Writing MSc projects

- General advice
- Discussion of some short pieces of mathematical writing, and possibly also Hamming's paper
- Typesetting
- Questions?

You can get all of this online at

`http://www.ma.rhul.ac.uk/~uvah099/teaching`

I don't want to spend much time reading my slides.

General advice

- Writing mathematics is hard but rewarding.
- There is a lot of good advice available (often free, online): see links in handout.
- **Summary**. Spend time thinking about the original sources. Read critically and tell a story. Show empathy with the reader.

General advice

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Marks Scheme

Knowledge of subject (25)

21–25: Deep understanding and near-comprehensive knowledge
18–20: Deep understanding
15–17: Very good understanding
12–14: Sound knowledge of relevant information
10–11: Basic understanding of the main issues
0–9: Little or no understanding of the main issues

Organisation of material (25)

21–25: Of publishable quality
18–20: Arguments clearly constructed; material very well-organised
15–17: Well-organised; aims met with no significant errors or omissions
12–14: Coherent and competent organisation
10–11: Lack of clarity in written presentation or aims only partially met
6–9: Major flaws in arguments; aims of project not met
0–5: Arguments are missing/deficient. Disorganised or fragmentary

Originality, interpretation and analysis (20)

17–20: Significant originality in the interpretation and/or analysis; project aims challenging
14–16: Some originality; evidence of excellent analytical and problem-solving skills
12–13: Good attempt to interpret and analyse existing literature
10–11: Minor flaws in interpretation/analysis of exisiting literature
5–9: Poor interpretation/analysis or project aims too simple
0–4: Little or no interpretation or analysis; project aims trivial

Originality

- Create your own examples
- Give your own versions of existing proofs
- Give extra background
- Critically compare results, proofs, or cryptoschemes from different papers
- For theorems: what happens if the hypotheses are weakened? Are stronger results known with stronger hypotheses?
- In cryptography: often authors are more positive about their own efforts than those of their competitors. Critically compare the various claims and counterclaims.
- Write a computer program (in a language of your choice) to test an open conjecture, or to attack a cryptoscheme.
- You are not expected to solve an open problem.

Mathematical writing doesn't have to be full of equations

Here is a complete paper by Edward Nelson *Mathematical Pearls: A Proof of Liouville's Theorem*, Proceedings of the American Mathematical Society **12** (1961) 995.

A PROOF OF LIOUVILLE'S THEOREM

EDWARD NELSON

Consider a bounded harmonic function on Euclidean space. Since it is harmonic, its value at any point is its average over any sphere, and hence over any ball, with the point as center. Given two points, choose two balls with the given points as centers and of equal radius. If the radius is large enough, the two balls will coincide except for an arbitrarily small proportion of their volume. Since the function is bounded, the averages of it over the two balls are arbitrarily close, and so the function assumes the same value at any two points. Thus a bounded harmonic function on Euclidean space is a constant.

PRINCETON UNIVERSITY

Received by the editors June 26, 1961.

Spot the errors and deficiencies in a fortunately non-existent project (there are MANY)

Prime numbers and cryptography

Prime numbers are essential to crytography, Euclid's famous theorem has held generations of mathematicians spellbound in it's inescapable beauty.

Theorem. (Euclid, 400) There are infinitely many prime numbers, where a prime is a number only divisible by itself and 1. (Throughout this project, number means element of $\mathbb{N}$.)

Proof Let $2, 3, 5$, .., p be the aggregate of primes up to p, and let $q = 2.3.5...p + 1$. Then q is not divisible by any of the numbers 2, 3, 5, ... p. It is therefore either prime, or divisible by a prime between p and q. In either case there is a prime greater than p, which proves the theorem.

Avoid accidentally committing plagiarism

If you quote text verbatim, this must be made clear. Verbatim quoting may be appropriate for certain definitions or cryptoschemes that have to be specified very precisely.

Do not paraphrase someone else's account with acknowledging that you are following them closely.

> **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.**

Accurate citation is vital (and worth 10 marks): refer to specific pages or theorems in a paper, e.g. [4, Theorem 3.3], or [Hamming, page 2].

Some cautionary tales

Since 2011, seven German politicians resigned in disgrace after their theses were found to be substantially plagiarised, including:

- Karl-Theodor zu Guttenberg (2011), *Verfassung und Verfassungsvertrag*
- Annette Schavan (2013) *Person und Gewissen. Studien zu Voraussetzungen, Notwendigkeit und Erfordernissen heutiger Gewissensbildung*

both with titles that now seem sadly ironic.

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Moral of the story: don't plagiarise.

Discussion of Hamming's paper

Error Detecting and Error Correcting Codes

By R. W. HAMMING

1. Introduction

THE author was led to the study given in this paper from a consideration of large scale computing machines in which a large number of operations must be performed without a single error in the end result. This problem of "doing things right" on a large scale is not essentially new; in a telephone central office, for example, a very large number of operations are performed while the errors leading to wrong numbers are kept well under control, though they have not been completely eliminated. This has been achieved, in part, through the use of self-checking circuits. The occasional failure that escapes routine checking is still detected by the customer and will, if it persists, result in customer complaint, while if it is transient it will produce only occasional wrong numbers. At the same time the rest of the central office functions satisfactorily. In a digital computer, on the other hand, a single failure usually means the complete failure, in the sense that if it is detected no more computing can be done until the failure is located and corrected, while if it escapes detection then it invalidates all subsequent operations of the machine. Put in other words, in a telephone central office there are a number of parallel paths which are more or less independent of each other; in a digital machine there is usually a single long path which passes through the same piece of equipment many, many times before the answer is obtained.

Some strengths and weaknesses identified by a previous year's M.Sc. students

Strengths

- Well motivated, lots of interesting real-world examples, and made-up small codes
- Clear logical structure, that revisits most topics twice: once from an intuitive point of view then from the geometric point of view.
- Diagrams and tables break up text. Readable by an intelligent non-expert. Empathy for the reader.

Weaknesses

- Some proofs could be shortened
- Typographic error in statement of triangle inequality,
- Long sentences.
- No abstract or conclusion.

More specific advice

- Notation: try to be consistent across your project. Mathematical notation is very dense: a single slip can change your intended meaning.
- Say 'We' if you are doing something with the reader, e.g. 'We now prove that the minimum distance . . . '. Use 'I' rarely, and only if you are expressing your personal opinion.
- A small amount of 'suspension', as in 'we shall show that $|C| = 2d/(2d - n)$ where d is the minimum distance of C' helps the text flow, but too much can be annoying.
- Write 'Chapter 2', 'Theorem 3' as they are proper names. It is still correct to write 'in the next chapter', 'the following theorem'.
- 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.

Typesetting

These days almost every mathematician uses LaTeX to typeset their papers and lecture notes.

- Read *The (Not So) Short Introduction to LaTeX*.
- Rather than start from scratch, you should modify someone else's file. There is a template available online (see handout for links).
- Example: document class declaration: change from `amsart` to `article`.

Any Questions?