Writing a Good Paper

Almost all of you are likely to find this challenging, as in very hard to do well. I don’t want to give you lots of mechanical rules, instead I will try to tell you about the proper frame of mind in which to write. The same ideas apply to preparing a talk, giving a lecture, etc. In a nutshell, you must learn to think as much like someone in your intended audience as you can. This means taking a large mental step back from the experiment you have just carried out, or the theory you have just developed. The problem is that you know pretty much everything about what you have done, and your reader doesn’t know much at all, and even worse, may not be sure he or she cares! To combat this situation, you must use your first paragraph to convince the potential reader that your paper is worth further scrutiny.

Once you have the reader interested, you must retain that interest as long as you can. The best way to do this with another physicist is to be clear, and develop your results step by logical step. Ask yourself, “Where can I begin, that is likely to be easily understood?” Then ask, “What can I add next that builds on what I have already written?” Go along in this way, building up an organized logical presentation of your work step by step. In doing this, always read what you write with the mindset that you don’t know anything about it, except what you have already read. This is all easier said than done! Just do your best, and Greg and I will try to help you improve your writing. Needless to say, it is at this early stage in the writing process that a well-thought-out OUTLINE is the proper tool to be using!

By way of providing you with some motivation write as well as you can, physicists who write well are the ones who get research funding in academia, and they are the ones who rise to positions of major responsibility in industry (which is where most physicists spend their professional lives).

Mechanics of Writing your Paper

The structure should be as follows:

a. An Abstract, which is a stand-alone short summary of what you did and the conclusions you have reached. Abstracts are placed in searchable data archives, and are often read without the paper.

b. An Introduction, in which you provide the reader with a short summary of the relevant background for your work, what you have done, and why it is important. This is your chance to get the reader interested.

c. An Experimental Methods section, in which you describe your apparatus, usually by means of a sketch or two, cover anything important about the materials used, such as where you got them, purity, etc., describe how you took the data, about how accurate it is and why you think that.
d. A Results section, in which you present the data. Data are usually presented graphically, because this is the best way to give the reader an understanding of the data. You should combine several data sets into one graph, if you can do so without losing information. The reader must be able to read the values of the data from the graph to a reasonable accuracy, say 10% or so. This means you cannot use a linear graph to present results that cover more than about a factor of 10. In that case you must use Log-Linear or Log-Log plots.

e. An Analysis section, in which you describe how you have analyzed the data to reach the conclusions you are presenting. For example, if you have found the data \( D(x) \) to be well described by a square root law \( D(x) \propto \sqrt{x} \), you might just graph the measured data vs. \( \sqrt{x} \), because if such a graph is a straight line, the reader can see for himself that you are right. Even better the reader can judge about how well the law is obeyed. Alternatively, you could use a Log-Log plot, because any power law will be a straight line on such a plot. It is in the Analysis section that you must construct an airtight case showing that your conclusions follow from the data.

f. A Conclusions section, in which you summarize in words the main conclusions you have reached, and possible discuss any ideas for further work that are suggest by the work you have just presented.

Each section should have a title in bold, Abstract, Introduction, etc.

Rules for Figures
Use one of the Mathematica programs to make nice figures. Note that the data are boxed on all sides, that the axes have tick marks on all four sides (why?), that the ticks point inward to use the precious journal space as efficiently as possible, that the horizontal axis is the thing you controlled, e.g. the length of the pendulum, and the vertical axis is the thing you measured (period). This is called a graph of period versus length; \( Y \) vs. \( X \), means \( Y \) is vertical and \( X \) is horizontal. Please get this straight!

Every figure must have a caption, which is a little sentence or two saying what the figure is. You must provide captions even if the text is perfectly clear about the figure, as it should be. The reason for the captions is that an expert in your field should be able to look at your figures, read the captions and pretty much know what you have done, and what he or she thinks of it. For this reason, preparing all the figures and the captions early in the writing process is a good idea, and usually makes it much easier to write the paper.

You can print out each figure at full-page size, collect them together and put them all in order at the back of your paper. This is much easier than trying to insert them into the text, but you can certainly do that if you want. If you do that, each caption goes right under its figure with a small space between the caption and the figure. You can also put them all at the end of the paper. In this case, the arrangement should be first the paper itself, then a page labeled “Figure Captions” containing all the captions and then the figures in order. Each figure
should have Fig. 1, Fig. 2, etc written at the bottom, and each caption should be in the form, “Figure 1. A graph of period vs. length for various pendulums.” Or, “Figure 2. A sketch of the apparatus used to measure the flow rate of water through capillaries of various diameters.”

Another rule about figures is that you must refer to each figure in the text, and you must refer to them in order. You cannot refer to Fig. 2 before you say a word about Fig. 1, and you cannot just avoid saying anything at all about Fig. 3!

You should use symbols and axis labels that are large enough so that when you use a Xerox machine to reduce the figure to a width of 3 inches, the result is clear and pleasing to the eye. The reason for this is that most figures are reduced to single-column width in journals, and the columns are 3 1/8 inches wide for most physics journals. A figure that cannot be made to work this way will be printed with a two-column width.

To show both data and theory, or a fitted function, on the same graph, use discrete symbols for the data, and a smooth curve for the theory.

Although it is tempting with the power of modern computers to make beautiful color figures, with different data sets having symbols of different colors, or with different color curves for various possible theories. Don’t do this. Color figures cost a fortune, and after your article is Xeroxed, some colors come out very light, some don’t show up at all, and all the dark ones just come out as black. Instead of using color, people plot different data sets using different symbols. Common choices are filled circles, squares, triangles, and inverted triangles, open circles, squares, triangles, and inverted triangles, as well as crosses, pluses, and asterisks. Different theoretical curves are distinguished by solid, dashed, dotted, and dash-dotted lines.