

Physics 391/491: Junior/Senior Seminar Equations

Mathematics is used as a language in physics to express ideas concisely and precisely. Therefore, mathematical symbols and equations should be treated as words and phrases in your writing, even though they are not English ones. Most of the rules for including equations in your writing follow from this simple idea. Here's a good example of some mathematics properly integrated into text:

Since the aluminum slug does not undergo a phase change and its temperature change, ΔT_{sl} , is relatively small, we can approximate that the change in the slug's internal energy is

$$\Delta U_{sl} = m_{sl} c_{Al} \Delta T_{sl}, \quad (1)$$

where m_{sl} is its mass and c_{Al} is the specific heat for aluminum around room temperature.

Since mathematics is a language, the primary rule is that equations should be integrated fluidly into your writing.

- **Integrate mathematics into your prose.** Your writing should flow smoothly and coherently, even in sections that include mathematics. For example, you'd never write:

My main point is expressed in the next sentence. Garfunkel's contribution to the partnership is often underestimated.

That is definitely not fluid writing. Instead you'd write:

My main point is that Garfunkel's contribution to the partnership is often underestimated.

Similarly, you shouldn't write something like:

My central result is expressed in equation 10.

$$c_{Al} = \frac{\Delta U_{sl}}{m_{sl} \Delta T_{sl}} \quad (10)$$

Instead, you should write something like:

My central result is that

$$c_{Al} = \frac{\Delta U_{sl}}{m_{sl} \Delta T_{sl}}. \quad (10)$$

It is technically correct to write something like, "My point is simply this: You're underestimating Garfunkel's contribution." However, this isn't very fluid and should be avoided. Likewise, you should avoid introducing an equation with a colon.

The next three rules follow because you should integrate mathematics with English as seamless as you would integrate another language with English.

- **Punctuate and capitalize properly.** If your equation is integrated in a sentence, then the proper punctuation should surround it. In case you're not certain about the punctuation required, try reading the sentence as if the equation were in English. In the example, that would be "My central result is that the slug's change in internal energy is equal to the product of its mass, specific heat, and change in temperature." In this version, it should be clear that you don't need any punctuation before "the slug's change...", but you do need a period after "temperature." The same is true for the version with a mix of English and mathematics. Notice that the word "where" just after Eq. 1 is not capitalized because it's a part of the same sentence.
- **Italicize.** In general, whenever you switch from writing in English to writing in another language, you're supposed to italicize the second language to cue the reader that you're stepping out of English. For example, you might write "The attempted *coup d'état* was unsuccessful." Since *coup d'état* isn't actually English (it's French), you italicize it. In the example involving equation 1, the same rule holds for the language of mathematics. Whenever you use a symbol, whether it's alone or in a whole string of them (an equation), you should italicize.
- **Define.** Unless a foreign word is commonly understood by English speakers (as is *coup d'état*), you need also provide your readers with a translation of it into English the first time you use it. This rule holds for mathematics, too. That's why ΔU_{sl} , m_{sl} , c_{Al} , and ΔT_{sl} are all translated into English in the example around Eq. 1. Of course, all those symbols are reused in equation 10, so there was no need for me to define them a second time.

The next four rules follow because equations should be easy to read and to reference.

- **Really format equations.** If you type equations, they will not look good. Also, it isn't possible to type complicated equations. Therefore, you should use an equation editor.
- **Separate and center equations.** While an equation should logically read as part of a sentence, that doesn't mean that it should be physically on the same line as the English. It takes extra focus to read equations, so they should usually be placed on a separate line and centered. You should also leave sufficient black space above and below them to make them easy to read.
- **Number equations.** There's a good chance that after you've introduced an equation you will refer to it again. Even if that isn't the case, a reader may want to do so when communicating with someone else about your work. That's why you should number each of your equations (not just the ones that you reference later). To make it particularly easy for your reader to find the equations, you should place the number on the far right of the page.
- **Reference equations properly.** Since your equations will be numbered, you can write something like, "Observe that Eq. 10 is simply Eq. 1 solved for the slug's specific heat." You could refer to them as equation 1 and equation 10, but it's better to use the abbreviation "Eq." as in Eq. 1 and Eq. 10. The abbreviation is easier to find when skimming text, which a reader might do when trying to find where you wrote something about an equation.

There are two more rules, completely unrelated to formatting, to consider when including math.

- **Don't show every step.** In your homework, we want to see every logical step you take, that's because the homework is supposed to communicate the *activity* of your solving a problem. In a paper, you don't want to bore your reader by including equations for every step. You can use English to simply allude to the process, for example, "solving Eq. 1 for ΔT , substituting it into Eq. 3, and integrating the resulting relation from the initial temperature to the final temperature yields..." Your audience will influence how many steps you show.
- **Cite your sources.** When you use someone else's idea, whether it's phrased in English or in mathematics, you should cite your source. This gives credit where it is due and to let your readers know where to look for more information. There are some exceptions, so let's consider a few common situations.
 - **Don't cite when presenting a "public-domain" equation that's explained in a text your reader should have.** A rule of thumb for whether or not an equation is in public domain is whether it is present without citation in multiple text books. As an example, Eq. 1 on the first page of this handout meets those criteria. Not only that, but it is bound to be in a text book that you (the audience for this handout) have. So I don't need to cite a source for it. Obviously, this depends on your audience. For example, a reference for the Navier-Stokes relation should be cited in a paper written for all undergraduate physics majors, but needn't be cited in a paper written for people doing research in fluid dynamics.
 - **Do cite when presenting an equation that is *not* explained in a text your reader should have.** Regardless of whether an equation appears in several texts, if your audience can't reasonably be expected to have one of these texts, then you should provide a reference where they can look it up.
 - **Don't cite when presenting an equation which follows logically from ones you've already presented.** You may need to cite sources for the equations you start with, but you do not need to do so for equations that follow logically from them.
 - **Do cite when reproducing someone else's non-trivial mathematical discussion or derivation.** Imagine you want to demonstrate how an expression for the population of electrons in a superconducting state follows from quantum mechanical and statistical mechanical considerations and the assumption that there is some energetic advantage to electrons forming Cooper pairs. There's a fairly good derivation of this in a text you have, though the book uses unfamiliar notation and digresses and belabors some details a bit. In your paper, you rephrase the text's derivation in notation that's more familiar to your audience and streamline it a little. You've essentially paraphrased the text, so you should cite it. For example you might write "...loosely following Goldstein's derivation³..." That's partly to give credit where it's due, and it's partly to give you license to skim over some details since your audience can now go get Goldstein's book and look up the full derivation.