

Guidelines for SCIENTIFIC WRITING

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DRAFT

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1 Organizing information

- To collect your work at intermediate stages, use (1) a notebook, (2) numbered pages collected in a manila folder or in a 3-ring binder;
- Experimentalists : Collect detailed descriptions of hardware; keep dated records of assembly, changes, repairs and observations;
- Theorists : Gather previously known formulas that are needed for your calculations in a separate and easily accessible entry;
- Keep notes of calculations and discussions in a manner clear enough that YOU yourself will be able to understand them 10 years from now, even if no one else would be.

2 Choosing your audience

The purpose of writing a paper is to *communicate with an audience of readers*.*

Before you start writing the first line of your paper, it is crucial that you identify who your audience will be. Precisely which aspects of your work should be presented, and how your paper should be written will critically depend on the level of expertise and on the interests of your audience.

For example, an article on a new high- T_c superconducting compound written for The New York Times will look quite different from a paper written on the same discovery for Physical Review B. In the first, you will have to explain what superconductivity is, while in the second you will have to give the precise composition of the materials under study, but not vice-versa. To get a better sense of who your audience will be, the following questions should be helpful.

- What is the level of expertise of your audience in the general subject ?
- How familiar is your audience with the specific problem you address ?
- Which aspects of your results are of greatest interest to your audience ?
- Which aspects of your methodology or experimental set-up are familiar and of greatest interest ?
- How much jargon and which technical symbols are familiar to your audience ?
- Should your paper be addressed to a larger (or smaller) audience than you had originally imagined ?

It is a common mistake of the novice to be wasting too much time reviewing familiar facts while leaving too little time for the technical discussion of results. It is an equally common mistake to jump into too many details of the research too quickly.

To familiarize yourself with the audience and style of a journal to which you plan to submit a paper, take a look at the papers they have been publishing recently.

*The guidelines of this section should apply to oral presentations given in seminars as well.

3 Defining your aims

The information has been organized and your audience has been chosen. Now, it is time to define the aims of your paper. The aims of your paper and the choice of your audience are intimately interrelated. Here are a few extra questions that may help you in defining your aims.

- Justify your subject; why is it interesting, important and timely ?
- Justify the specific problem; why is it interesting and important ?
- What was known in the subject prior to your work ?
- What was known on your specific problem prior to your work ?
- What are your results; to what extent are they new ?
- What are your methods and arguments; are they new ?
- What is the range of applicability of your results ?

Generally, all these aspects of your work need to be addressed in your paper.

4 The power of an outline

If there is to be only a single guideline that you are to retain from this course, it is *to make an outline* of your paper first.

- What is an outline ? It consists of a list of topics and arguments which plan to address in your paper. The purpose of the outline is to divide the task of writing the entire paper into a number of smaller tasks. Ideally, each item in the outline will cover only a page or two. Often the items of your outline will become the sections and subsections of your paper.
- A good outline should delineate which parts of your work fit into which sections, subsection and so on. Ideally, there should be as little overlap between these entities as possible, so that the outline provides a *partitioning* of your paper.
- A good outline will provide an *ordering* of the various topics and arguments in a preliminary way. Having an ordering of the topics is key to identifying gaps in argumentation and gaps in information that you might still have before writing the paper. If such gaps appear at the time of the outline, you will have to decide whether it is best to complete your argumentation and information or to begin writing right away. Often, it is much better to delay writing until you have accomplished this extra research.
- Producing a good outline first is a possible remedy against *writer's block*. Indeed, once you have the outline, writing focussed smaller sections may be an easier a task to contemplate than writing a whole paper. Start with the section you are most excited about if that can help.
- Producing an outline does not necessarily require that you sit behind your desk. In my experience, rough outlines are often produced while walking, driving, or other. The back of an envelope, a napkin, or a little pocket notebook (for the hyper-organized) are all suitable media to start an outline.
- If you cannot produce an outline despite trying, you are probably not ready with your research, with defining your subject, defining your audience or all of the above.

5 Clarity

A paper written in a sloppy, confusing, obscure and misleading manner will almost certainly produce less impact on the scientific community than a clear paper. In the best case, such a paper will be ignored altogether. In the worst case, a misleading paper could damage your reputation as a scientist.

The credit for a simultaneous discovery made by several groups has sometimes gone to the authors who wrote the clearer paper, even if that paper actually appeared later than that of the other group(s).

5.1 Defining the new and the unfamiliar

- *New terms*, concepts and symbols should always be defined the first time they occur in the body of your paper. Keep the definitions crisp and concise without giving up on clarity. An important new term or concept may be mentioned in the abstract but should not be defined there. Avoid new symbols in an abstract.
- *Unfamiliar or infrequently used* terms, concepts or symbols should also be defined the first time they are used in your paper. Whether a term, concept or symbol is familiar or not, however, critically depends on the audience to which your paper is addressed. Publication in a specialized journal often requires supplying fewer definitions than in a journal with a broader readership.
- It is often helpful to spell out the notations used in the paper, even if they are relatively familiar. Mathematicians even have a dedicated phrase, often used as a preamble to introducing notations[†] : “To fix notation, ...”.
- When in doubt, defining unfamiliar terms is always a safe course of action.

5.2 Examples help the reader

Examples may help clarify abstract definitions. Choose your examples as representative and as simple as possible. An example may also help in illustrating a general result by describing its application to a simple special case.

[†]I am grateful to James Hansen for bringing up this point.

6 Honesty and trust

Gaining the trust of your readers ...

6.1 Knowledge before and after your paper

Your paper is going to contribute new results to your field ! By the time you write the paper, it should be clear to you which results were known before your work, and which results are newly obtained by you. To your prospective readers, however, this distinction is usually not so clear, in large part because you have spent the last year or so of your life working on this topic and they have not.

For the sake of clarity as well as for the sake of scientific honesty, it is crucial that you describe in precise terms which aspects of your topic were known before your work and which results are new.

6.2 Hard facts versus wild speculation

The dream of every scientist is have a brilliant idea which, with the use of flawless logic, demonstrates the existence of an important new phenomenon or solves a famous long-standing problem.

In reality, life is only rarely that generous to a scientist. Often, your new idea, combined with flawless logic only goes some distance towards solving the famous long-standing problem. If only you could make this extra little assumption, you could go much farther. The trouble is that the extra little assumption is something that you believe should be true but which you cannot, at present, prove.

Should you still write a paper ?

The answer is probably yes. But, your paper should clearly distinguish between *hard results* of which you have flawless proof; *conjectures* on which you are willing to bet your life but which you cannot, at present, prove; and *wild speculations*. If you fail to properly make the distinction between these categories, the reader will be free to look upon your wild speculations as outlandish claims and yet to doubt your truly hard results.

7 Some tips for style

- Think carefully about the words you use : most terms have a specific meaning. Common mistakes include the following; the ingredients of a sum are *terms*, those of a product are *factors* and not the other way around; the temperature is not *hot*, it is high, etc.
- Avoid using “clearly” (or “it is clear that”), “evidently”, “it is easy to show”. If your argument is that clear or that evident or if the proof is so easy, then why report on it in your paper ? Only occasionally, perhaps after you have gone through various complicated arguments and/or complicated proofs, could you use the above expressions to stress a contrast.
- Avoid “very”, “extremely”, “extraordinarily”. Most of the time, these adverbs express a personal opinion and are not needed.
- Never use colloquial expressions and/or contractions.
- Use *italics*, **bold face**, or underlined expressions in a systematic manner. For example, an author may use italics to make definitions stand out or to stress that new terminology is being introduced. Generally, however, it is best to keep the use of these style fonts to a minimum.

8 Drafts, rewriting and finalizing

Your first goal is to produce a *rough draft*, in which you delineate the subject, clarify prior results, describe your specific results, arguments and evidence. A rough draft is for your own use only; it is usually not ready for others to see.

8.1 From a rough draft to a good draft

- Is the development of your arguments logical and sequential ?
- Are all terms, concepts and symbols uniquely defined when first used ?
- Can your arguments and proofs be made more precise, and more concise ?
- Are all immediate questions addressed in the paper ?
- Are examples needed to clarify obscure definitions or to illustrate results ?
- Are your statements and formulas accurate ?

Apply the test of each of these questions to your manuscript and rewrite accordingly. Often, simple rearrangements of individual sentences, paragraphs or entire sections can improve the logical development of an argument and the readability of your paper.

8.2 Finalizing your manuscript

- Make sure the bibliography is complete;
- Include acknowledgments to funding sources and institutions;
- Acknowledge helpful correspondence or conversations with colleagues;
- Carefully proofread text, formulas, check titles and section headings.

9 Bibliography

[1] J.G. Paradis and M.L. Zimmerman, *The MIT guide to science and engineering communication*, The MIT Press, Cambridge (1997).

[2] J. Enders, *Guidelines for good paper-writing*, UCSB, Department of French and Italian, internal report (1998).