

# Writing about Physics in Junior Lab Using LaTeX

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We present a written summary template for use by MIT Junior Lab students, using  $\LaTeX$  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 4 pages when the figures are inserted into the text.

## 1. INTRODUCTION

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 urge you to use **Emacs**,  $\LaTeX$ , and **RevTeX-4** on Athena and the source file for this document as a template for writing your own summaries. Spending a couple of hours making alterations to this document will allow you to develop sufficient mastery of  $\LaTeX$  and **RevTeX-4** to easily generate all manner of physics papers throughout your career.

At the Athena prompt, type: `> setup 8.13`, then copy all of the files from `/mit/8.13/samplepaper` to your desired directory. The ‘setup’ command automatically appends to your path the location of the **RevTeX-4** files. Compile this template using the command `build sample-paper` which produces both postscript and Adobe PDF versions of your paper. Examine the ‘build’ file for details on how this is done at the command line.

**Remember to `ispell -t filename.tex` to perform a  $\LaTeX$  safe spell check before handing in your paper!**

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

## 2. 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 - Physical Review Letters, <http://prl.aps.org/>. One helpful website is the APS Physics Review Style and Notation Guide at <http://publish.aps.org/STYLE/>. It should be brief and have an ABSOLUTE page limit of 4 pages which INCLUDES figures. Inserting the figures into the natural flow of the text makes a paper

more readable than one in which all the figures are tacked on at the end.

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 8.13 student could follow your presentation (although perhaps not in complete detail).

One of the great powers of  $\LaTeX$  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 *Physical Review*:

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

$$\left\{ \mathbb{1}234567890abc123\alpha\beta\gamma\delta123456\alpha\beta \frac{1 \sum_b^a}{A^2} \right\}. \quad (2)$$

And referenced; see Eq. (2).

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

A long equation may be broken up with a single equation number, like in Equation 4.

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

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

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 Eqs. (5a) and (5b) below:

$$\left\{ abc123456abcde f \alpha\beta\gamma\delta123456\alpha\beta \frac{1 \sum_b^a}{A^2} \right\}, \quad (5a)$$

$$\mathcal{M} = ig_Z^2 (4E_1 E_2)^{1/2} (l_i^2)^{-1} (g_{\sigma_2}^e)^2 \chi_{-\sigma_2}(p_2) \times [\epsilon_i]_{\sigma_1} \chi_{\sigma_1}(p_1). \quad (5b)$$

### 3. 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  $^{13}\text{CHCl}_3$ , a NMR spectrometer, and a control computer, as shown in Figure 1.

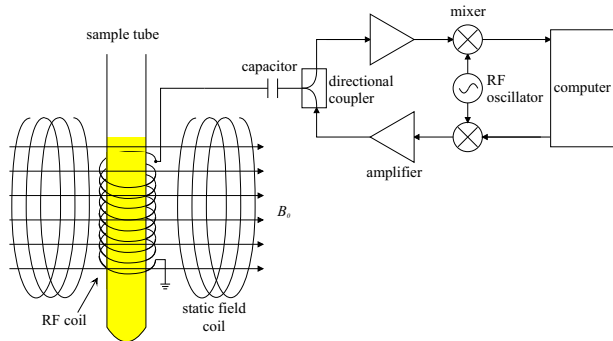


FIG. 1: This is a schematic of the main apparatus. Use the caption space to elaborate on specific issues or complication, or operating procedures. Especially valuable given the limited about of space in the main body of text. The size of this graphic was set by the width command, the aspect ratio defaults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

An important graphic is one which shows the instrument calibration, with or without some raw data as shown in Figure 2.

### 4. DATA AND ANALYSIS

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

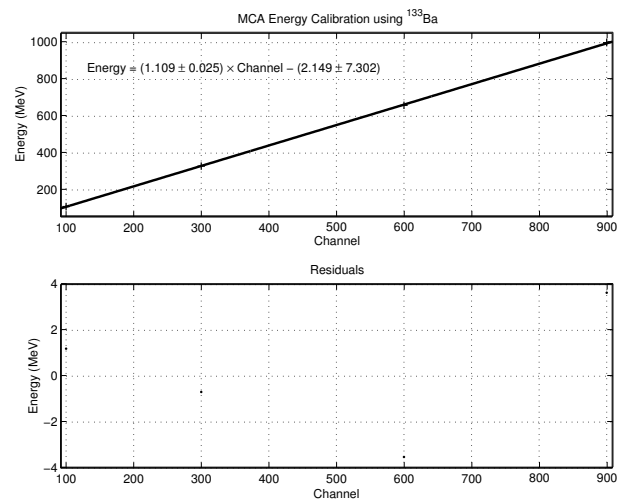


FIG. 2: Sample figure describing the calibration of the apparatus. Use the caption space to provide more details about the calibration procedure, results or implications if you do not have sufficient room in the main body of text. The size of this graphic was set relative to the textwidth, see the TeX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

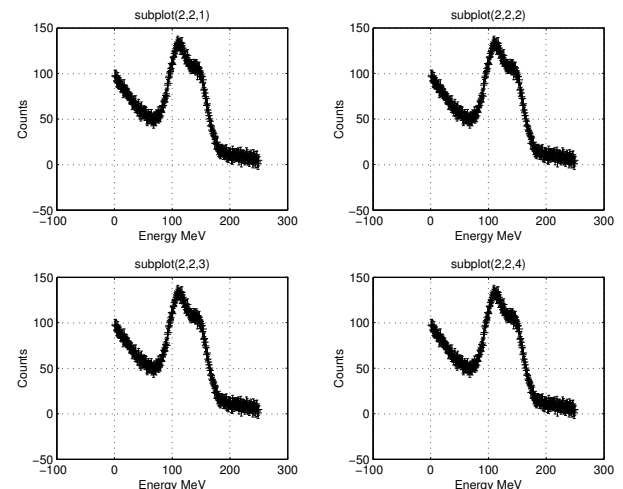


FIG. 3: Sample paneled figure created in Matlab using the subplot(2,2,x) command where x is the element of the plot array into which all subsequent commands such as plot(x,y) and xlabel('Volts'), etc. get processed. Use the caption space to provide more details about the data, their acquisition or how 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

can be useful in some circumstances to have a table of results, see Table I

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

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

	$r_c$ (Å)	$r_0$ (Å)	$\kappa r_0$		$r_c$ (Å)	$r_0$ (Å)	$\kappa r_0$
Cu	0.800	14.10	2.550	Sn <sup>a</sup>	0.680	1.870	3.700
Ag	0.990	15.90	2.710	Pb <sup>b</sup>	0.450	1.930	3.760
Au	1.150	15.90	2.710	Ca <sup>c</sup>	0.750	2.170	3.560
Mg	0.490	17.60	3.200	Sr <sup>a</sup>	0.900	2.370	3.720
Zn	0.300	15.20	2.970	Li <sup>b</sup>	0.380	1.730	2.830
Al	0.230	15.80	3.240	Rb <sup>c</sup>	1.330	2.800	3.590
Tl	0.480	18.90	3.550				

<sup>a</sup>Here's the first, from Ref. [1].

<sup>b</sup>Here's the second.

<sup>c</sup>Etc.

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.**

Consult the MIT Writing Center's web page at <http://web.mit.edu/writing/> for further guidance on technical writing.

## 5. 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 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 re-**

**sults 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 [1, 2] ..." 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.[? ]

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

## 6. SUGGESTIONS FOR WRITTEN REPORTS BY PROFESSOR DAVID E. PRITCHARD

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.

Point 2 is frequently absent in 8.13 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.

### 6.1. Style Suggestions

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.

### 6.2. Suggestions to avoid Common Deficiencies

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.

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- [1] D. R. P.R. Bevington, *Data Reduction and Error Analysis for the Physical Sciences* (McGraw-Hill, 2003).  
 [2] A. Melissinos, *Experiments in Modern Physics* (Academic Press, 1966).

### Acknowledgments

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