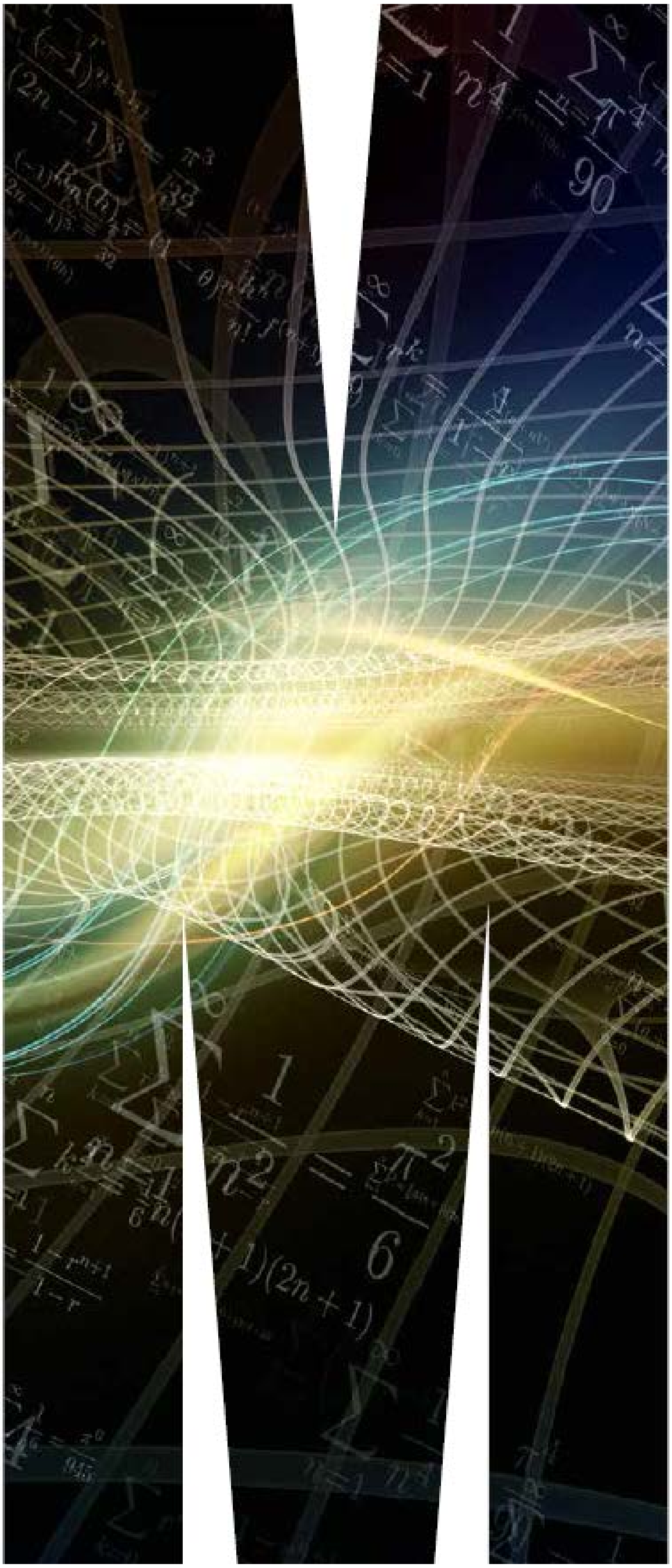
MONASH University

School of Mathematical Sciences

Honours handbook

2019



MONASH
SCIENCE

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Introduction

This booklet is intended to provide an overview of the honours lecture topics and the structure of the 2017 honours program at the School of Mathematical Sciences.

Applying for Honours

Entry Requirements and Enrolment

The normal minimum requirement for honours (fourth year) in mathematics is:

i. an average of at least 70 in 24 points of relevant third year units, or equivalent*
ii. a willing supervisor for your honours project before the end of the first week of December of the year before commencing your honours degree.

How to apply

1. Read the list of potential honours projects and supervisors: School of Mathematical Sciences Honours Projects (PDF, 0.15 MB). This will generally be posted on the School's website in mid-August each year, for projects starting the following year.

2. During late August-mid-November, contact potential supervisors and arrange to discuss the projects that they are offering. Ensure that you come prepared (i.e. an idea of your research interests and what you want from honours, a print out of your academic transcript from WES) to the meeting. Develop a project title and outline with your project supervisor. Do not hesitate to contact a potential supervisor even if he/she has nothing offered officially. Oftentimes, academics have many projects available.

3. Make an appointment with the Honours coordinator. Bring your academic transcript and your project form to your appointment.

4. Complete the Faculty of Science Online Honours Application.

Honours structure

Honours students are enrolled in two 24-point units MTH4100 – Mathematics Research Studies and MTH4200 – Advanced studies in Mathematics

MTH4100 – Mathematics research studies (24 points)

M40110 - Writing and Presenting for Honours (3 points)
Research project (15 points)
One fourth year honours lecture unit (6 points)

MTH4200 – Advanced studies in mathematics (24 points)

A combination of lecture units that make up to 24 points. This can include a number of 4-point units* with permission from Honours coordinator and project supervisor.

Note:

1. It is the student's responsibility to ensure that sufficient units are taken to meet the points requirement.
2. Students must have permission from the honours coordinator before enrolling in 4-point units*.
3. If students take more than 24 points, the best weighted 24 points will be used as the final mark

*see page 4 for information about 4-point units

Honours research project

The form of the research project is decided by the supervisor depending on whether the project requires any extra reading or new skills. The focus of each research project will vary. Some research projects will have a higher computational focus, while other projects may be more reading and/or proof based.

The research project should have a research objective that has not already been developed in the literature. This does not mean that the research project needs to result in publishable material. It can consist of a minor variation of a known result that has not been published before. For example, a generalization/extension of a result that an expert could establish on their own, but instead leaves as an exercise for the readers of a paper to complete. The research project can also be in terms of new insights into a possibly well-established area, rather than a genuinely novel result.

Assessment for Research projects

1. Intermediate report (25% of project mark). Due 4pm last Friday first semester.
   Comprising of a literature survey, and discussion of any new mathematical techniques that you needed to complete the project.
   Recommended length: 10-20 pages.
   Assessed by supervisor(s).

2. Final report: (60%) Due 4pm last Friday of second semester.
   Recommended length: 25-40 pages.

   Assessed by two staff members of the School (other than the supervisor).
   The final mark will be based on the degree to which the student is able to reach the objective by the end of the project, or is able to detail scientific reasons for why the planned objective was not achieved

3. Oral presentation: (15%). During swotvac, second semester. Assessed by all staff who attend the Honours presentations.

Notes about the research project

The time you spend on the intermediate report and the project should be similar to the time spent on the equivalent (credit points-wise) number of lecture topics. You should start your intermediate report and project at the beginning of your first semester. You should meet with your supervisor regularly as soon as the teaching semester begins, eg: weekly.

Late submissions for Assignments and Reports will be penalised with 10% per day or part thereof late, including weekends. Work submitted more than 1 week late without special consideration will not be marked except in exceptional circumstances. This is in accordance with the Faculty of Science policy: http://intranet.monash.edu.au/science/staff/education/policies-procedures/late-submission.html. Students who cannot submit work by the due date because of illness or other special circumstances are covered by the special consideration policy.

Keep copies of all your submissions for your own records.

Honours lecture topics

You can select lecture units from any group, as long as the requirements of your enrolled honours units are met. You can add units until the end of week 2. You can discontinue units until the end of week 8.

Semester 1

Compulsory for all honours students
Writing and Presenting for Honours (3 points)

Pure mathematics topics
Measure theory (6 points)
Computational group theory (6 points)
Advanced graph theory (6 points)

Stochastic lecture topics
Computational statistical inference (6 points)
Stochastic calculus and mathematical finance (6 points)
The theory of martingales in discrete time (6 points)

Applied mathematics topics
Methods of applied mathematics (6 points)
Methods of computational mathematics (6 points)

Semester 2

Pure mathematics topics
Differential geometry (6 points)
Algebraic topology (6 points)
Partial differential equations (6 points)

Stochastic lecture topics
Markov chains and random walks (6 points)
Markov Chains and Mixing Times (6 points)

Applied mathematics topics
Optimisation for data analytics (6 points)
Fluid dynamics and turbulence (6 points)
Mathematical biology (6 points)

Other topics – **only with approval of Honours coordinator**

- AMSI Summer School units can count as credit towards your honours degree. Either one 4-week course or a two 2-week courses (6 points).
- External honours units via AMSI Advanced Collaborative Environment (ACE) http://highered.amsi.org.au/ace-hons-courses/ (4 points).
- Some third-year ASP3xxx, ATM3xxx or MTH3xxx mathematics lecture units (4 points each). An additional 2 points worth of extra assessment must be arranged.
- Some relevant fifth-year or master's level lecture units at Monash University (6 points).

For permission to enrol in any of these, contact the Honours Coordinator at least three weeks before the start of the unit.

Notes about 5th year units

1. Where the 5th year unit is a shared course with an honours unit, Honours students will only be enrolled in the honours version of the unit.

2. Honours may also enrol in one relevant non-shared 5th year unit for credit but must have the permission of both their supervisor and the Honours Coordinator.

Honours scholarships

All students enrolled in honours in the School of Mathematical Sciences are eligible for the following grants scholarships:

Alan Pryde Honours Study Grant
The school reduces tuition fee (in HECS debt) by $5000

Maria Athanassenas - Honours Scholarship
$3000 for a full-time study load (48 credit points).

Gordon Preston Pure Mathematics - Honours Scholarship
$5000 for a full-time study load (48 credit points).

Peter Finch Mathematical Statistics - Honours Scholarship
$5000 for a full-time study load (48 credit points).

Rene Van der Borght Applied Mathematics - Honours Scholarship
$5000 for a full-time study load (48 credit points) paid for a maximum of one year only.

For more information see http://www.monash.edu/science/schools/mathematical-sciences/honours/honours-scholarships

Honours prizes

All students enrolled in honours in the School of Mathematical Sciences are eligible for the following prizes:

Leo Gleeson prize
Prize for the best honours student completing the Applied Mathematics honours program.

Carl Moppert prize in Mathematics
Prize for the best all-round Mathematics honours student.

Pure Mathematics prize
Prize for the outstanding honours student in Pure Mathematics.

Statistics prize
Prize for the best honours student in statistics.

Contacts

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Deputy Honours Coordinator Dr Andy Hammerlindl
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Pure Mathematics Advisor (Honours) A/Prof. Burkard Polster
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Applied Mathematics Advisor (Honours) Dr Janosch Rieger
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Statistics Advisor (Honours) A/Prof Jonathan Keith
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Appendix A- Honours lecture topics

Writing and Presenting for Honours

Lecturer(s): Simon Clarke and Leo Brewin
Contact details: Simon.Clarke@monash.edu and Leo.Brewin@monash.edu

M40110 is a compulsory topic for ALL honours students in Mathematical Sciences. There will be an introductory lecture, but most of the work will be a study guide that needs to be read through, along with practical reports and presentations

Objectives: Proposed topic is to give honours students guidance and feedback on presenting and writing mathematics, prior to their Intermediate report and presentation at the end of the first semester of study. Also to teach students LATEX, BibTEX and Beamer, however guidance on writing and presentation style will be hopefully be technology independent.

Syllabus:
Technical Aspects:

1. LATEX and BIBTEX software.
2. Structure of BibTeX, LaTeX and Beamer documents.
3. Managing and citing references using BibTeX.
4. Writing mathematics in LaTeX.

Writing:

1. Structure of documents, e.g. reports, papers, theses, presentations.
2. What to include and referencing.
3. Writing Introductions, Conclusions and Abstracts.
4. Equations: formatting, e.g. spacing, inline vs display equations, multiple line equations and subequations, when to include equation numbers and referencing.
5. Tables and figures: guidelines, e.g. should always be discussed in text and captions.
6. Table of Contents.
7. Appendices.

Presenting Mathematics:

1. Audience awareness.
2. Timing.
3. Content: how much and what to include.
4. Know your audience.
5. Handling questions.

Mode of Delivery:
Self-paced Study Guide with good and bad initial presentations and examples.

Assessment:
Practical presentations, e.g. 10MT (4 slides of less) with feedback.
10 page report on classical paper with feedback.
Pass/Fail (will be assessed in mid-semester and final reports and presentations).

References:
Fowler's Modern English Usage.
Higham, N.J., Handbook of Writing for the Mathematical Sciences, SIAM, 1998.
Krantz, S.G., A Primer of Mathematical Writing, AMS, 1997.
LATEX tutorial material, http://www.ctan.org/topic/tut-latex

Markov Chains and Mixing Times

Lecturer(s): Tim Garoni and Yan Dolinsky
Contact details: Tim.Garoni@monash.edu and Yan.Dolinsky@monash.edu

Aims: Markov chains with large finite state spaces play a fundamental role in a diverse range of disciplines, including combinatorics, computer science, mathematical physics (statistical mechanics), and of course probability. This course aims to present an introduction to the significant developments that have occurred in this cross-disciplinary field over the past three decades.

The classical theory of Markov chains studied fixed chains, and the goal was to estimate the rate of convergence to stationarity as time tends to infinity. In modern applications, however, a different asymptotic analysis is required. The "mixing time" of a Markov chain is introduced to quantify how many steps are required to reach approximate stationarity. One then considers families of Markov chains, and the goal is to understand how the mixing time grows as the size of the state space increases.

This course will emphasise the cross-disciplinary nature of the field. From the probabilistic side, we will introduce important concepts such as couplings and stationary times, and use them to study random walks on groups and graphs. This will include a discussion of card shuffling, and the famous "seven shuffles suffice" theorem. From the mathematical physics side, we will discuss how to construct and analyse Markov chain Monte Carlo methods for studying Gibbs distributions. From the combinatorial/computer science side, we will discuss how to use Markov chains to construct efficient algorithms to solve #P-hard counting problems.

Syllabus: Foundations of finite Markov chains. Properties of total variation distance, distance from stationarity, mixing time. Couplings, and the coupling method for upper-bounding mixing times. Strong stationary times, random walks on groups, and card shuffling. Spectral methods, the relaxation time, and combinatorial bounds. The cut-off phenomenon, and exact sampling via coupling from the past. Lower bounds via the bottleneck ratio and distinguishing statistics. Metropolization and approximate sampling from Gibbs distributions. Approximate counting, random sampling of combinatorial structures, and fully-polynomial randomized approximation schemes.

Prerequisites: Familiarity with probability and/or combinatorics would be useful, but will not be assumed.

References:
Markov Chains and Mixing Times, by D. Levin, Y. Peres and E. Wilmer (AMS, 2009)
Reversible Markov Chains and Random Walks on Graphs, by D. Aldous and J. Fill, (http://www.stat.berkeley.edu/~aldous/RWG/book.html)
Finite Markov Chains and Algorithmic Applications, by Olle Haggstrom (Cambridge University Press, 2002).

Appendix B - Marking guidelines for Honours projects

H1 (80 - 100)
An ‘upper H1’ (90 - 100) student has strengths in all of the following areas:
• outstanding command of expression and logical argument in a skilfully structured manuscript;
• superior evaluation and integration of existing literature;
• evidence of significant insight and original thought in dealing with the critical issues;
• sophisticated understanding of research methods;
• thoughtful and appropriate choice of data analysis (where appropriate) and outstanding presentation and reporting of results;
• clear and coherent interpretation of the thesis results, and/or the results of other studies;
• comprehensive understanding of the importance of the results in the context of research topic.
A ‘lower H1’ (80 -90) student displays many of the above strengths but is less well-balanced in overall quality.

H2A (70 - 79)
The project is characterised by most of the following:
• the manuscript is well written, logically argued and generally well structured;
• the evaluation and integration of the existing literature is very sound without being outstanding;
• reasonable insight and some evidence of original thought in dealing with the critical issues
• evidence of a solid understanding of research methods;
• choice of data analysis (where appropriate) that is appropriate (although less well justified than might be expected of H1 standard), and clear presentation of results;
• generally sound but pedestrian interpretation of results and their importance to the research topic.

H2B (60 - 69)
The project is characterised by most of the following:
• generally competently written, although some problems exist in the logical organisation of the text and the way it is expressed;
• provides an adequate coverage of the literature, although it tends to be more descriptive than evaluative, and arguments are often disjointed;
• occasional evidence of insight into the issues underlying the thesis or essay, but little evidence of original thinking;
• basic but somewhat limited understanding of the research methods;
• serviceable choice of data analysis (where appropriate), although other approaches may have been more appropriate;
• the presentation of results lacks clarity and the interpretation of results or other studies is adequate but limited.

H3 (50 - 59)
The project is characterized by most of the following:
• the work is not well written and shows flaws in the structuring of logical arguments;
• coverage of the necessary literature is weak, with insufficient information provided to support the arguments made, or conclusions drawn, within the thesis or essay;
• little evidence of insight and ideas tend to be highly derivative;
• knowledge of research methods is deficient;
• data analysis techniques (where appropriate) are arbitrary or inappropriate;
• the results are poorly presented;
• interpretations are superficial, demonstrating a weak understanding of the results and their relevance to the research topic.

Fail (0 - 50)
The project is characterized by most of the following:
• the work is very poorly written and shows a serious inability to structure and present a logical argument;
• coverage of the necessary literature is inadequate, with little information provided relevant to the claims made, or conclusions drawn, within the thesis;
• serious misunderstanding of key concepts and issues;
• knowledge of research methods is lacking;
• data analysis techniques (where appropriate) are inappropriate and the results are presented inadequately;
• an inability to show how the results of the research project relate to the research topic; serious misinterpretations of results.