WRITING MATHEMATICS FOR MSC/MSCI PROJECTS

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1. Project rules / guidelines

Some main points to note:

- MSci (MT400) and MSc projects should be between 8000 and 16000 words. This usually corresponds to between 25 and 50 pages of normally typeset text. BSc (MT300) projects should be between 7000 and 8000 words.
- MSc students should consult §8 of the postgraduate handbook. In §8.7 of the handbook there are some things that the dissertation **must** include. On the title page please include your: **name, candidate number, project title and supervisor's name**.
- The marking template is in §8.12. The same template is used for BSc and MSci projects. You should note that 20 out of 100 marks are allocated to the bibliography, and style, spelling, punctuation and grammar.
- You can demonstrate originality by creating your own examples, by giving your own version of existing proofs, by giving original analysis of existing results and methods, and by making new connections between published papers. Originality is encouraged and rewarded, but you are not expected to solve an open research problem.
- Your supervisor will comment on drafts. Be sure to give him or her plenty of time to do this. You should already have agreed an outline with your supervisor.
- **Deadlines:** If you are an MSc student you **must** submit your project by by 2pm on the first Thursday of September (September 5th 2019).

2. Advice on reading and writing mathematics

Reading papers. Reading mathematical papers or advanced textbooks is hard work and will take a long time. Try to work through examples in parallel: you can use these later in your project. Force yourself to think

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Download from `www.ma.rhul.ac.uk/~uvah099/Maths/ProjectAdvice.pdf`.

about the material. For example, imagine you have to give a talk on some part: what are the main points you would want to hear yourself saying?

Finding papers. MathSciNet is the main database of mathematics papers. It also has reviews; these can be very useful when finding your way into a new field: see `www.ams.org/mathscinet`. (You will need to be on the college network or use VPN.)

General writing advice. In summary: **respect the reader**. Ideally it should be a pleasure to read your project. To achieve this you will need to spend a lot of time writing, and re-writing: "What is written without effort is, in general, read without pleasure" (Samuel Johnson).

- **Maybe most important:** Try to create your own examples, and give your own approach to the material. Do not just regurgitate the papers you have read. Some arguments and proofs will benefit from having many details added; for others you might prefer to summarise the key ideas, omitting technical details. Do not leave the reader feeling that he or she might just as well have struggled through the original sources.
- Think of your reader as an interested and intelligent friend who knows a reasonable amount of general mathematics, but nothing about your particular subject.
- Your project should read like a well-written piece of English. So write in complete sentences, not in the style of abbreviated lecture notes. A formal style is appropriate. Contractions such as 'don't, can't' and other forms common in speech will grate on the reader.
- Think about the logical structure. Either write the introduction last, or be prepared to rewrite it as you proceed.
- Try to provide a convincing narrative. This can be informed by the problems you are considering, or by the logical structure of a proof, or by the history of the subject. There should be coherent reason, explained in the introduction, for the scope of your project.
- For each sentence you write, make sure that you understand it, that it is true, and that it makes sense. Reading aloud is a good way to expose poorly worded sentences.

Further sources of advice. There is much good advice available on writing, often available free online. In no particular order I recommend:

- `web.mit.edu/jrickert/www/mathadvice.html`.
- Notes from a course run by Donald Knuth: `tex.loria.fr/typographie/mathwriting.pdf`.

- Steven G. Krantz, *A Primer of Mathematical Writing*, American Mathematical Society (1997).
- T. W. Körner, *How to Write a Part III Essay*, `www.dpmms.cam.ac.uk/~twk/Essay.pdf`.
- George Orwell, *Politics and the English Language*, `www.mtholyoke.edu/acad/intrel/orwell46.htm`.
- Some grammatical errors (and non-errors) from the Guardian: `tinyurl.com/hlzakdq`.
- Gardiner and Kearns: 'Turbo-charge your writing today': `www.nature.com/naturejobs/science/articles/10.1038/nj7354-129a`

For many other links and thoughts see: `mathoverflow.net/questions/1243/how-to-write-math-well`.

It will take longer than you expect[1]. Even if you have a very good idea what you are going to say, **do not expect to average more than one page of typeset text per day**. If you have never written a project before, this may seem absurdly low; note however that at this rate, you will still have your project written in one month. If you have done something similar before, then you will be able to make a better estimate.

Specific writing advice. See also Knuth's notes and the other links above.

Definitions. Clear and consistent definitions help to unify your project. Some technical terms are part of the common language of mathematics and do not need definitions (for example, 'prime number', 'field', ...). Others, are standard but still need a few words of clarification. For instance, if you use graphs, are they permitted to have loops? If in doubt consult your supervisor.

Signposts. The outward structure of your project should be clear to the reader. You are writing a mathematics paper, not a detective story! Outline what you are going to do in your introduction. Make forward and backward references to connect related ideas.

Notation. Think carefully about the mathematical notation you use. You may need to change it from your sources in order to be consistent throughout your project. Mathematical notation is very dense and needs words to pad it out. Do not start sentences with symbols. So rather than 'C has length 8 because ...' write

'The code C has length 8 because ...'.

[1]This is Hofstadter's Law [2, page 152]. A stronger version of Hofstadter's Law states that Hofstadter's Law still holds if one applies it.

Do not use punctuation to separate two mathematical clauses. For example

'Hence $v_i = 0$, $i \in \{1, \ldots, 8\}$ ...'

should be replaced with

'Hence $v_i = 0$ for $i \in \{1, \ldots, 8\}$ ...'.

Write out numbers when they are used as adjectives in sentences. This helps to avoid some potential ambiguities. For example, 'there are two symbols equal to 1 in the codeword 00112'. Do not use $=$, $\leq$, $\geq$ or similar symbols as the verb in a long sentence. For example,

'Hence $|C| \leq 4$.'

is fine. But

'Therefore the number of codewords $= 5$'

is terrible compared to

'Therefore the number of codewords is 5.'

We versus I. Say 'We' if you are doing something with the reader, for example 'We now prove that the minimum distance is ...'. Use 'I' more rarely, and only if you are expressing your personal opinion.

Suspension. A small amount of 'suspension', as in 'we now prove that $d_n/n! \to 1/\mathrm{e}$ as $n \to \infty$, where d_n is the number of derangements of $\{1, 2, \ldots, n\}$' can help the text flow, but used unnecessarily it can be annoying. If there is a lengthy 'where ...' clause following a statement, it would probably be better rephrased.

Displayed equations. Use displayed equations (centred in the text) for long equations, or any equation that needs to be emphasised. Each displayed equation should be presented as part of a sentence.

Punctuation. The semicolon is very tempting, but becomes ridiculous if overused. A displayed equation at the end of a sentence should end with a full-stop; a comma may be appropriate if a displayed equation is in the middle of a sentence.

Proper nouns. Write 'Chapter 2', 'Theorem 3' as these are proper names. It is still correct to write 'in the next chapter', 'the following theorem'.

Proof reading. Get a friend to proof read your project for its style and to catch typographic errors.

Avoid accidentally committing plagiarism. Do not paraphrase someone else's account without acknowledging that you are following them closely. For some technical definitions, mathematical algorithms or cryptographic protocols, which have to be specified very precisely, it may be best to quote verbatim, making it clear you are doing this. If you use someone else's examples or ideas, you must say so, and indicate this by a precise reference. Conversely, make it clear when you have created your own examples, or are adding details to someone else's account.

> **Even if you cite the original paper, if you present as your own words a block of text that follows another author's paragraph and sentence structure, making only minor word changes or re-orderings, then you are committing plagiarism.**

If you leave things to the last minute, then it is probably inevitable you will write something very similar to the original source. So instead leave plenty of time: read the material one day, think about it some more on the next day, write your own account of it later. Doing this will make your own work seem more interesting to you, and it will lead to a much better project.

Citation. Accurate citation is vital (and worth 10 marks): refer to specific pages or theorems in a paper, for example [4, Theorem 3.3], or [7, page 2]. (Imagine you are the reader: you do not want to read an entire textbook to find the one result the author requires.) It is often appropriate to mention the author's name in the text, for example 'as Erdős proved in [1]', but titles and other information are best left to the bibliography. Definitions also need citations, unless they are basic and can be expected to be known to all readers. Make sure the style of your bibliography is consistent. Unless the journal specifies otherwise, I use

> [1] P. Erdős, *On an elementary proof of some asymptotic formulas in the theory of partitions*, Ann. of Math., **43** (1942) 437–450.

Here **43** is the volume number. If use LaTeX then you can use the bibliography environment to help you organize references and citations. (See example at end.)

3. Typesetting

Almost every mathematician uses LaTeX to typeset their papers and lecture notes. I strongly advise you to do the same. If you use Microsoft Word, or a similar word-processing package, then things may seem easy at the start, but you risk ending up with a structureless and unattractive document that gets increasingly hard to edit as it grows in size. By the end you will wish you had used LaTeX.

Getting started with LaTeX. See `www.ma.rhul.ac.uk/latex-help`. Dr Kay has made a very helpful tutorial: `www.ma.rhul.ac.uk/akay/teaching/latex/`.

Installation.

- On Mac OS X, I recommend TeXShop: `pages.uoregon.edu/koch/texshop/obtaining.html`.
- Almost any Linux distribution will have it installed already.
- On Windows try `miktex.org/2.9/setup`.

First steps.

- Read *The (Not So) Short Introduction to LaTeX*. `www.ctan.org/tex-archive/info/lshort/english/lshort.pdf`.
- Rather than start from scratch, you should modify someone else's file. The LaTeX source for this document is available from `www.ma.rhul.ac.uk/~uvah099/Maths/ProjectAdvice.tex`. If you look at the end you'll find some small examples of how to typeset equations. The LaTeX source for some old MT5461 notes is available from `www.ma.rhul.ac.uk/~uvah099/Codes/MScNotes.tex`.

Diagrams. Diagrams and other figures can be very useful to the reader. Drawing your own figures to illustrate your arguments or examples is time-consuming, but it is a good way to show your originality. Any drawing program that can produce scalable graphics in pdf or postscript format is suitable. There are LaTeX packages, for example, xypic, that make it easier to draw many sorts of diagrams commonly used in mathematics.

Acknowledgements

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References

[1] P. Erdős, *On an elementary proof of some asymptotic formulas in the theory of partitions*, Ann. of Math., **43** (1942) 437–450.

[2] D. Hofstadter, *Gödel, Escher, Bach: An eternal golden braid*, Basic Books 1999, new edition.