.
• Results	What did you find?
• Conclusions and Discussion	What do your results mean?
• References	Citation of and connections to others' work.

Title

Your title succinctly describes the contents of the paper. Use descriptive words that associate with the content of your paper. Do not use vague terminology such as "a study of". Shy away from humor and puns for formality. Be aware that the title will affect who finds and who reads your paper. Scientists are looking for information, so convey your most basic point as succinctly and clearly as possible. If your title is too short or uninformative, such as "The Franck-Hertz Experiment", it is unlikely that many will bother to read the paper. A better title would be "The Effects of Temperature on the Measured Excitation Energies in the Franck Hertz Experiment".

- The title should be centered at the top of page 1.
- Do not use a title page.
- The title is not underlined or italicized.

Authors' Names

The authors' names and institutional affiliation are double-spaced from and centered below the title. When there are more than two authors, the names are separated by commas except for the last which is separated from the previous name by the word "and". The primary author is listed first, with lab partners alphabetized following.

Abstract

The abstract is a one-paragraph summary of your experiments and the results you obtained. The goal is to the catch the reader's attention and convey the major aspects of the entire paper. It should include (probably in the following order):

- the purpose of the paper,
- the experimental design and methods used,
- the major findings including key quantitative results,
- a brief summary of your interpretations and conclusions.

Although the abstract should include the above, the length of your abstract should be kept to one medium-length paragraph. Write your Abstract using concise, but complete, sentences, and get to the point quickly. Use past tense. The Abstract SHOULD NOT contain:

- lengthy background information,
- references to other literature,
- abbreviations or undefined terms,
- any sort of illustration, figure, or table, or references to them.

Introduction

Quite literally, the Introduction must answer the questions, "What was I studying? Why was it an important question? What did we know about it before I did this study? How will this study advance our knowledge?" Thus the function of the Introduction is to:

- State the purpose of the work you investigated.
- Establish the context of the work being reported by discussing the relevant primary research literature (with citations) and summarizing the current understanding of the problem.
- Clearly explain any new or novel features of your experiment.
- Briefly explain your rationale and approach and, whenever possible, the possible outcomes.

The length of introduction is one to three paragraphs concentrating solely on the items above. It should not:

- Focus solely on history.
- Contain references to non-primary literature (Wikipedia, lab manual).
- Describe other experiments ‘one could do’.

Theory

The theory section provides a brief description of the background physics or mathematics of the experiment, in the space of two to four paragraphs. In this section you should present in sentences, most of the equations that will be used for your analysis. Do not just list equations. Only derive equations that are essential for your analysis and that cannot be found elsewhere. Make sure equations have references to literature, if needed, and that all of the variables in the equations are defined in the text of the paper. Be careful because this section is the one that tends to be the most disconnected from the main flow of the rest of the paper. Thus the theory section should:

- Be connected to introduction before and apparatus afterwards.
- Introduce terms as needed.
- Focus on the experiment.

Apparatus

Here, describe the apparatus you used in sufficient detail that a "knowledgeable" reader can supply the details of the experiment. Do not just re-write the lab handout. Be concise. If the section on procedure is longer than either the sections on analysis or results, you have not been sufficiently concise. Usually, this section will refer to a figure that also diagrams some part, or the full setup. Given the connectedness to the next section, it is often combined with experimental procedure.

You may want to identify certain types of equipment by vendor name and brand or category, particularly if they are not commonly found in most labs. When using a method described in another published source, you can save time and words by providing the relevant citation to the source. Always make sure to describe any modifications you have made of a standard or published method.

Experimental Procedure

Like the apparatus section, the procedure section details the protocol for collecting data, i.e., how the experimental procedures were carried out, and, how the data were analyzed. Describe your experimental design clearly including any controls, calibrations, number of trials etc. Use sufficient detail that other scientists could repeat your work to verify your findings. Foremost in your description should be any "quantitative" aspects of your study that another scientist needs in order to duplicate your experiment.

- NOTE: Very frequently the apparatus and procedures for an experiment cannot be separated and must be integrated together. If you find yourself repeating lots of information about the experimental design when describing the data collection procedure(s), likely you can combine them and be more concise.

Describe how the data were summarized and analyzed. Here you will indicate what types of descriptive statistics were used and which analyses (usually hypothesis tests) were employed to answer each of the questions or hypotheses tested and determine statistical significance. The information should include:

- Statistical software used.
- How the data were summarized (Means, percent, etc)
- How you are reporting measures of variability (SD,SEM, 95% CI, etc)
- Any other numerical or graphical techniques used to analyze the data.
- What probability was used to decide significance.

Several things should be included in the lab book but NOT the procedure section. They include:

- DO NOT say that you made graphs and tables.
- Do not include the ‘trial number’ or the ordering of events (unless crucial to the experiment)
- Do not say that you or a program ‘recorded the data’.

Results

The function of the Results section is to objectively present your key results, without interpretation, in an orderly and logical sequence using text, tables, and figures. The results section always begins with text, reporting the key results but should be organized around tables and/or figures that should be sequenced to present your key findings in a logical order. Write the text of the results section concisely and objectively. Do not interpret the data here.

- The outcome of a statistical analysis is not a key result, but rather an analytical tool that helps us understand what is the key result.
- Tables and figures are assigned numbers separately and in the sequence that you will refer to them from the text.
- Each table or figure must include a stand-alone caption of the results being presented and other necessary information.

When reporting results, pay attention to differences, directionality, and magnitude. Report your results so as to provide as much information as possible to the reader about the nature of differences or relationships. A full error analysis is always required when giving the error on results.

- Do not reiterate each value from a figure or table - only the key result or trends that each conveys.
- Do not present the same data in both a table and figure.
- Do not report raw data values when they can be presented more clearly when analyzed.
- Avoid devoting whole sentences to report a statistical outcome alone.
- In scientific studies, the use of the word “significant” implies that a statistical test was employed to make a decision about the data. Limit the use of the word "significant" to this purpose only.
- For a choice of statistical significance (for example, the 95% confidence rule), the result either “agrees” or “disagrees”.
- Always enter the appropriate units and errors when reporting data.

Conclusions and Discussion

This section should consist of a critical evaluation of the experiment, discussing its precision and accuracy as well as its good and bad features. You should compare your results to those in the literature (if available) and/or to those of other students (if appropriate).

If the result disagrees with an accepted value (see results above), give reasons, or at least plausible explanations, of any differences observed. Many students are tempted to use this section to list every possible source of error they can think of, regardless of the magnitude of that error or the likelihood that it entered into the experiment in a significant way. You should use the results of your error analysis to make an informed decision as to which sources of error may have contributed to your measurements.

If the result agrees with the accepted value, give suggestions for improving the experiment. Do not rehash the experimental method or procedure in the discussion. Also, do not justify any differences between your value and the accepted value. After all, they agree!

The act of writing the discussion section is really part of the scientific method. You have made measurements, made observations, performed calculations, drawn graphs, etc., but now you need to draw some conclusions. What do you think it all means?

- Do not present new results.
- Do not restate your results.
- Be wary of mistaking the reiteration of a result for an interpretation.

References

You must include citations for any material which is not your own. That includes blatant use of the ***structure*** of another author's paper.

- Do not label this section "Bibliography". A bibliography contains references that you may have read but have not specifically cited in the text. Bibliography sections are found in books and other literary writing, but not scientific journal-style papers.

Figures and Tables

Figures and tables are to convey information in a manner that text alone cannot do. All important results and apparatus that are more clearly explained using a figure should use one. Each table and figure must be numbered, and must be referred to by number in the paper. Each must have a self-contained caption which explains what is in the graph or table. Captions should be typed below the figure and, for figures, should be standalone in that they fully explain the figure and its importance without referring to the text. Although the captions must be standalone, each figure and table must directly relate to and be discussed in the paper (and be referenced in the text as said above). Finally, the content and presentation of figures and tables and their captions must look professional, including appropriate axes, labels, use of variables and equations, and references.

IV. GENERAL FORMATTING

General formatting summary:

- Hand writing of any kind is not allowed, including on the figures
- Cutting and gluing/taping is not allowed. Use a screen shot and the clipboard or save your figure as a jpeg and insert for inline figures.
- Papers must begin with: Title, Author(s), and Date each centered on its own line.
- Abstracts shall be limited to 150 words or less.
- All paragraphs shall begin with a standard one-tab indent.

The following requirements are not AIP formatting requirements. They are instituted here to ease your writing and our grading in the educational environment. **Use these requirements unless your specific assignment states otherwise: in all cases follow the directions of the assignment first.**

Gustavus physics writing format summary:

Assignments must be written using Microsoft Word, (which is included in Office 360 and is provided at no charge through Gustavus). Exceptions must be made in advance with the instructor. The following settings must be used throughout the paper:

- Times New Roman size 12 point font
- "Normal" 1" margins
- Single spacing for the abstract and figure captions
- Double spacing for all other text
- 0pt spacing before and after paragraphs
- All main text sections should contain a title header on its own line
    - INTRODUCTION
    - THEORY
    - APPARATUS
    - PROCEDURE
    - RESULTS
    - CONCLUSION
    - REFERENCES

Note: Occasionally, due to the short length and/or overlap of topics, the apparatus and procedure sections and the results and conclusion sections may be combined.

- All figures and tables, and their corresponding captions shall be printed inline, immediately after the paragraph in which they are first referenced.

V. EQUATIONS, EXPRESSIONS and NUMBERS

Equation format summary:

- Small, unreferenced equations may be placed inline with text.
- Important, and large, equations are placed on their own line, centered.
- Each equation is numbered in order of appearance with the number right justified surrounded in parentheses.
- Each variable within the equation must be defined either before or immediately after the equation.
- All equations and variable definitions must use Microsoft Equation Editor (the Equation Editor is found in the insert tab of the ribbon) and formatting between the inline text and equation must match. Note that the general insertion of symbols does not produce correct and matching format.
- Variables are normally italicized.
- One full equation is treated as one full word and must be placed within a grammatically correct English sentence including punctuation. Thus, if an equation finishes a sentence, the period goes after the equation. Or if an equation is placed in the middle of a sentence, appropriate commas must be used and the sentence continues in text after the equation.
- Referencing an equation within the text uses the following format (e.g. for equation 1): Eq. (1). The reference "Eq. (1)" is also to be treated grammatically as a single word.

Writing sample including equations:

The charge to mass ratio e/m of the electron can be determined by observing its path within a magnetic field $\vec{B}$. In such a field, a charged particle with charge e and velocity $\vec{v}$ is acted upon by the Lorenz Force, $\vec{F} = e\,\vec{v} \times \vec{B}$. If the velocity and field are perpendicular and constant, then *e/m* is determined as

$$\frac{e}{m} = \frac{v}{B\,r}\,, \tag{1}$$

where r is the radius of the resulting circular path and B and v are the magnitudes of magnetic field and velocity respectively.

Since it is difficult to measure the velocity of the electron directly, it is necessary to find an expression for v within Eq. (1). This can be done since the electron was accelerated from rest through a potential difference V and the kinetic energy acquired is equal to the work done by the field; $e\,V = mv^2/2$. Plugging this into Eq. (1) gives the following,

$$\frac{e}{m} = \frac{2\,V}{B^2\,r^2}\,. \tag{2}$$

Comments on the example above:

- Note many variables are defined before the equation.
- Note $\vec{B}$ is different than *B* and requires separate definitions.
- Note the use of grammar and punctuation in the two inline and two standalone equations.
- Note the right justified number and equation reference "Eq. (1)" in the text.

Number Formatting Summary:

- All numbers must include error, generally given as one standard deviation for single measurements and one standard error of the mean for averages.
- Errors must use $\pm$ and not +/-.
- Scientific notation is used once for both the measurement and error. Both are multiplied by the trailing $\times 10^{x}$.
- All numbers must use proper significant figure rules (as discussed in PHY-205).
    - One sig-fig for errors (two sig-figs for a leading value of one)
    - Least-significant digit of measurement matches error
    - Leading zeros are not significant but trailing zeros are
- All numbers must include units
    - Use prefixes to express the number in a reasonable (readable) magnitude

Number Examples:

$B = 1.2345 \pm 0.0005$ nT	(note: both the error and measurement are in nT)
$B = 1234.5 \pm 0.5$ pT	(also acceptable)
$v = 6.543 \pm 0.003 \times 10^{6}$ m/s	(note: both measurement and error are multiplied by 10^6, and leading zeros are not significant)
$N = 103 \pm 10$ counts	(note: all trailing zeros are significant, so 10 counts as 2 sig figs)

VI. FIGURES and TABLES

Figure format summary:

- Figure labeling must be consistent with the rest of the paper. Use the same abbreviations, symbols, and upper- and lowercase letters throughout.
- Label each axis including the appropriate units. Do not use powers of 10 if possible; instead use the appropriate prefixes of the SI.
- Number each figure consecutively in the order in which it is discussed in the paper.
- In the text refer to "Figure 1" if it begins a sentence and in "Fig. 1" if it is in the middle of the sentence (no quotes in your text).
- Captions must begin with "FIG. 1." (no quotes)
- Titles are given in the caption, not the figure. The title (sentence fragment OK) immediately follows "FIG. 1.".
- Define all variables not used in the text, otherwise do not redefine.
- All figures must be referenced in the text in the order that they appear.
- Data values should be displayed as discrete points with error bars if appropriate.
- If a theory curve is shown, or if a fit analysis has been made, draw them as a solid curve.
- For all fits, the equation of best fit should be presented in the caption, no on top of the graph.
- Connecting lines between data points should be thin dashed or avoided altogether.

Differences for tables:

- Table 'captions' should be as short as possible (perhaps only a title) and discussion should take place in the text.
- Captions begin with "TABLE 1." (no quotes)
- Tables are referred in the text without abbreviation "Table 1" (no quotes)

Figure caption sample:

FIG. 1. Continuous line: solution of the Lippmann-Schwinger equation, Eq. (13), with the use of dynamical self-energy of Eq. (5). Broken line: static Coulomb wave function given by Eq. (9) of the text. The inset shows the behavior in the near-surface region.

Table caption sample:

TABLE 1. Example local magnetic field measurements with differing bar magnet orientations.

VII. REFERENCES

To reiterate what was stated in the preface, we will use AIP style for formatting. A complete AIP style manual is available online at: http://publish.aps.org/files/styleguide-pr.pdf

Reference format summary:

- A reference to a source is given by numbers enclosed in brackets (such as [1] or [4-6]).
- When the word "reference" is used to specify a reference, use the abbreviation Ref. (unless it is at the beginning of a sentence, then use the whole word).
- References are numbered by order of appearance.
- The references are included at the end of the paper in a separate section labeled 'REFERENCES'. Do not label this section "Bibliography", as the purpose and content of a bibliography are different.
- Although footnotes are allowed in actual papers, at your level of writing, it is highly unlikely you will need them. Furthermore, footnotes are not for references.
- Authors are indicated by their initials followed by their last name.
- If a paper has more than 4 authors, quote only the first author's name followed by *et al*.
- Never place a reference number adjacent to an equation, symbol, another number, or other similarly confusing location.
- Abbreviate the title of journals and eliminate words like "of" or "the." Some of the more common abbreviations are: American (Am.), Journal (J.), Letters (Lett.), Physics (Phys.), Review (Rev.), Scientific or Science (Sci.). This means "American Journal of Physics" would be abbreviated "Am. J. Phys." and "Physical Review Letters" is "Phys. Rev. Lett."

Specific types of references:

- **Reference to Article in a Journal:** Indicate the Author(s) name, Journal Name (using abbreviations) Volume Number (in Boldface), Starting page number, (year). For some journals (such as Physics Today and Scientific American), you need to specify the issue number since they start at page 1 each issue. For example, for an article which starts on page 25 of the November 1995 (Issue number 11) Physics Today, use

  [1] H.H. Seliger, Phys. Today **48** (11), 25 (1995).

- **Reference to Material in a Book:** To refer to material in a book (in this case, pages 100-102 from Serway), the reference would be similar to:

  [1] R.A. Serway, *Physics for Scientists and Engineers*, 3rd Ed. (Saunders, New York, 1990), pp. 100-102.

- **Reference to an Unpublished Handout or Discussion:**

  [1] C.N. Niederriter, *Radioactivity and Ionizing Radiation*, Gustavus Adolphus College Lab Handout (Unpublished).
  [2] D.C. Henry, (Private Communication).

- **Reference to a Computer Program:** Note that you should only be referencing a computer program anywhere in your text if the program is:

- Relatively unknown. **OR**
- Essential to the computation done (and could not be replaced by another program).

Thus, general references to programs like Mathematica, MatLAB, SigmaPlot, and Excel should not appear in your paper. Specific, critical, references to these programs can appear.

[1] S. Mellema, Computer Program MODELFIT, (Gustavus Adolphus College, Unpublished).

[2] COMSOL Multiphysics v. 5.4. www.comsol.com. COMSOL AB, Stockholm, Sweden.

- **Reference to a WWW Document:** Include the full URL address of the source, and the title of the page. Start with the author if you can find out who the author is.

[1] T.M. Huber, *How To Locate Material for Formal Reports*, `http://physics.gac.edu/~huber/misc/finding.htm`.

Writing sample including references:

[Modified excerpt from: T.M. Huber *et al.*, Phys. Rev. D **41**, 2709 (1990).]

The first experimental search of muonium-antimuonium conversion, in 1968, placed a 95% confidence upper limit [1] of $G<5800G_F$ on the four-fermion coupling constant [2]. A number of experiments such as in Ref. [3-5] have placed more stringent limits on this conversion. The first run of the current TRIUMF experiment [6] published the limit $G<0.88G_F$ (90% confidence). A preliminary upper limit of $G<0.5G_F$ has been quoted by a LAMPF experiment [7]. Using a longer run than our previous result [6], we report the final results of the TRIUMF experiment of $G<0.29G_F$ (90% confidence) on the conversion of muonium to antimuonium.

[1] J.J. Amato *et al.*, Phys. Rev. Lett. **21**, 1709 (1968).
[2] G_F is the Fermi coupling constant $1.16637(2)\times10^{-5}$ $GeV^{-2}(hbar\ c)^3$, from *Review of Particle Properties*, Phys. Lett. B **204**, 51 (1988).
[3] W.C. Barber *et al.*, Phys. Rev. Lett. **22**, 902 (1969);
[4] G.M. Marshall *et al.*, Phys. Rev. D **25**, 1174 (1982)
[5] G.A. Beer *et al.*, Phys. Rev. Lett. **57**, 671 (1986).
[6] T.M. Huber *et al.*, Phys. Rev. Lett. **61**, 2189 (1988).
[7] H.J. Mundinger *et al.*, *Rare Decay Symposium,* edited by D. Bryman, J. Ng, T. Numao, and J.-M. Poutissou (World Scientific, Singapore, 1989).

Comments on the sample above:

- The physical constant G_F is quoted from a standard reference (with full errors). Always use a standard reference such as the Reviews of Particle Properties or CODATA.
- Multiple sources may also be grouped as in [3,4] or [3-6, 7] etc.
- Always place the reference before punctuation marks such as references 2, 5, and 6 above.
- Repeated reference of the same source uses the same number as it had before. For example, reference 5 is used twice, once before and once after reference 6. The next original source would then use the next available number in sequence.

Use of Reference/Bibliography tools:

Highly refined (and free!) tools exist for the creation and management of references and reference sections (and bibliographies for non-physics classes). Two such examples:

- Zotero: https://www.zotero.org/
- Easybib: http://www.easybib.com/

include web browser plugins to automatically collect publication information from scientific sources and word processor plugins to create references within papers and the desired reference and/or bibliography sections. Although the use of these tools is not generally required (remember to follow the assignment), learning and using them will be advantageous to you in the long run.

If you know how to use these tools, and can make the formatting match the requirements of this style manual, you are welcome to use them in your assignments.