

Writing About Physics Using L^AT_EX

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Test

We present a written summary template for use by UH Junior Lab students, using L^AT_EX and the **RevTeX-4** macro package from the American Physical Society. This is the standard package used in preparing most Physical Review papers, and is used in many other journals as well. The individual summary you hand in should show evidence of your own mastery of the entire experiment, and possess a neat appearance with concise and correct English. The abstract is essential. It should briefly mention the motivation, the method and most important, the quantitative result with errors. Based on those, a conclusion may be drawn. The length of the paper should be no more than four single-sided pages including all figures.

1. WRITING PAPERS IN THE PHYSICS COMMUNITY

An important part of your education as a physicist is learning to use standard tools which enable you to share your work with others. In Junior Lab, we will instruct you in the use of L^AT_EX on your own personal computer to write scientific papers in a widely accepted professional style. This source file (sample-paper.tex) for this document should be used as a template for your Junior Lab papers. Spending a few hours studying and altering this document will allow you to develop sufficient mastery of L^AT_EX to easily generate all manner of technical documents.

In order to make .tex documents you will need to install L^AT_EX. Creating a .tex file is easiest if you also use a LaTeX editor. To find the version of L^AT_EX for your operating system go to <http://latex-project.org>. There are several free editors; TexMaker is a L^AT_EX editor available for free at <http://www.xmlmath.net/texmaker/> for the WIndow, MacOSx, and Linux platforms. You can also try MiKTeX (pronounced *mik-tech* for the Windows platform, a freely available implementation of TeX and related programs available from www.miktex.org. Note that MiKTeX itself runs from a command line prompt and is not terribly convenient. Once you've installed the above software, you can obtain this .tex file on <http://www.phys.uh.edu/~rforrest/> and put it on your computer in order to 'rebuild' this document from scratch.

If you wish to view postscript files under Windows, we suggest downloading and installing Ghostscript available from www.cs.wisc.edu/~ghost.

The introduction section of any paper should succinctly report the motivation, purpose and relevant background to the experiment.

2. GUIDELINES FOR GOOD WRITING [1]

The essence of expository writing is the communication of understanding through a clear and concise presentation of predominately factual material. Most people cannot compose successful expository prose unless they put the need to communicate foremost among their priorities. Two things predominate in generating understanding in the reader:

1. ORGANIZATION: The reader must be provided with an overview or outline, know how each fact that he reads fits into that overall picture, and he must be alerted if it is an especially important fact. Furthermore, the facts must be presented in a logical order (so that fact 17 is not important for understanding fact 12).
2. UNIFORM DEPTH of PRESENTATION: Bearing in mind the preexisting knowledge of the reader, the writer must budget the length of discussion allotted to each topic in proportion to its importance.

Of course clarity of presentation and elegance of explanation will greatly enhance the ease and pleasure of understanding; still, a murky explanation can be fairly useful if the reader has been told what he is reading about and where it fits into the overall scheme of things - especially if the reader is familiar with the general subject matter under discussion.

The Junior lab writeup is one of the few opportunities undergraduates are given to practice technical writing. Thus we urge you to concentrate on your overall presentation, not only on the facts themselves. We strongly recommend that you:

1. Base your report on an outline.
2. Begin each paragraph with a topic sentence which expresses the main area of concern and the main conclusion of the paragraph. Put less important material later in the paragraph.

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Point 2 is frequently absent in reports; they are your mechanism for telling the reader what the topic under discussion is and where it fits into the overall picture.

You can check your topic sentences by reading them in order (i.e. omit all the following sentences in each paragraph) - this should give a fair synopsis of your paper.

If you are individually writing up results you obtained with a partner, use we and I appropriately.

Use the past tense for your procedure and analysis, the past perfect for preparation and the present for emphasis or conclusions, e.g. Since we had previously installed Matlab, we quickly concluded that electrons are waves.

1. Be sure your Figures have comprehensible captions.
2. Make a complete estimate of your errors (not just statistical) - even if it's crude.
3. Trace origin of formulae you use (eg. Moseley's Law) to well known physics (in this case to the Bohr atom) - don't derive, just indicate what new assumptions are needed.

Please consult the UH Writing Center's web page at <http://www.uh.edu/writecen> and the UH Library Phys 3313/3214 Research Guide at <http://guides.lib.uh.edu/phys3313/> for further guidance in all aspects of writing, style and to make appointments with consultants for free advice.

Lastly: Remember to proofread your paper for spelling and grammar mistakes. Few things are as offensive to a reviewer as careless writing and such mistakes will count against you!

3. THEORY

The report should be type-written in a form that would be suitable for submission as a manuscript for publication in a professional journal such as the American Journal of Physics. One helpful website is the American Institute of Physics Preparing your Manuscript page at <https://publishing.aip.org/authors/preparing-your-manuscript>. Figures (created as PDF files) should be inserted into the text in their natural positions. The body of the summary should include a discussion of the theoretical issues addressed by the experiment. This should be done at a level so that another student could follow your development.

3.1. Typesetting Mathematics

One of the great powers of L^AT_EX is its ability to typeset all manner of mathematical expressions. While it does take a short while to get used to the syntax, it will soon become second nature. Numbered, single-line equations are the most common type of equation in *Junior Lab*

papers and are usually referenced in the text; e.g. see Equation (1).

$$\chi_+(p) \lesssim [2|\mathbf{p}|(|\mathbf{p}| + p_z)]^{-1/2} \begin{pmatrix} |\mathbf{p}| + p_z \\ px + ip_y \end{pmatrix}. \quad (1)$$

Mathematics can also be placed directly in the text using delimiters: $\vec{\psi}_1 = |\psi_1\rangle \equiv c_0|0\rangle + c_1|1\rangle\chi^2 \approx \prod \sum \left[\frac{y_i - f(x_i)}{\sigma_i} \right]^2 |\psi_1\rangle \sim \lim_{\mu \rightarrow \infty} p(x; \mu) \geq \frac{1}{\sqrt{2\pi\mu}} e^{-(x-\mu)^2/2\mu} P(x) \ll \int_{-\infty}^x p(x') dx' a \times b \pm c \Rightarrow \nabla \hbar$.

Infrequently, you may wish to typeset long equations which span more than one line of a two-column page. A good solution is to split-up the equation into multiple lines and label all with a single equation number, like in Equation 2. See the L^AT_EX file to see how this is done.

$$\sum |M_g^{\text{viol}}|^2 = g_S^{2n-4} (Q^2) N^{n-2} (N^2 - 1) \times \left(\sum_{i < j} \right) \sum_{\text{perm}} \frac{1}{S_{12}} \frac{1}{S_{12}} \sum_{\tau} c_{\tau}^f. \quad (2)$$

Finally, it is often useful to group related equations to denote their relationship, e.g. in a derivation. Enclosing single-line and multiline equations in `\begin{subequations}` and `\end{subequations}` will produce a set of equations that are “numbered” with letters, as shown in Equations. (3a) and (3b) below:

$$\left\{ abc123456abcdef\alpha\beta\gamma\delta123456\alpha\beta\frac{1}{A^2}\frac{\sum_b^a}{A^2} \right\} \quad (3a)$$

$$\mathcal{M} = ig_Z^2 (4E_1 E_2)^{1/2} (l_i^2)^{-1} (g_{\sigma_2}^e)^2 \chi_{-\sigma_2}(p_2) \times [\epsilon_i]_{\sigma_1} \chi_{\sigma_1}(p_1). \quad (3b)$$

4. EXPERIMENT

This section describes the main components of the apparatus, procedures used and always makes reference to a figure(s) which contains a block diagram or schematic of the apparatus and perhaps includes the most important signal processing steps. **The figure should be referenced as early as possible in this section with the placement of the figure as close to the descriptive text as is possible.** It is usually necessary to place additional information within the figures themselves or in their captions for which there is no room in the main body of text. This will help you stay within the two page limit.

Example first sentence of an experimental section The experimental apparatus consists of a specially prepared chemical sample containing ¹³CHCl₃, a NMR spectrometer, and a control computer, as shown in Figure 1.

Graphics, such as Figure 2 should be well thought out and crafted to maximize their information content while

FIG. 1: This is a schematic of the main apparatus. Use the caption space to elaborate on specific issues or complication, or operating procedures. Especially valuable given the limited amount of space in the main body of text. The size of this graphic was set by the width command, the aspect ratio defaults to 1.0 if the height is not also set.

retaining clarity of expression! If you ‘reuse’ graphics from your paper in oral presentation slides, make sure to increase the size of all the fonts so that they remain legible from 20 feet away!

5. RESULTS, ANALYSIS, AND DISCUSSION

All papers should have at least one graphic showing some assemblage of raw data, see for example Figure 3. There should also be one graphic which summarizes the experimental data, and which conveys primary finding(s) of the laboratory exercise. You may find that you need more but these two should be a minimum. Finally, it can be useful in some circumstances to have a table of results, see Table I

FIG. 2: Sample figure describing a set of data, fit procedures and results. Use the caption space to provide more details about the fitting procedure, results or implications if you do not have sufficient room in the main body of text. The size of this graphic was set relative to the textwidth, see the TeX file for details.

TABLE I: A example table with footnotes. Note that several entries share the same footnote. Inspect the L^AT_EX input for this table to see exactly how it is done.

	r_c (Å)	r_0 (Å)	κr_0		r_c (Å)	r_0 (Å)	κr_0
Cu	0.800	14.10	2.550	Sn ^a	0.680	1.870	3.700
Ag	0.990	15.90	2.710	Pb ^a	0.450	1.930	3.760
Tl	0.480	18.90	3.550				

^aHere’s the first, from Ref. [4].

Try to avoid the temptation to inundate the reader with too many graphics. It is worth spending some time thinking of how best to present information rather than just creating graph after graph of uninformative data. All figures and tables must be properly captioned. Material and ideas drawn from the work of others must be properly cited, and a list of references should be included at the end of the text but before the graphics.

If circumstances in an experiment are such that you cannot get your own data (e.g. broken equipment, bad weather), **you may use somebody else’s data provided you acknowledge it.**

6. CONCLUSIONS

And finally, conclusions. Remember to report all your results with appropriate significant digits, units, and uncertainties, e.g. $Q = (2.12 \pm 0.06)$ disintegrations s^{-1} . It is often very useful to express the quality of your result by measuring how many standard deviations it lies from other published values.

It is worth mentioning here some thoughts on **ethics and writing in Science.**

When you read the report of a physics experiment in a reputable journal (e.g. Physical Review Letters) you can generally assume it represents an honest effort by the authors to describe exactly what they observed. You may doubt the interpretation or the theory they create to explain the results. But at least you trust that if you repeat the manipulations as described, you will get essentially the same experimental results.

Nature is the ultimate enforcer of truth in science. If subsequent work proves a published measurement is wrong by substantially more than the estimated error limits, a reputation shrinks. If fraud is discovered, a career may be ruined. So most professional scientists are very careful about the records they maintain and the results and errors they publish.

In keeping with the spirit of trust in science, Junior Lab instructors will assume that what you record in your lab book and report in your written and oral presentations is exactly what you have observed.

Fabrication or falsification of data, using the results of another person’s work without acknowledgement, or copying from “living group files” are intellectual crimes as serious as plagiarism, and possible causes for dismissal from the Institute.

The acknowledgement of other people’s data also applies to the use of other people’s rhetoric. The appropriate way to incorporate an idea which you have learned from a textbook or other reference is to study the point until you understand it and then put the text aside and state the idea in your own words.

One often sees, in a scientific journal, phrases such as “Following Bevington and Melissinos [2, 4] ...” This means that the author is following the ideas or logic of these authors and not their exact words.

If you do choose to quote material, it is not sufficient just to include the original source among the list of references at the end of your paper. If a few sentences or more are imported from another source, that section should be

indented on both sides or enclosed in quotes, and attribution must be given immediately in the form of a reference note.[3]

If you have any question at all about attribution of sources, please see you section instructor.

FIG. 3: Sample paneled figure created in Matlab using the `subplot(2,2,x)` command where `x` is the element of the plot array into which all subsequent commands such as `plot(x,y)` and `xlabel('Volts')`, etc. get processed. Use the caption space to provide more details about the data, their acquisition or how they were processed if you do not have sufficient room in the main body of text. Figures can be rotated using the `angle` command, see the TeX file for details. If a figure is to be placed after the main text use the “figure*” option to make it extend over two columns, see the L^AT_EX file for how this was done.

7. REFERENCES

Bibliographies are very important in Junior Lab papers. Beyond the requisite citation of source material, they provide evidence of your investigations beyond the narrow scope of the labguide, something explicitly required of all Junior Lab students! Good bibliographies are doubly important in the real world where they are

very (often the most) important sources of information for researchers entering the field. Bibliographic entries may be made either in the ‘.tex’ file itself or within a separate ‘.bib’ file which gets attached during process of building a final PDF document. This latter method is the preferred method and is then one used in this template by default. An example of the alternative style, currently commented out, is contained in the ‘.tex’ source file.

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- [1] Professor D. Pritchard, Personal Communication
 - [2] Melissinos, A.C., Experiments in Modern Physics - 1st Edition, Academic Press, [1966]
 - [3] Melissinos, A.C., Napolitano, J., Experiments in Modern Physics - 2nd Edition, Academic Press, [2003]
 - [4] Bevington and Robinson, Data Reduction and Error Analysis for the Physical Sciences - 3rd Edition, McGraw-Hill, [2003]

Acknowledgments

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