Physics 231 LaTeX Report Template

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Abstract

This is a template to use for preparing your reports in Physics 231. You can compare the `.tex` file with the printed output to learn how to use some useful LaTeXcommands. Further reference material is given in the bibliography.

I. INTRODUCTION

LaTeX (pronounced "lay-tek" or "lah-tek," but never "lay-teks") is the standard method for laying out scientific and mathematical manuscripts, just as HTML, or HyperText Markup Language, is the standard method for laying out web pages. Its main strength is that it enables a user to rely on standardized templates, typically provided by a publisher, for formatting equations, figures, tables, and bibliographies. This standardization puts the formatting decisions in the hands of professionals who write the layout packages, so that the user can (mostly) focus on the content. Among its other advantages, LaTeX is available for free with just about every platform you can imagine, the output it generates is platform-independent, it is widely used in the scientific community, and once you are familiar with its basic features, it is fairly simple to makes documents that look professional.

LaTeX is an open-source program available for Windows, Macintosh, and Linux machines. The discussion below mostly assumes a Windows installation, as that is what we currently have in the lab; however, whatever platform you run at home is OK. Indeed, one of the nice things about LaTeX is that it is independent from the specific operating system.

The Windows implementation of LaTeX, called MiKTeX, is available on all of the lab computers, together with the text editor TeXnicCenter. If you open the document `LaTeXReportTemplate.tex` in TeXnicCenter and set it to produce `.pdf` documents by selecting `LaTeX` → `.pdf`, you can then press the "compile and view" button to eventually see the formatted output in an Adobe Acrobat Reader window (you will also need to put the figures, such as `figure1.pdf` in the same directory as `LaTeXReportTemplate.tex`). Technically, this process will use PDFTeX, which is a variant of LaTeX. The only real difference between the two is in the types of graphical formats that they can import, as discussed in Sec. III.

For additional information about LaTeX, I have listed some good references in the bibliography [1–4].

II. ENTERING MATH

There are two categories for entering math in LaTeX, *inline*, or *displayed.* An inline formula goes right in the paragraph like this, $r = \sqrt{x^2 + y^2 + z^2}$. This could also be separated from the text in a displayed math environment,

$$r = \sqrt{x^2 + y^2 + z^2}.$$

In general, expressions with fractions or large characters look better in a displayed environment since they get shrunk in an inline environment. Look at this equation inline, $\frac{x+y}{2z}$. You would probably be better off using $(x + y)/(2z)$ inline and the fraction form for a display equation.

A. Displayed math

There are several formats for displayed math environments. To automatically add an equation number, use the `equation` environment,

$$i\hbar\left(\frac{\partial\psi}{\partial t}\right) = -\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial t^2} + V(x). \tag{1}$$

The `\label` and `\ref` commands allow one to easily reference Eq. 1 later in the text. For several aligned math equations, use the `align` environment. This uses the `amsmath` package. Note the use of `\left(` and `\right)` commands in the LaTeXsource to Eq. 1 to make large parentheses in the left-hand side. Finally, note that there are other notations for derivative. For example, instead of $\frac{dx}{dt}$, you might want to write $\dot{x}$ or $\dot{x}(t)$.

$$\begin{aligned}
\nabla\cdot\mathbf{E} &= \frac{\rho}{\epsilon_0} \\
\nabla\times\mathbf{E} &= -\frac{\partial\mathbf{B}}{\partial t} \tag{2} \\
\nabla\cdot\mathbf{B} &= 0 && \text{math comment example} \\
\nabla\times\mathbf{B} &= \mu_0\mathbf{J} + \mu_0\epsilon_0\frac{\partial\mathbf{E}}{\partial t} && \text{comments are aligned} \tag{3}
\end{aligned}$$

The placement of the & characters in each line specifies where to align the equations. The && is used for a second alignment point in the same line (for the comments). Notice that there are automatically equation numbers on the second and fourth lines, where I did not include a `\notag` command. Note, also that sometimes people will write a vector as $\vec{E}$ rather than $\mathbf{E}$.

III. GRAPHICS

In order to use the `\figure` commands in this template, be sure to include the `graphicx` package in the `usepackage` command in the preamble. The best format for graphics in PDFLaTeX is `.pdf`, which has the advantage that lines and characters are drawn at whatever the required scale is. (Bitmap formats look ok at the scale they were drawn at but less so at other scales.) In IGOR, you can save graphs as a `.pdf` file. Note that, in IGOR, you can create (and save as .pdf) Layouts that combine several graphs, with extra annotation, etc. These are very useful for figures that have several parts, which are usually labeled (a), (b), etc. Finally, the program you use for creating your schematic diagram may not have .pdf export. In that case, a bit-mapped format such as .png will also work.

Figure 1 was produced in IGOR. Note that the convention is to spell out the word "Figure" when it is the first word in a sentence. Otherwise, one refers to Fig. 1. One small stylistic point: Note that the default marker that Igor offers, a + symbol, was changed to a $\bullet$. This is perhaps a better choice, since the bars on the plus will get confused with the error bars. Indeed, even if there were no error bars, it's easier to see where the points are with other symbols. Don't forget to say explicitly what the form of the function being curve fit was, either in the caption (as we did here) or by reference to an equation in the text.

The (fake) data were generated by

```
make /n=10 fake_dat, fake_dat_errs      // create waves for data, error bars
fake_dat = 0.5 + x + gnoise(0.3)        // gnoise adds Gaussian random noise
fake_dat_errs = 0.3                     // uniform errors
```

Of course, you can make the command via the `Make waves...` option in the `Data` menu. The curve fit was then done using the dialog in `Analysis / Curve` fits. Note that the

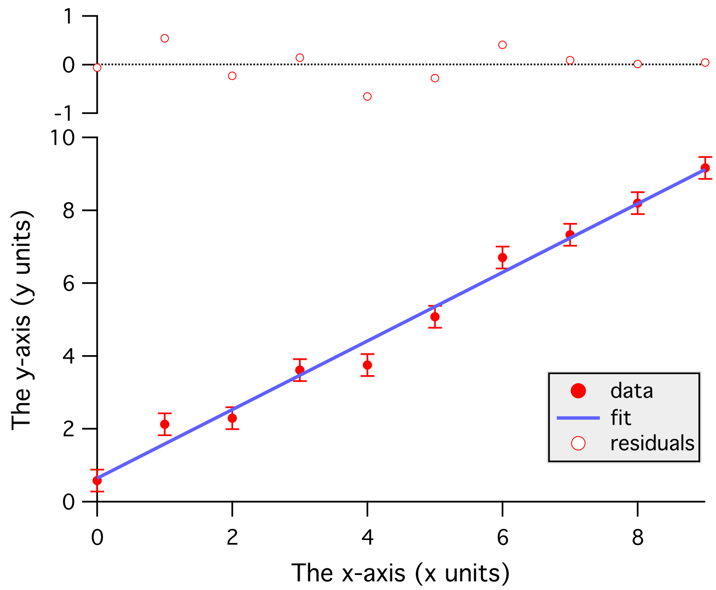

FIG. 1: Example of figure included in LaTeX. It's also a demonstration of a good graph – data points as markers, error bars, theoretical fit as a solid line, residuals shown, etc. Note how lightly shading the background of the legend makes it stand out nicely. For completeness, the curve fit was to a line of form $a + bx$, with slope $b = 0.94 \pm 0.03$ and intercept $a = 0.64 \pm 0.18$, with a χ^2 of 11.8 for $10 - 2 = 8$ degrees of freedom – all reasonably consistent with a good fit. Because the error bars are 1-σ deviations, one expects that about a third of the error bars will miss the fit curve. Here, there are three misses and two marginal hits – just what one expects! The actual slope and intercept used to generate the data were 1 and 0.5, respectively. Figure from [5].

residuals are displayed. The graph was then made pretty by using various options (double-clicking on the axes, etc.) Finally, the graph was set to a specific size (use the `Modify Graph...` dialog) and saved to a `.pdf` file. If there are several parts to a figure that you want to arrange with respect to each other (e.g., two graphs that are parts (a) and (b) to the same figure), put the graphs (and / or tables) in an IGOR Layout, and then save the Layout as described above.

One difficulty that people often encounter with LaTeX is that the program refuses to put the figures exactly where you want them. In the source code here, there are some notes on flags (*h, t, b*, etc.) that you can use to influence the location. In general, a smaller figure will have a greater chance of ending up where you want. For the skeleton draft that you prepare, the problem is particularly bad, as there is not enough text for the program to place the figures gracefully (in automatic mode). Don't worry about it here. (Or, if it really annoys you, put in some fake text as a placeholder until you write the rest of the report.)

IV. DISPLAYED TEXT

A. Lists

There are three standard list environments in LaTeX.
Bullets use the `itemize` environment:

- first item
- second item
- third item

Numbers use the `enumerate` environment:

1. first item
    (a) The list environments can be nested
    (b) second nested item
2. second item
3. third item

The `description` environment puts its argument in bold face. This is good for listing definitions:

Columbia A university in New York, or a recently disintegrated space shuttle

Colombia A country in South America

B. Tables

Here is an example of the standard table format.

	f_0 (s^{-1})	γ (s^{-1})	Q
undamped	12.00(1)	0.898(2)	20.(1)
damped	13.00(2)	3.434(3)	3.2(1)

TABLE I: Random table of random data. Note how the labels at left are right justified while the numerical columns are all centered. (Sometimes they might look better right justified, too.) Note, too, the use of the brackets to indicate the error in the last significant digit. See the reference manual for other styles.)

Tables and figures such as Tb. I can be referenced just like equations. It is a standard convention to label equation, table, and figure keys as `eq:equationkey`, `tb:tablekey`, and `fg:figurekey`.

V. CITING REFERENCES

Listing references is particularly easy in LaTeX. All the references of the paper are listed in the `thebibliography` section. All citations are then made by referencing the "key," or argument of the `bibitem` command.

Here is an example of a physics paper citation [6]. You should also give references to any commercial software or equipment that you use. This is so that a reader would know where to obtain a particular item. It used to be that one gave a street address and phone or fax number. These days, a website is more useful. As an example, in this course, the experiments use the LabVIEW software program [7].

Acknowledgments

The very last section (before the bibliography) is an Acknowledgments section. Here, you thank the people who gave you money to do the experiment and those who gave other kinds of help. Unless someone is giving you money to do the experiment, you don't have to go into finances! On the other hand, you should acknowledge the efforts of your partner...

In other acknowledgments, Steve Dodge wrote almost all of this, so I would like to thank him for letting me copy his work. Actually, he copied from lots of other people, as well, so you can thank them, too! In general, it is OK to use material by other people IF you acknowledge them. In particular, if you copy a figure, you should acknowledge that IN THE CAPTION. If you ever were to publish such a figure, you would need to get written permission from both the author of the figure AND the copyright holder. (Often, the journal – not the author – owns the copyright to the particular figure.)

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[1] L. Lamport, *LaTeX: A document preparation system*, Addison-Wesley, 1994.

[2] G. Grätzer, *Math into LaTeX*, 3rd ed., Birkhäuser, Boston; Springer, New York, 2000.

[3] T. Oetiker *et al.*, *The Not So Short Introduction to LaTeX 2ε*, www.ctan.org/tex-archive/info/lshort/english/lshort.pdf (Note that this file is 1.8 MB.)

[4] You can find a hyper-linked LaTeX reference manual – useful for looking up specific commands, etc. – at http://www.giss.nasa.gov/latex/.

[5] Actually, the data were just generated in Igor. But if you did take the figure (or the data) from somewhere else, you would reference it here. Of course, if the data are from the report itself, you don't need to give a reference!

[6] C. Davisson and L. H. Germer, Phys. Rev. **30**, 705 (1927).

[7] LabVIEW 8.2.0, National Instruments (Austin, TX). www.ni.com.