Guidelines for Writing

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3. Preparing Written Communications

The primary purpose of a thesis, scientific article or technical report is to communicate effectively and efficiently with your target audience. There are likely to be other subsidiary goals related to the type of text under consideration. For example, the purpose of a thesis is to demonstrate that you have acquired the relevant set of research skills, that you can apply these skills and that you can communicate the outcome in a clear and coherent manner. The purpose of a publishable scientific article is to inform your peers about progress in your field, placing the progress in the context of existing knowledge. The purpose of a technical report is to communicate progress in your scientific work to your sponsors. In all cases, it is essential to adopt the style and content to match the expectations of your target audience.

3.1 Planning and Structure

The keys to writing a successful scientific communication are **PLANNING** and **FLEXIBILITY**. Few people can write any large text from beginning to end in a coherent style without making some sort of plan.

Although there is flexibility in the detail, written scientific communications generally adopt the following format:

Abstract – Provide a summary of the main research questions, approach adopted, results obtained and conclusions drawn. The abstract is placed at the beginning of the work. In the case of a thesis, the abstract should be limited to one page, which is usually written last.

Table of contents - The contents table should contain the subheadings of each chapter, as well as the chapter titles (not usually necessary for a scientific paper).

Nomenclature – A list of symbols, meanings and units as well as abbreviations should be included if these are significant to the work. If a nomenclature is included, it should list *all* the symbols and abbreviations used.

1. Introduction – The introduction describes the context of the research, the research questions of interest, why they are of interest and the benefits likely to arise from answering the questions. The introduction should conclude with a description of the thesis / paper / report structure, indicating how the work is organised and where the reader can find key components. For theses and reports, the introduction is the first chapter and starts on page 1 (does it? – yes it does!), the earlier pages should have Roman numerals.

2. Background or Literature Review – This provides the state-of-the-art knowledge at the start of the research and sets the context within which your results should be discussed. All advances made must be placed within the context of existing knowledge to be readily understandable to the reader. Statements made should be supported by appropriate references throughout the section / chapter. Highlight disagreements and inconsistencies in published work. If you disagree with an author, you can say so provided you argue your point on sound scientific principles. The chapter / section should conclude with a summary of relevant research to date, indicating the most important ideas and concepts. Indicate what information is missing from the literature that is required to progress your research, and which aspects of this missing information you will be addressing in your work.

3. Methods, Equipment and Procedures – Describes what you have done and how you did it, with sufficient detail to ensure that the work can be reproduced with the same results by someone else with a similar educational background.

4. Results – Describe what you have observed from your modelling and/or experimental activities.

5. Discussion – Describe why the observed results arise and explain the physical / mathematical / engineering / … etc principles which give rise to the observed results. Conflicts and agreements with existing knowledge should be highlighted here with reference to the literature, and attempts should be made to resolve disagreements in the light of the new knowledge obtained.

6. Conclusions – This section contains a series of stand alone, self-evident statements arising from the results and discussion. Conclusions should be simply stated; their justification should be embedded in the discussion. Conclusions should not contain any statement that has not been put forward in the discussion.

Acknowledgements – Express appreciation for organisations and individuals who have helped with the realisation of the work. The acknowledgments section is titled like a chapter, but is not numbered.

References – A full list of articles used in the work to describe the state-of-the-art in the literature and to support the points raised in the discussion. The reference section is titled like a chapter, but is not numbered. References can be numbered and indicated by superscripts,[33] where the superscript is placed after any punctuation mark.[27] Alternatively, the reference can be placed in square braces [33] in line with the text, or by surname of the lead author (without initials), together with the year (Hawking, 1997). If more than one paper is published in a year, these should be referred to by a letter after the year e.g., (Hong *et al.* 2005a). Whatever style you choose, be consistent throughout the work.

Such a format is used because it offers a clear and concise structure for communication, which meets the expectation of the readers.

For any written work it is advisable to devise an outline containing chapter / section headings, first level sub-headings and second level sub-headings, with notes and comments to indicate what you wish to place in each location. Once you have a list of chapters / sections and, under each heading, a reasonably complete list of things to be reported or explained, you will have made considerable progress toward planning the work. When you sit down to write, your aim is no longer to write the entire work, but something simpler, such as to write a paragraph or section under one of the subheadings. Whilst writing, as ideas occur to you, make notes under appropriate sub-headings, so that you do not forget to address important points later on. This is particularly important when writing the results section and preparing for the discussion.

Theses – Additional Considerations

Thorough planning for your thesis should be undertaken, within the first year for a Ph.D. study or within the first two months for a masters research project. In addition to the general structure described above, it is common to include a section on **Further Research**, which contains recommendations for future studies, arising from the new knowledge presented in the thesis. A number of structural variations are also permissible, such as splitting of the

results and discussion into several chapters dealing with different aspects of the same problem. The structure that you adopt should be approved by your supervisor. It should also meet any formal requirements of the University.

Scientific Articles – Additional Considerations

Most journals and conferences have their own style conventions for published papers, these are available in *Instructions for Authors*, and should be rigorously followed. Papers can be automatically rejected, regardless of content, if the required style conventions are not followed. It is a good idea to examine a few papers already published in a journal or conference proceedings to determine what is considered acceptable.

Research Reports – Additional Considerations

Research reports are generally written for the benefit of sponsors, and should conform to the sponsors' wishes in all details. In most reports, it is desirable to include a status summary, comparing progress with planning, and to defend or explain any changes in the research plan. In addition to the research results, discussion and conclusions, it is important to include an **Executive Summary**, describing the highlights of the research and focusing on the goals of the sponsors.

Research reports must always be delivered by the agreed deadline. No matter what the circumstances, it is completely unacceptable to miss reporting deadlines.

3.2 Execution

When you sit down to write any text, write the text. It would be nice if clear, coherent prose appeared at the first attempt, but for most of us, the first draft is far from perfect. Nevertheless, it is important to commit your ideas to a written form. It does not matter whether you write chapters, sections, subsections or simply additional notes in sub-headings, just as long as that the overall definition improves and the fraction completed increases. Plotting graphs, analysing data, reading background literature etc. are important parts of the learning curve, but are not parts of the writing process. Do not delude yourself that because you spend hours plotting a particularly intricate graph that you have made progress writing, this is simply procrastination[2]. It is important to **set time aside for writing and to use this time to write!**

Writing a Masters Thesis

It is advisable to begin writing your thesis as early as possible. Inevitably, the percentage of time spent writing will rise as you approach the end of the research; however, it is inefficient to leave all the writing to the end. It is far better to write up your results on a rolling basis as the research progresses. This gives two important advantages; firstly, you have a substantial amount of text already in draft form when you come to complete the thesis and secondly, and most importantly, you have already analysed and discussed your results, avoiding nasty surprises associated with missing data.

[2] Wasting time

Writing a Ph.D. Thesis

The most efficient approach to writing a Ph.D. thesis is to construct the core of the work from your published journal and conference papers (see section 1.5 *Requirements for a Successful Ph.D.*). However, please be aware from the outset that a Ph.D. thesis is not simply a collection of disparate papers. A Ph.D. thesis represents a coherent body of work founded upon a clear theme. The thesis should present a logical, lucid and reasoned story, without repetition, or inclusion of material irrelevant to the stated aims and objectives of the work. In addition to the published papers, the thesis will require an introduction, and discussion linking the subjects covered in the various papers. It is also advisable to include a conclusions section indicating the key advances made during your research. Inevitably, your papers will require some editing to avoid repetition in the thesis and, where necessary, to produce a consistent style.

It is of critical importance that you plan your publications carefully to ensure that the final thesis presents a coherent and self-consistent story.

Timing

In the latter stages of thesis preparation, it is important to have a written timetable for completion of various chapters and sub-chapters. The timetable should be mutually agreed with your supervisor and should then be rigorously followed.

Final Thought

When writing a thesis, spare some thought for those around you. Writing can be difficult; it can mess up your social life, strain family relationships, sometimes close to breaking point, generate huge amounts of stress and dominate your life. Good planning and disciplined execution can help to minimise these effects.

4. Writing

Written communication is essential in a research environment; however, there is often confusion about the purpose of a written text. Whilst the *reason for writing* may be to publish a paper, to complete requirements for graduation, to report to sponsors, to meet project milestones or simply because someone asked, the *purpose* of a written text is to **communicate**. It is therefore essential to constantly think from the point of view of your future readers.

All written communication should have a logical framework. This includes an aim (reason for writing) a definition (statement of the problem), and a structure. It should be possible to state the aim in one or two sentences. The definition should be made clear in the title, the abstract and the introduction to the work. Structure applies at three levels: the text as a whole (see for example sections 1 and 3), the paragraph level and the sentence level. At the paragraph level always check that:

- Paragraphs cover 1 subject.
- Paragraphs have one key sentence (where appropriate).
- Key sentences are always in the same place within the paragraph. This should be the first, second or last sentence. The key sentence position can be different in the Introduction and Conclusion to provide a style contrast.
- The theme of one paragraph should lead into the theme of the following paragraph OR a new heading or sub heading should be inserted.
- Always follow a consistent lay-out.

The key sentence in a paragraph conveys the main idea you wish to communicate and the reason for existence of the paragraph. Additional sentences provide supporting material that should:

- Be properly described.
- Have a clear purpose.
- Follow a common style.
- Be properly referenced where necessary.

At the sentence level, sentences within a paragraph should link common themes, should have a common subject and should provide reasoning links between the various aspects of the subject addressed within the paragraph. Sentences should generally contain a subject, a verb and an object. It is advisable to:

- Avoid repetition.
- Avoid long sentences (>30 words).
- Avoid short sentences.

4.1 Writing Style

Good grammar and thoughtful writing will make any text easier to read. Scientific writing has to be somewhat formal and should avoid slang, none literal expressions and constructions normally confined to the spoken language. Remember that scientific English is an international language, which must be clearly understandable to an international audience.

Write in the third person singular style, i.e. avoid being personal. For example ….*let us look at an example*.... is better expressed as ….*consider an example*.... The phrase ….*we can also see martensite in the base material*.... should be written ….*martensite can also be seen in the base material*.... This style has the advantage of clarity, but does not attribute ownership. In the example ….*the machine was calibrated prior to the start of the study*…. the text does not indicate who carried out the calibration. Where this is desirable, specific reference should be made; this is particularly important when you wish to make it clear what your personal contribution to original knowledge has been. One way around this problem is to ensure that all ideas or actions not specifically referenced are attributed to the author. This is usually implicit, but care must then be taken not to abuse this position, as omitted references can subject the author to suspicion of plagiarism.

Short, simple phrases and words are often better than long ones. Phrases like ….*at this point in time*…. can readily be replaced by ….*now*…. However, do not sacrifice accuracy for the sake of brevity ….*black is white*…. is simple and catchy but also incorrect ….*Objects of very different albedo*[3] *may be illuminated differently to produce similar reflected spectra*…. is longer and uses less common terminology, but, compared to the former example, it has the advantage of being true.

If your primary statement requires several qualifications, each of these may need a subordinate clause: ….*When* [qualification], *and where* [proviso[4]], *and if* [condition] *then* [statement]…. Make sure that sentences are appropriately linked and follow logical constructions.

Abbreviations are often misused in scientific texts. Use them sparingly and only for terms which are either internationally recognised (SEM for scanning electron microscope, HAZ for heat affected zone *etc*.) or for terms which must be continuously repeated during the text. A good rule is: do not abbreviate unless a term is used more than a dozen times within a text. The same rule should be applied to texts involving reference to chemical elements; use the name of the element, not the abbreviated symbol unless it will be constantly repeated. Foreign (to English) terms should be written in italics. Examples often occurring are the Latin abbreviations *et al.*, *e.g.* and *i.e.*

4.2 Equations

All equations in the text should be numbered and their significance described. Various numbering schemes are permissible and all of these have Arabic numerals and parentheses as common components. References to equations in the text should be of the form eq. (3), eqs. (3) and (5), eqs. (5) to (8) etc. or, preferably, equation (1), equations (3) and (5), equations (5) to (8).

[3] The ratio of radiant flux falling on a surface to that reflected by it.
[4] A limiting clause.

Symbols introduced for the first time should be explained in the text preceding or following the equation. This applies even to well-known symbols like *T* for temperature. For a clear distinction, in the text symbols should be written in italics using a times roman font. A definition of a symbol by means of an equation should be in displayed format, such as

$$c = \left(a^2 + b^2\right)^{0.5}, \qquad \ldots . (1)$$

otherwise the equation could be hard to find. It is a good idea to indent equations to make them visually distinct from the surrounding text.

Equations are grammatically *part of the running sentence.* Always check the punctuation marks on both sides of an equation. This is best done by treating the equation as a word or expression, in-line with the running text. In the example above, no punctuation mark is necessary before the equation, but a comma is necessary after the equation. Do not use a colon (:) before an equation, unless the introductory text contains an anticipatory expression (usually *the following*:). When you must use a colon, remember that the sentence cannot continue beyond the equation.

If an equation will not fit on a line, break the equation into parts, beginning each new line with a mathematical operator.

Be careful with equations taken from published works, there are many errors propagating through the literature. It is a good idea to perform a dimensional analysis on any expression before incorporating it into a model, performing calculations or adapting the expression for a different application.

4.3 Tables

Table captions should span the top of the table, and must be complete and intelligible without reference to the text. Conversely, the text must remain intelligible even if the reader does not refer to the table. Captions for tables do not start with an article (the, a or an) and references to tables are not abbreviated (table 1 not tab. 1). The word table should only start with a capital letter when it begins a sentence. In addition:

- Make sure that all tables are described in the text.
- Ensure that all numerical quantities have clearly displayed units.
- Note that tables usually have no vertical lines, and only a minimum of horizontal lines.

4.4 Figures

Figures can be used to great advantage to convey large quantities of complex information rapidly. The notation on figures must correspond to that used in the text. There should be no information in a figure that is not discussed in the text. Describe the main features of the figure in the text to help the reader interpret the figure. SI units should be used (see section 4.6) and old diagrams with non-SI units must be redrawn. Any diagrams obtained from the

literature must be acknowledged even though they may have been redrawn, especially if the intellectual content of the diagram is not significantly modified.

Figure legends should be placed under a figure. In common with tables, the legend should not start with an article (the, a or an) and the legend should give sufficient description of the content without reference to the text. When a figure has multiple parts (e.g., 4a, 4b, 4c etc.), reference should be made to each part in the legend and the part label in parentheses should precede the description. For example, *Figure 6 Fusion zone microstructure showing (a) the centre of the weld bead and (b) the boundary with the heat affected zone.*

References to figures should be of the form fig. 4, figs. 3 to 5, figs. 2 and 8 (note the full stop followed by a space) or better still figure 4, figures 3 to 5, figures 2 and 8. Do not capitalise the word figure unless it appears at the start of a sentence.

The following points should be addressed when preparing graphs:

- A graph should have a closed rectangular frame; all four sides should have ticks, normally only two have text and numbers alongside.
- Logarithmic axes should be clearly marked as such; e.g., 10^3 ... 10^4 ... 10^5 at the major ticks.
- Corresponding graphs should have the same axes.
- Use the same line and point styles and colours for similar data throughout the work.
- Avoid large areas of unnecessary white space, but the previous rule prevails. Where possible, make the axis values start at zero.
- If possible, use solid curves for theoretical or model predictions and points or dashed lines for experimental data.
- Do not add lines between data points without reason.
- Consider showing data in some sensible *relative* or *normalized* form. This facilitates making comparisons.
- Label curves with short explanatory phrases unless this would clutter the graph too much. When there is no room, use a key; if possible, have the same top-to-bottom order in the key as in the graph.
- Lines, symbols, and letters should be able to withstand any reduction required for the final published form. The smallest letters and symbols should be at least 1.5 mm after reduction.
- Numbers along the axes should not have superfluous decimals but should have the same number of decimals for all numbers on an axis.
- Avoid using shading in the background of a graph; it does not reproduce well.
- Avoid grid lines on graphs; they make the presentation look cluttered.
- Texts along the axes should mention the quantities displayed and show the units in parentheses. A quantity is indicated by its symbol(s) or an explanatory phrase.
- Quantities plotted are dimensionless numbers, and formally should be divided by the units on the axis legends. For example, Distance *d* / m. Dividing the distance *d* in

metres by the unit meters delivers the required dimensionless quantity. However, this formal rule is often misunderstood and division is implicit thus, Distance *d* (m).

- Use parentheses for dimensions, not square or curly brackets.
- The quantity or the unit may be modified by powers of ten.

4.5 Symbols and Units

International SI units should be used for all numbers unless there is a specific and strong convention within a particular discipline for using a different unit. Examples of such conventions are the use of inches for pipeline diameters or metres per minute for wire feed speeds. If none SI units are used by convention, they must always be changed to SI units for the purposes of calculation.

Units should not be used in an equation but quoted with the description on the variable in the text and if desirable, in a nomenclature table. SI units are implicitly assumed in equations. None SI units should be avoided or explicitly indicated where their use is unavoidable. The only acceptable non-SI units are shown in the table below.

Unit	**Symbol**
bar (pressure)[5]	bar
minute	min
hour	h
litre	L or
electronvolt	eV

All other units should be quoted with an SI equivalent; *e.g.*, ….*water freezes at* 273.15 *K* (32 °*F)*....

There are internationally recommended symbols for most physical quantities and these should be used, do not make it up as you go along.

Never begin a sentence with a symbol; this avoids confusion with mathematical notation and with capitalization conventions.

Quantities and units should be separated by spaces, for example the specific heat capacity of water at constant pressure and 25 ºC should be written 4.17×10^3 J kg^{-1} K^{-1}. Note the spaces separating the number and the unit and separating each symbol in the unit. It is much better to use the power notation than to write 4.17×10^3 J / kg / K, as the division is ambiguous and could be interpreted as J K kg^{-1}. Conversely, 4.17×10^3 J / kg K can also be ambiguous as it can be unclear whether or not the K belongs to the denominator.

Hardness values measured on the Vickers scale should be denoted by Hv_x where the subscript x is the load measured in grams or kilograms.

[5] Note the plural of bar is bar (not bars)

Finally, be careful to use the correct capital and small letters for units. For example, 10 KN is meaningless, 10 K N is ten Kelvin Newton and 10 kN (ten kilo-Newton) is probably what is intended.

4.6 English or American?

Texts can be written in a variety of styles, with either English or American punctuation and spelling, both are equally acceptable. Whichever you choose, it is important to be consistent throughout the text. Examples of differences in spellings include:

English	American	Examples and comments
-ise or -ize	-ize	characterize / characterize, (but always: to devise)
-yse	-yze	analyse / analyze
-re	-er	centre, millimetre, fibre / center millimeter fiber
-our	-or	colour, behaviour / color behavior
-ogue	-og	prologue / prolog
-ence	-ense	defence / defense
-ise	-ice	practise / practice
aluminium	aluminum	-
modelling	modeling	-
(lighter)	(heavier)	Use of punctuation

Preference within the department is for English spellings and punctuation.

4.7 Checklist and Common Errors

After writing any text, you should apply the following checklist:

- Proof read your text <u>after completion</u> of the first draft.
- Is there a clear framework?
- Is the text structure clear, consistent and appropriate?
- Paragraph Structure:
  - Is there a key sentence?
  - Is the key sentence in the correct (consistent) position?
  - Is there a single theme per paragraph?
  - Is supporting material properly described?
  - Is external material correctly referenced?
- Sentence Structure
  - Are the sentences properly formulated?
  - Are there sufficient links between sentences?

- Check for common errors and rectify them before handing in your text.

Common Errors

1. There can be no excuse for spelling mistakes - use spell checking software.
2. Avoid inconsistent notation. The thesis must share a common terminology, best ensured by using a nomenclature list. Use international standard notation where possible.
3. There should be a space after a full stop or a comma. However, accredited abbreviations (such as Ph.D.) do not have spaces after full stops. Initials in names should be separated by spaces (A. N. Other).
4. There are no spaces after an opening bracket or before a closing bracket.
5. Include titles in the reference list.
6. There is a space between numerals and units (*e.g.* 45 MPa) and between units (*e.g.* 9.81 m s^{-2}). The units themselves are in roman font. Use strict SI conventions. For example, there is a gap between MN and mm when writing MN mm. Use exponents: m s^{-1} rather than m/s.
7. Check for incorrect or unspecified units.
8. The past tense should be used to report what has been done, the present tense to report what is time invariant. For example, the sample *was* placed on the test bed; the results *show* that lead is toxic.
9. Abbreviations must be defined when first introduced (HAZ, TTT, XRD etc.).
10. Use "Compared *with*" rather than "Compared *to*". Do not use "*as*" to precede compared.
11. The plural of datum is data.
12. Use *programme* of work as opposed to computer *program*.
13. Full names of chemical elements do not begin with capital letters unless they appear at the beginning of a sentence.
14. <u>All</u> equations, tables, figures must be numbered.
15. Mathematical notation is in italics whether it occurs in the text or in equations. Terms such as log, exp, and sin are nevertheless in non-italicised roman font even when in equations. Mathematical notation in figures should be the same as in the text.
16. When referring to authors by name, quote the surname only unless the author is the main subject of the sentence.
17. Make sure that you leave no hanging comparatives. For example, the phrase ….*the pressure in the centre of the arc was higher*…. raises the obvious question - higher than what? Always make sure that the comparison is complete …. *the pressure in the centre of the arc was higher than that in the surrounding shielding gas*…. is adequate, whilst ….*the pressure in the centre of the arc was* 30 *mbar higher than that of the surrounding shielding gas, which had an absolute pressure of* 1.18 *bar*…. is preferable as it is both comparative and quantified.
18. Where feasible, avoid using the following words: do, does, done, get, got, set-up, versus, so called.

19. Avoid constructions such as ….*the obtained results show*…. The correct structure is ….*the results obtained show*…. However, ….*the results show*…. is best because it avoids using unnecessary words.
20. Avoid subjective descriptions of results, especially when describing accuracy. Statements such as ….*the model predictions gave a good (or accurate) fit to the experimental data*…. is both annoying and meaningless. Accuracy should always be quantified *e.g.*, ….*the model predictions match the experimental data to within 0.1%, which represents a tenfold improvement in accuracy over previous published works*….
21. Avoid using unnecessary words. For example in the phrase ….*the hardness values varied between* 255 *and* 298 Hv_{10}…. the word "*values*" is redundant.
22. Check all graphs have correctly labelled axes, including units.
23. Check all graphs have consistent styles and correctly labelled curves.
24. Check equations are properly numbered.
25. Check equations have consistent dimensions.
26. Chapters, sections or sub components cannot perform actions. Phrases such as ….*chapter 5 investigates the influence of welding stresses*…. is therefore nonsensical. If the chapter could carry out the actions, we would not need researchers! Here the intended meaning could better be expressed as ….*investigation of the influence of welding stresses is reported in chapter 5*….

Finally, be aware that whilst it is not advisable to irritate your target audience with a poorly constructed text, or a text containing many errors; it is absolutely unforgivable to irritate your supervisor with the same.

References

Thijsse B.J. Guidelines for Writing a Paper, Department of Materials Science and Engineering, Delft University of Technology 1996.

Wolfe J. How to Write a Ph.D. Thesis, School of Physics, The University of New South Wales, Sydney, Australia.

Bhadeshia, H.K.D.H. Thesis Information, http://www.msm.cam.ac.uk/phase-trans/thesis-info/

Cipolla, R. Guidelines on Ph.D. Research and Supervision, August 1995. http://mi.eng.cam.ac.uk/~cipolla/Ph.D.guide.html