

Guide for Writing in Physics and Dual-Degree Engineering

About Writing in Physics

The main goal of writing in physics is to clearly convey information about the results of calculations and/or experiments that were carried out by the author. A secondary goal is to provide improved understanding of various physical theories, models, and calculations.

All writing for the physics department **must have the appropriate structure** for a given writing project. Most writing for the physics department falls into two categories: 1) lab reports and 2) papers (i.e., term paper, capstone paper, journal manuscript for publication, conference poster).

Types of Writing in Physics

Lab Reports

In classical lab report formatting, tables, graphs and figures are added at the end of report. However, the SU physics department wants to develop student skills in writing papers in its labs. Therefore in lab write-up assignments—particularly in advanced labs—more often than not there will be instructions to embed tables, figures, and graphs into the body of the lab report as would be seen in a published journal article.

A typical lab report includes: a title, the author and collaborator name(s) and the date, an abstract, an experiment description section, a data and analysis section, a results and conclusions section, and (possibly) a references section.

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About this guide

This guide contains the following sections:

- About Writing in Physics
- Types of Writing in Physics
- Evidence in Physics
- Conventions of Writing in Physics
- Citations & Formatting
- A Few Other Tips

The Disciplinary Writing Guides are designed to provide an introduction to the conventions, or rules, of writing in different subjects. These guides have been designed by Southwestern professors to help you understand what will be expected of you in your classes.

Papers (i.e., Term, Capstone, Honors Thesis, Conference Poster, Journal Manuscript)

Papers written for the physics department should be in manuscript format, generally following the AIP Style Manual 4th ed.

If the paper is to be an SU honors thesis, additional items (such as a signature page and a table of contents) are required, and the order of some elements is changed. An honors thesis has a very specific format. The library and DEWC staff can provide specific details. For term papers, capstones, honors thesis papers, and conference posters, the physics department requires figures, tables and graphs to be properly embedded in the document. Manuscripts for publication in a journal must follow the guidelines specific to that journal. In general figures, tables, and graphs are not embedded in manuscripts submitted for publication.

A typical manuscript includes: a title, an authors list, an abstract, an introduction, the main body of the work, conclusions, acknowledgements, appendices, and references (usually in this order).

Evidence in Physics Writing

Numbers

Numbers should be written in scientific notation. Numbers whose absolute value is greater than or equal to 0.1 and less than 100 may be written without exponent. The number of significant digits depends on the particulars. Here are several examples with **four** significant digits: in the first number a leading zero is used to highlight the presence of the decimal point.

0.3459

−2.558

10.31

−99.76

Numbers whose absolute value falls outside the range less than 0.1 and greater than 100 should be written with an exponent. Here are several examples with **three** significant digits:

1.97×10^{-2}

6.67×10^{-11}

-1.97×10^5

3.22×10^{42}

Most numbers in the physical sciences are associated with units. It is important that the units are shown next to the number. For example, the average magnitude of the acceleration due to gravity at the surface of the earth is 9.80 m/s^2 (or 9.80 m s^{-2}). To avoid visual clutter, the units of numbers in tables are not shown by the numbers but rather in the row or column titles.

In the physical sciences, most numbers have associated uncertainties (experimental or computational) and it is important to convey this uncertainty.

For example, suppose an experiment that repeatedly measured the acceleration of gravity found a mean value of 9.82 m/s² and an experimental uncertainty of $\pm 5 \times 10^{-2}$ m/s². One would then write

$$(9.82 \pm 0.05) \text{ m/s}^2.$$

Technically there is a cheat in not writing the error in scientific notation, but writing it this way has more clarity.

Tables

Embedded tables and/or graphs should have appropriate captions, scaling, and labeling. A table should have an identifier centered above it such as “TABLE 1” linking it to any references in the text to the table. Below the identifier should be a title (also centered), for example, “Strengths of Select Quasar Emission Lines.” In general, tables do not have captions, though they occasionally have a footnote immediately below referring to exceptional table entries. An example of a table from a published paper (Bottorff M.C., Ferland G.J., Baldwin, J.A., and Korista, K.T. 2000, ApJ, 542, 644) is shown below:

TABLE 2
LINES WITH $\log [EW(10^4)/EW(0)] \geq 1.5^a$

LINE		SINGLE CLOUD ^b		STANDARD LOC MODEL				
Ion	λ (Å)	$\log \left[\frac{EW(10^4)}{EW(0)} \right]$	EW(0)	EW(10)	EW(10 ²)	EW(10 ³)	EW(10 ⁴)	$\log \left[\frac{EW(10^4)}{EW(0)} \right]$
O V	630	2.13	2.0	2.0	3.2	14.9	82.9	1.62
S IV	655	2.33	0.1	0.1	0.9	5.2	21.1	2.32
N III	678	1.95	0.1	0.1	1.1	5.7	18.7	2.27
O III	698	2.44	0.2	0.3	1.6	9.4	52.5	2.41
S IV	737	2.12	0.5	0.1	0.8	3.7	13.2	1.42
N III	752	1.65	0.1	0.2	0.7	2.4	4.9	1.60
N IV	765	1.99	0.2	0.5	1.7	8.5	45.2	2.35
S V	786	1.95	0.7	0.2	1.0	5.0	25.0	1.55
H I	973	1.67	1.0	1.1	1.7	7.8	42.0	1.62
N II	1085	2.52	0.6	0.6	2.6	18.3	67.0	2.05
Fe III	1122	1.91	0.2	0.2	0.9	2.9	5.2	1.41
Si II	1260	2.64	0.6	0.6	3.2	25.6	158.0	2.42
Si II	1305	2.88	0.3	0.3	2.6	21.5	98.9	2.51
C II	1335	1.57	10.5	10.3	12.5	38.5	190.8	1.26
Si II	1527	2.56	0.8	0.8	3.0	22.5	113.9	2.15
Fe II	UV191 1787	2.60	2.6	2.5	5.2	27.3	162.6	1.79
Al II	1671	2.38	1.3	1.1	3.0	21.5	113.3	1.94

^a Values for C II 1335, Fe II 1787, Si II 1260, and Si II 1305 also appear in Table 1.

^b Values for $[\log (n_H), \log (\Phi)]$ fixed at (10.0, 18.5).

Figures & Graphs (or Plots)

Embedded figures and graphs (or plots) will have appropriate captions, scaling, and labeling. Unlike tables, figures and graphs (or plots) do not have titles. Both figures and graphs are referred to as “figures” in the text that embeds them and are

identified by figure captions that appear just below the figure or graph. The caption includes an abbreviated version of the description of the figure or graph found in the text. Here are some examples of figure captions:

“Figure 7. The figure shows an image of the inclined plane apparatus. Arrows indicate the positions of the photogates. For this arrangement the angle of the incline is 37.5° . A meter stick at the base of the apparatus shows the scale.”

“Figure 2. A graph of position (m) vs. time (s) for three different orientations of the inclined plane: (blue) 22.0° , (green) 35.5° , (red) 47.3° .”

Graphs should have axis titles and include the units of the variables being plotted. For axis titles, use a font style (i.e. Times New Roman) that is the same as document in which the graph is embedded.

The axes of the graph should show both major and minor tick marks. The divisions should be chosen for easy measurement of positions on the graph. The range of each axis should (just) cover the range of the data and make any data trends visually apparent. If the uncertainties are larger than the plot markers on the graph then error bars (or boxes) should be shown. The best plots have tick marks surrounding all sides of the graph area. While the graph is bounded by axes with tick marks, there should be no bounding box surrounding the entire graph (axis labels and graph). An example plot is shown below in figure 1. Note that the font size is larger than the text in this document. This is on purpose. If this were a figure for a manuscript, the size would need to be large so that the journal editors can rescale it to fit their journal formats without the axis titles or labels appearing too small. The text of the article would then explain in detail the elements of the figure. Typically, only the left axis and the bottom axis of a graph are labeled. However, on some occasions there is an additional plot scale for easy reference or conversion to another variable (in this case, meters to yards). The AIP Style Manual 4th ed. provides additional visual examples.

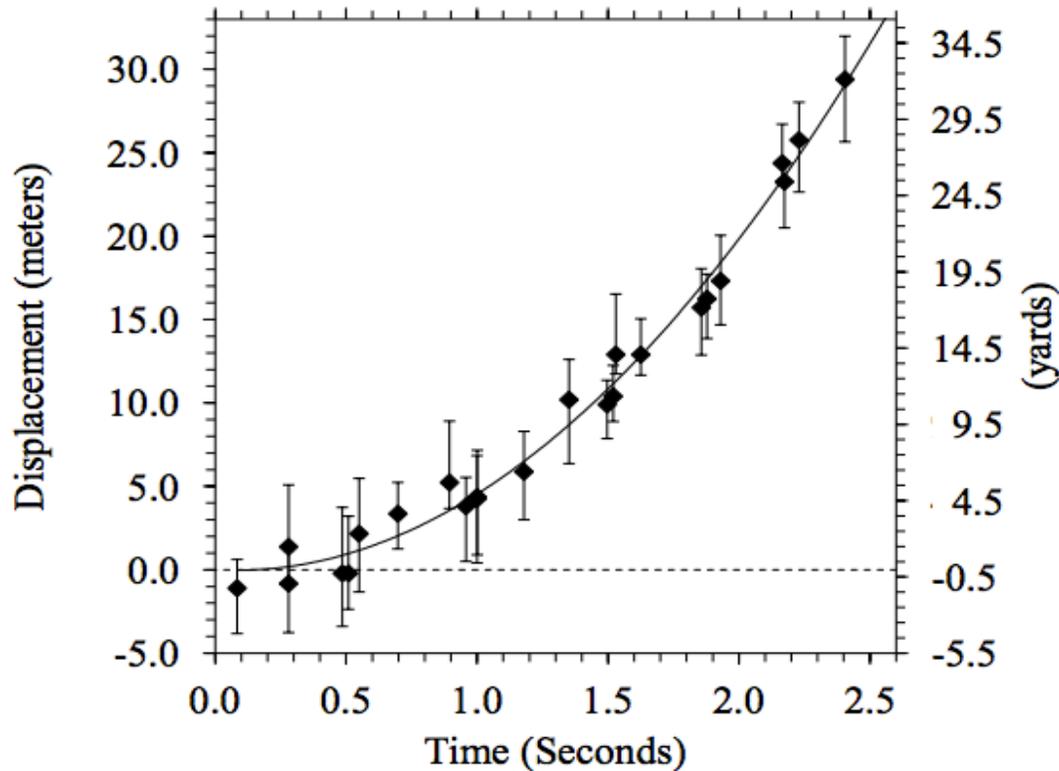


Figure 1. Example graph for journal submission. Axis labels and markers are purposely made large to allow for editorial rescaling in a journal.

Typeset Equations

Most modern word processing software has an equation editor. There is no excuse for not typesetting equations in a scientific document. **All equations appearing in documents will be typeset.** Variables are typeset in italics.

This document was created using an outdated version of Microsoft Office without any special add-ons, and it is capable of producing the following equation describing the one-dimensional motion of a free particle in quantum mechanics.

$$\psi(x,t) = \frac{1}{\sqrt{2\pi\hbar}} \int_{-\infty}^{\infty} \phi(p) \exp\left[\frac{ipx}{\hbar} - i\omega(p)t\right] dp \quad (1)$$

Note that the equation is left biased and a “(1)” meaning “equation number 1” appears right biased. In addition the equation is given its own line with a space above and below it. For numbered equations this will be true even if the equation is part of a sentence.

Here is an example:

“The energy of a photon is given by

$$E = h\nu \tag{2}$$

where E is the photon energy, h is Planck’s constant and ν is the frequency of the light.”

If the equation is not to be numbered and is compact, it can be integrated into a sentence. Here is an example:

“Substituting $\nu = c / \lambda$, where c is the speed of light and λ is the wavelength of the light, into equation 2 gives the photon energy as a function of wavelength.”

All elements must be appropriately integrated into your document. This means that equations, tables, and graphs should not occur before they are mentioned in the text. Generally, they are placed at the end of the paragraph they are first mentioned. In addition, it is preferable if the element does not appear much later than where it is mentioned in the text (though sometimes this is unavoidable). The reason is that it can be frustrating for a reader reading the description of a graph to have to constantly flip several pages forward to look at the graph. Finally, the font size in a table, in an equation, and in graphs, as well as any text appearing in figures, should reasonably match the size of the text.

Conventions of Writing in Physics

Clear and Logical Connections

A good scientific paper makes **clear and logical connections** between the work being reported and previous work done on the same topic. It explains how the work presented supports or refutes previous work and how the field is now extended as the result of the new work. **A scientific paper is therefore an argument.** To be convincing, the argument has to be logical and have a logical flow of connected ideas. Below are three topics listed in the writing rubric for SU Physics and Dual Degree Engineering in which clear and logical connections are emphasized.

Theory and Experiment:

In the case of a lab report or paper in which the author has conducted an experiment, there must be a **clear and logical discussion** of the underlying physical theory or engineering practice tested by the experiment. In addition, a **clear and logical connection** between the experimental apparatus and the experimental procedure must be made with the theory tested by the experiment. If the author is reporting on theoretical work, a **clear and logical connection** of the author’s work must be made with current physical theory or engineering practice.

Data Analysis Discussion:

In the case of a lab report or paper in which the author has conducted an experiment or is conducting an analysis of experimental data collected by others, there must be a **clear and logical description** of the experimental data, a **clear and logical discussion** of the salient elements of the data analysis, and a **clear and logical discussion** of experimental errors.

Conclusions:

Conclusions must have a **clear and logical discussion** of how the experimental results relate to theoretical predictions and what (if any) ramifications the new results have for the field.

Concise Writing

If a paper is difficult to read or too long, it risks being ignored by its intended audience. In addition, the cost of publishing an article today in most reputable peer-reviewed science journals now exceeds \$100 per page. So a twenty-page article may cost an author over \$2,000! Writing in the physical sciences must therefore be **clear and concise**.

In general, sentences should only be long enough to convey a single idea. If a sentence “reads long” the writer should try to break the sentence up into shorter sentences. After crafting a sentence, the writer should consider whether the same idea could be effectively conveyed using a shorter sentence. Some scientific writers who struggle with being concise have employed the trick of reading concisely written literature (like that written by Ernest Hemingway) before writing. The claim is it puts them in a concise writing mindset. In general, scientific writing **need not be in the passive voice**, though there are exceptions when “essential facts” are described. (See Section 9, pages 14 and 15 of the AIP Style Manual 4th ed.)

Grammar, Punctuation, Spelling, and Acronyms

The use of **correct grammar and spelling is essential** to all writing. The AIP Style Manual 4th ed. provides many examples of appropriate grammar and punctuation. The physical sciences utilize a lot of acronyms. It is important that all acronyms are defined **before** first using them in a document. For example, “The Hubble Space Telescope (HST) was used to take ultraviolet spectra of all objects in the field. Twelve objects were found to be active galactic nuclei (AGN). Follow-up optical spectra showed that seven of the HST detected AGN exhibit broad hydrogen alpha emission lines.”

References

Thorough references must be made to any external sources of data and/or theory associated with the writing of a lab report or a paper. Each reference must be made **immediately** after the information is given. Different journals in the physical sciences have different ways of denoting references. Some use a numbering system in order of first appearance in the paper. The numbers appear as a numerical superscript at the end of a sentence or as a number in square brackets. So if a reference first appeared as the fourth in the paper, the reference indicator appears as ⁴ or as [4]. If the same reference appeared later in the paper, then it is still listed as ⁴ or as [4]. The references are then listed numerically in the references section that appears at the end of the paper.

Many astronomical journals use a simple alphabetical system. All the references are listed in the reference section in alphabetical order by the primary author's last name. In the body of the text, the author name and the year of publication appear in parentheses. Here is an example:

“Pure hydromagnetic wind models have used self similar scaling to characterize AGN outflow (e.g., Blandford and Payne 1982; Emmering, Blandford and Schlosman 1992; and Bottorff, et al. 1997).”

The reference structure in papers and lab reports should reflect the specific requirements of the course instructor, lab instructors or adviser. It might be helpful if term papers, capstones, and honors thesis papers use the reference style that most closely matches journals in the discipline of the subject of the paper. An exhaustive list of examples of references for journal, articles, books, private communications etc. is found in the AIP Style Manual 4th ed.

AIP & AAS Style

The Physics Department at SU uses the fourth edition of the *American Institute of Physics (AIP) Style Manual* as a writing guide. The document has a wealth of detail. Physics students, Dual Degree Engineering students, and DEWC staff should make heavy use of this document, and a hard copy should be kept within reach when writing physical science-related documents.

For astronomy-related writing or for additional writing guidance, the American Astronomical Society (AAS) has a section of their website devoted to manuscript preparation. The online document can be found on [the website of the AAS \(aas.org\)](http://www.aas.org).

Links to each of these guides are also available online in the “[Student Resources](#)” section of the Debby Ellis Writing Center website.

A Few Last Notes on Writing in Physics

To achieve a logical flow of ideas, the creation of an outline at some point in the writing process is helpful. Outline construction usually occurs after a literature search (including the taking of detailed notes) has been conducted; the experimental, observational, or theoretical results have been obtained; and an analysis of the results is nearly complete. The main ideas, or results from the work can then be listed in outline form and then grouped, regrouped and edited to achieve the desired information flow. The main ideas can then be placed in the relevant structures of the lab report or paper (i.e., introduction, main body of the work, conclusions) to become topic sentences of various paragraphs in those sections.

The result of expanding an outline is a rough first draft. This will be the first of multiple redrafts. Many new to scientific writing are not aware of the level of scrutiny that scientific writing receives. Because of its concise nature, the density of relevant ideas is high. Therefore, careful attention must be given to virtually every sentence.

As a result, many drafts are often required to “get it right.” Adjustments are usually needed not only to correct spelling and grammar errors, but also to adjust the scientific content and logical flow. These adjustments are often due to the fact that **during the writing, new ideas and questions needing resolution can occur.** Sometimes this requires minor rewriting while in other cases major structural revisions are needed. In theory, once a paper nears completion, an abstract can be formulated. Like the paper, the abstract will most likely evolve as the paper reaches its final form.