The University of Melbourne
School of Mathematics and Statistics

Master of Science and Graduate Diploma (Advanced) in Mathematics and Statistics Guide*

Version 2022.9†

*This guide has been prepared to assist you in deciding whether to apply for the Master of Science or the Advanced Graduate Diploma program in Mathematics and Statistics. It will also assist with choosing your coursework.
You are advised that the rules governing these programs are definitively stated in the official University Handbook. In the event of a disagreement between this Guide and the Handbook, it is the Handbook that is to prevail. The information in this Guide is given in good faith and is correct (to the best of our knowledge) at the time of writing (September 2021). It has been carefully checked, but the School of Mathematics and Statistics accepts no responsibility for the accuracy of the information.

†Prepared by J. Hall and J. Osborne. The Guide contains material prepared for its past editions by, or with the participation of, K. Borovkov, D. Crowley, J. Flegg, O. Foda, C. Haesemeyer, P. Norbury, D. Ridout and S. Zhou.

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1 Overview

For up-to-date information on the University's COVID-19 response and its impact on teaching and learning see the COVID-19 webpage

https://students.unimelb.edu.au/student-support/coronavirus

In 2022, the following advanced-level programs will be offered by the School of Mathematics and Statistics:

- **MC-SCIMAT** Master of Science: Mathematics and Statistics.
  Coordinator: Dr James Osborne.
- **GDA-SCI** Graduate Diploma in Science (Advanced): Mathematics and Statistics.
  Coordinator: Dr James Osborne.
- **MC-DATASC** Master of Data Science.
  Coordinator: A/Prof Karim Seghouane. *This course is not covered in this guide.*

The Master of Science (MSc) program (two years full time) and Graduate Diploma in Science (Advanced) (GDA) program (one year full time) in Mathematics and Statistics are flexible programs that allow students to study subjects in five broad specialisations:

- Applied Mathematics and Mathematical Biology (AMMB),
- Mathematical Physics and Physical Combinatorics (MPPC),
- Operations Research and Industrial Optimisation (ORIO),
- Pure Mathematics (PURE),
- Statistics and Stochastic Processes (SASP).

The Master of Science program serves as a necessary preparation for research in Mathematics and Statistics, including PhD studies; it has both a coursework and a thesis component. The GDA is a one-year, coursework-only program.

The breakdown, by credit points, for these programs is as follows:

- MSc: 200 credit points = 150 points coursework + a 50-point research project,
- GDA: 100 credit points = 100 points coursework.

Recall that a standard full-time student load is 100 credit points per year, equivalent to eight standard one-semester subjects. Be aware that the **maximum course duration** for the full-time MSc (GDA) program is six (four) years.[1]

You will have nominated your specialisation when applying to the program. As usual, each MSc coursework subject you choose will typically have prerequisites (usually undergraduate-level) that must be completed before commencing the MSc subject. There is a space in the MSc program to include a couple of undergraduate prerequisite subjects, in case you have missed some.

Each MSc student will have an academic supervisor from their chosen specialisation, who will give regular one-on-one advice on the student's research project and can assist in developing an individual course plan for that student. The School has in addition several MSc specialist advisors whose names will be communicated to newly enrolled students at induction. These advisors are also able to assist GDA students (and also beginning MSc students, if they have not yet found a supervisor) with course planning.

Students will have to take a prescribed number of master's-level discipline subjects offered by the School of Mathematics and Statistics. In addition, MSc students are required to complete a research project and a professional skills subject. For the master's-level discipline subjects available to MSc and GDA students in 2022 and 2023, please see the tables in Section 14 showing the subjects' semester allocation.

[1] According to Clause 4.187 of MPF1327.

A few of these subjects may be replaced by master's-level subjects offered by other schools or even undergraduate subjects (subject to the approval of the supervisor and the program coordinator). For precise formulations, see the program descriptions in the next section and refer to the University Handbook entries for the programs.

Finally, MSc students in Mathematics and Statistics are **NOT** usually allowed to go on exchange unless they are prepared to extend the duration of their course.

2 Course Structure

2.1 MSc

The Master of Science in Mathematics and Statistics is one of the research-training streams of the Master of Science. These streams give students the opportunity to undertake a substantial research project in a field of their choice as well as a broad range of coursework subjects including a professional tools component. The aim is to provide students with a pathway to PhD study or to the workforce.

Students must complete a total of **200** credit points over the two-year full-time (or equivalent part-time) program, comprising:

- Discipline Subjects: 137.5 points,
- Professional Tools Subject: 12.5 points,
- Research Project: 50 points.

It is **very important to carefully plan** one's coursework from the very beginning, ensuring that all prerequisites will be satisfied for all the subjects and that all the coursework program requirements listed in the Handbook (see the table below) will be satisfied at the conclusion of the program. Seek advice from your supervisor. If you do not have one yet, ask an MSc specialist advisors (the Academic Support Officer provides all enrolled students with a list of advisors at the start of the program).

Upon enrolment, students will be assigned to the specialisation they applied for: one of the five specialisations listed on p.3. Students may change their specialisation, subject to the approval of the School's MSc program coordinator. The 137.5 points of discipline subjects must be chosen as in the following table. The list of compulsory and elective master's-level subjects for each specialisation is presented after the table.

Number of Subjects	Total Points	Chosen from...
Two	25	Compulsory master's-level subjects from the student's selected specialisation
Three	37.5	Elective master's-level subjects from the student's selected specialisation
Two	25	Any master's-level subjects from a single specialisation that is **not** the student's selected specialisation
Four	50	Any master's-level discipline subjects (see below). These four subjects may include up to two further discipline subjects offered by other schools.[2] Moreover, up to two of these subjects may be replaced by approved undergraduate subjects.[3]

Master's-Level Discipline Subjects. The discipline subjects in each specialisation of the MSc are listed below. Some of these are offered every year, but some are only offered **in alternate years**. Subjects offered only in odd years are labelled with an (o). Similarly, (e) labels subjects that are only offered in even years. For semester allocation of the subjects, see the table on p.18–19.

[2]This may also include at most one **approved** AMSI Summer School subject; fees and enrolment rules apply to that subject (see Section 6 and https://ss.amsi.org.au/ for more detail).

[3]If it is necessary for the student to acquire the required knowledge for master's-level Mathematics and Statistics discipline subjects, up to two further master's-level subjects can be replaced with approved undergraduate subjects.

Applied Mathematics and Mathematical Biology (AMMB)

Compulsory Subjects
- MAST90064 Advanced Methods: Differential Equations (o)
- MAST90067 Advanced Methods: Transforms (e)

Elective subjects
- MAST90011 Mathematical Biology (e)
- MAST90026 Computational Differential Equations (e)
- MAST90060 Mathematical Statistical Mechanics (o)
- MAST90103 Random Matrix Theory (e)
- MAST90113 Continuum Mechanics (o)
- MAST90125 Bayesian Statistical Learning
- MAST90127 Advanced Biological Modelling (e)
- MAST90129 Infectious Disease Dynamics (o)

Mathematical Physics and Physical Combinatorics (MPPC)

Compulsory Subjects (students to complete **at least two**)
- MAST90030 Advanced Discrete Mathematics (o)
- MAST90060 Mathematical Statistical Mechanics (o)
- MAST90067 Advanced Methods: Transforms (e)

Elective subjects
- MAST90031 Enumerative Combinatorics (e)
- MAST90064 Advanced Methods: Differential Equations (o)
- MAST90065 Exactly Solvable Models (o)
- MAST90069 Introduction to String Theory (e)
- MAST90103 Random Matrix Theory (e)
- MAST90132 Lie Algebras (o)

Operations Research and Industrial Optimisation (ORIO)

Compulsory Subjects
- MAST90014 Optimisation for Industry
- MAST90098 Approximation, Algorithms and Heuristics

Elective subjects
- MAST90013 Network Optimisation (e)
- MAST90050 Scheduling and Optimisation (o)
- MAST90137 Mathematical Game Theory (o)
- MAST90142 Advanced Nonlinear Optimisation (e)

Pure Mathematics (PURE)

Compulsory Subjects
- MAST90012 Measure Theory (o)
- MAST90023 Algebraic Topology (e)

Elective subjects
- MAST90017 Representation Theory (o)
- MAST90020 Functional Analysis (e)
- MAST90029 Differential Topology (o)
- MAST90056 Riemann Surfaces and Complex Analysis (o)
- MAST90068 Groups, Categories and Homological Algebra (e)
- MAST90097 Algebraic Geometry (e)
- MAST90132 Lie Algebras (o)
- MAST90133 Partial Differential Equations (o)
- MAST90136 Algebraic Number Theory (e)
- MAST90143 Differential Geometry (e)

Statistics and Stochastic Processes (SASP)

Compulsory Subjects
MAST90081 Advanced Probability[4]
MAST90082 Mathematical Statistics

Elective subjects
MAST90019 Random Processes[5]
MAST90027 Practice of Statistics & Data Science (e)
MAST90051 Mathematics of Risk (e)
MAST90059 Stochastic Calculus with Applications (o)
MAST90083 Computational Statistics & Data Science
MAST90084 Statistical Modelling
MAST90111 Advanced Statistical Modelling (e)
MAST90112 Advanced Topics in Stochastic Models (e)
MAST90122 Inference for Spatio-Temporal Processes
MAST90125 Bayesian Statistical Learning
MAST90138 Multivariate Statistics for Data Science

Where a subject is listed in two specialisations, students may classify the subject as belonging to either specialisation for the purpose of meeting the requirements of their individual study plans. This currently applies to:

- MAST90060 Mathematical Statistical Mechanics (AMMB & MPPC),
- MAST90064 Advanced Methods: Differential Equations (AMMB & MPPC),
- MAST90103 Random Matrix Theory (AMMB & MPPC),
- MAST90125 Bayesian Statistical Learning (AMMB & SASP),
- MAST90132 Lie Algebras (MPPC & PURE).

There are also discipline subjects that are not listed under any specialisation. This currently applies to:

- MAST90053 Experimental Mathematics,
- MAST90104 A First Course in Statistical Learning,
- MAST90126 Advanced Statistical Genomics.

Note that MAST90104 is 25 points and therefore counts for **two undergraduate subjects**. (It is regarded as being equivalent to MAST30025 Linear Statistical Models and MAST30027 Modern Applied Statistics.)

Further Discipline Subjects. There are certain "further discipline subjects" offered by other schools that are preapproved for MSc Mathematics and Statistics students. At most two further discipline subjects from outside our School may be taken over the duration of the MSc. Currently, the preapproved subjects are:

- BINF90001 Statistics for Bioinformatics,
- BINF90002 Elements of Bioinformatics,
- BMEN90027 Systems and Synthetic Biology,

[4] MAST90081 Advanced Probability became a core subject in the SASP specialisation at the beginning of 2021. Students completing their MSc in 2022, or later, may count MAST90081 as a core subject in the SASP specialisation.

[5] MAST90019 Random Processes ceased being a core subject in the SASP specialisation at the end of 2020. Students who started their MSc in 2020, or earlier, may count MAST90019 as a core subject in the SASP Specialisation in place of MAST90081 Advanced Probability.

- COMP90038 Algorithms and Complexity,
- COMP90043 Cryptography and Security,
- COMP90046 Constraint Programming,
- COMP90048 Declarative Programming,
- COMP90051 Statistical Machine Learning,
- PHYC90007 Quantum Mechanics,
- PHYC90008 Quantum Field Theory,
- PHYC90009 Physical Cosmology,
- PHYC90010 Statistical Mechanics,
- PHYC90011 Particle Physics,
- PHYC90012 General Relativity.

Students wishing to take a subject from another school that is not on this list must get approval from both their supervisor and the MSc program coordinator.

Professional Skills Subjects. MSc students must complete a professional skills subject. There are five approved choices, three of which (indicated below in *italics*) require the student to have already completed one of the introductory programming subjects MAST30028, COMP10001, COMP10002, COMP20005 or INFO10001 (or equivalents):

- COMP90072 The Art of Scientific Computation,
- MAST90045 Systems Modelling and Simulation,
- *SCIE90012 Science Communication*,
- *SCIE90013 Communication for Research Scientists*,
- *SCIE90017 Science and Technology Internship.*

Research Project Component. The Research Project (50 points) is an integral part of the MSc program in Mathematics and Statistics; the main requirement for this component is a thesis. Candidates must pass the Research Project to be awarded the Degree.

For technical reasons, students will have to enrol in one or more "Research Project subjects" MAST90116–118 to ensure that they have completed the required 50 points by the end of their course. Full time students are advised to structure their enrolments as follows:

Semester 1: 50 points of coursework and **no research project**,

Semester 2: 37.5 points of coursework and 12.5 points of research project,

Semester 3: 37.5 points of coursework and 12.5 points of research project,

Semester 4: 25 points of coursework and 25 points of research project.

Non-allowed MAST-coded Subjects. Not all MAST-coded master's-level subjects are generally permitted by the MSc Mathematics and Statistics. This currently applies to:

- MAST90007 Statistics for Research Workers,
- MAST90044 Thinking and Reasoning with Data,
- MAST90057 Elements of Probability,
- MAST90058 Elements of Statistics,
- MAST90072 Data and Decision Making,
- MAST90101 Introduction to Statistical Computing,
- MAST90105 Methods of Mathematical Statistics (equivalent to MAST20004 & MAST20005),
- MAST90139 Statistical Modelling for Data Science.

Other structures that are suitable for part time study, or for students who enrol with credit from earlier degrees, can be negotiated with the student's supervisor and the School's MSc program coordinator.

Under special circumstances, with the permission of the program coordinator, students may be allowed to complete two 25-point Research Projects instead of a single 50-point Project. For more information about the rules for the Research Project component, please refer to Section 8 of the present Guide.

2.2 GDA

The GDA program in Mathematics and Statistics consists of **eight** coursework discipline subjects (**100** credit points). At least **four** of them must be master's-level Mathematics and Statistics discipline subjects, at least three of which normally belong to a single specialisation. The remaining subjects can be higher undergraduate- (normally third-year) or master's-level Mathematics and Statistics subjects.

2.3 Some Common Comments on the Programs

The MSc and GDA in Mathematics and Statistics are graduate coursework programs. The aims of these programs are to train students so that they are prepared for further postgraduate study at the University of Melbourne (or other institutions) and are equipped with a range of skills demanded by today's employers. The programs are well regarded and recognised both within academia and industry.

For many students, the advanced coursework and research project that they undertake after completing their undergraduate courses is the most exciting and valuable time in their studies. Following up on their special interests enables students to develop their research and analytic skills, thereby substantially extending the knowledge gained in earlier years. In some areas, students will have the opportunity to apply the theory being learned to real-world problems.

The MSc program in Mathematics and Statistics provides the means for students to work on a research project under the supervision of a staff member who is an expert in the field. They will also learn how to effectively present their findings in print by using document preparation programs such as LaTeX. Students will also prepare and deliver a professional oral presentation to other students and staff on at least two occasions during their program. Training in both types of communication is provided by the program.

In addition, students will have the opportunity to acquaint themselves with various internet-based tools essential for mathematical and statistical research such as *MathSciNet* (AMS Mathematical Reviews online), to attend seminars that will further extend their specialised knowledge, and to inform themselves about research and job opportunities in Mathematics and Statistics.

MSc and GDA students are part of the Australian mathematical and statistical community. As such, they are encouraged to consider becoming a member of the appropriate professional organisations. Graduate students at Australian Universities receive free membership to the Australian

Mathematical Society (https://austms.org.au/) and significantly discounted membership to the Statistical Society of Australia (https://www.statsoc.org.au/).

3 Entry Requirements

For both the MSc and the GDA, the *necessary* entry requirement comprises an undergraduate degree with a major in Mathematics, Statistics or Mathematical Physics, with at least an H3 (65%) in the major, or equivalent. By "major", the University means *completion of 50 points of study at third-year level*, so that the average will be calculated for the prescribed (by the University Handbook) third-year subjects constituting the respective specialisation in the major.

Quotas may be applied and preference may be given to applicants with evidence of appropriate preparation or potential to undertake research. Entry to the MSc is subject to the capacity of the School to provide adequate supervision in, and resources for, a research project appropriate to the interests and preparation of the individual student. In particular, entry may be subject to the agreement of a member of academic staff to supervise the project component. Selection is not automatic and, in particular, is subject to competition.

4 How to Apply

Applications to the Master of Science and GDA programs are made online at the following urls:

https://study.unimelb.edu.au/find/courses/graduate/master-of-science-mathematics-and-statistics/how-to-apply/

https://study.unimelb.edu.au/find/courses/graduate/graduate-diploma-in-science/how-to-apply/

Please refer to these websites for application deadlines. If you experience any difficulties with the online application process, please contact the University's Stop 1 service.

Letters of acceptance are usually sent by the Faculty of Science in mid-December (mid-June) for commencement in Semester 1 (Semester 2).

5 CSPs and Scholarships

5.1 CSPs

The MSc (Mathematics and Statistics) program will have Commonwealth Supported Places (CSPs) available for domestic students, although students with a relatively low Weighted Average Mark (WAM) may still be offered an Australian full fee place:

> A limited number of Commonwealth Supported Places (CSP) will be available to domestic students. To be considered, you will need to have achieved a Weighted Average Mark (WAM) of at least 70% in the best 50 points of appropriate discipline studies at third year level. A Commonwealth Supported Place is subsidised by the Australian Government. Students pay a contribution amount that is determined by the Australian Government, based on the subjects undertaken. You may be eligible for HECS-HELP to assist with payment of your tuition fees
>
> If you are not eligible for a Commonwealth Supported Place, you will automatically be considered for an Australian Fee (AF) place if you have achieved a WAM of at least 65% in the best 50 points of appropriate discipline studies at third year level. You may be eligible for FEE-HELP to assist with payment of your tuition fees.

For more information, visit

https://study.unimelb.edu.au/find/courses/graduate/master-of-science-mathematics-and-statistics/fees/

The GDA program is also supported by the Commonwealth. For more details, see

https://study.unimelb.edu.au/find/courses/graduate/graduate-diploma-in-science/fees/

For more detail concerning CSPs, please visit the Commonwealth Government's Department of Education website:

https://studyassist.gov.au/sites/StudyAssist/

For information about future International students (including tuition fees) please refer to

https://study.unimelb.edu.au/how-to-apply/graduate-coursework-study/international-applications

MSc students may wish to consider taking on some part-time tutoring in the School during their programs. For further information, please contact the Director of the Mathematics and Statistics Learning Centre[6] as early as possible to register your interest.

5.2 Scholarships, Studentships, Awards and Prizes

Faculty of Science

The Faculty of Science offers a range of scholarships, awards and prizes. For more information, visit

https://science.unimelb.edu.au/students/scholarships

Graduate Access Melbourne provides access to applicants whose personal circumstances have had a sustained adverse effect on their academic achievement at undergraduate level or who are members of a specified group known to be under-represented in higher education. For more information, visit

https://study.unimelb.edu.au/how-to-apply/special-entry-access-schemes/access-melbourne-graduate

School of Mathematics and Statistics Scholarships

Our School provides scholarships for MSc (Mathematics and Statistics) students who satisfy certain criteria. After each semester of the student's study, the Weighted Average Mark (WAM) for all coursework subjects attempted by the student at that time in the MSc program will be calculated. Provided that

- The student's calculated WAM is at least 80,
- The student was studying full-time in the last completed semester,
- The student is enrolled full-time in the next semester,
- The student is not in receipt of a "National Scholarship" or any other Scholarship valued at more than $4,000 that year,

then the student will be paid a scholarship instalment of $2,000. The maximum total scholarship amount, over the course of the degree, is thus $6,000.

Helen Freeman Scholarship

The Helen Freeman Scholarship for Mathematics and Statistics (valued at $20,000) supports *female* students enrolled, or enrolling, in the first year of their MSc. For more details, please visit

https://scholarships.unimelb.edu.au/awards/helen-r-freeman-scholarship-master-of-science-mathematics-and-statistics

[6] https://ms.unimelb.edu.au/study/mslc#tutoring

Maurice Belz Scholarships

The School may offer up to three Maurice Belz scholarships (valued at $7,000 each) to students enrolled in our MSc program, specialising in Statistics and undertaking a research project in one of the following areas:

- Applied Statistics,
- Applied Probability and Stochastic Processes,
- Operations Research.

For more details, please visit

https://scholarships.unimelb.edu.au/awards/belz-scholarships

Prizes

The School also awards the following scholarship and prizes for which MSc students are eligible:

- *The Wyselaskie Scholarship*: awarded to the best MSc student in Mathematics and Statistics.
- *The Dwight Prize*: awarded to the best MSc student in Statistics.
- *The M L Urquhart Prize*: awarded to the MSc student with the best overall performance in Mathematics.
- *The Nanson and Wilson Prizes*: awarded to the best original memoir/thesis by a student in Pure or Applied Mathematics.

6 How to Enrol in Individual Subjects

Enrolment is managed by Student Services and should be completed online whenever possible. **Always seek course advice** from your supervisor or, in the absence thereof, from an MSc specialist advisor for your specialisation. If in doubt, talk to the program coordinator. In case you have any difficulties with the enrolment procedure, talk to our Academic Support Officer. (Contact details may be found in Section 11.)

(i) If the subject in question is a master's-level discipline subject offered either by our School (see p.18–19) or by another School **and** it is approved for our program (i.e. it is in the Handbook's list of approved master's-level subjects from other Schools), then:

  (i.a) If you meet all the prerequisites for that subject, login to the Student Portal and use it to enrol online. For more detail, visit

  https://students.unimelb.edu.au/admin/enrol-in-subjects

  (i.b) If you **do not meet** the formal prerequisites for that subject, but you believe that you have the prerequisite knowledge, you can still ask the subject coordinator to give you a requisite waiver. You will need to justify your request to persuade the coordinator to give you permission to enrol (send them a scan of your academic transcript, see them to talk about your background, etc). If the coordinator gives you the desired permission (an email from them to that effect would suffice), submit it online with an *Enrolment Variation Form* to enrol.

(ii) If this is a third-year Mathematics and Statistics undergraduate subject or a master's-level subject which is offered by another School but not automatically approved for our program (i.e. it is not in the Handbook's list of approved master's-level subjects from other Schools), then:

(ii.a) If you meet all the prerequisites for that subject, contact your supervisor to get their approval to enrol in that subject. If their approval is granted, contact our MSc/GDA Coordinator to get their approval to enrol. If both approve your enrolment, submit the approval online (an email from the program coordinator would suffice) with an *Enrolment Variation Form* to enrol.

(ii.b) If you **do not meet** the formal prerequisites for that subject, but you believe that you have the prerequisite knowledge, you can still ask the subject coordinator to give you a requisite waiver. First, you will need to obtain a requisite waiver from the subject coordinator, as described in (i.b) and then obtain School approval as described in (ii.a). Submit both online (emails are fine) with an *Enrolment Variation Form* to enrol.

(iii) If this is an AMSI Summer School subject, you first need to talk to the MSc program coordinator to find out if you will be allowed to take that subject for credit. It often happens that only a few of the AMSI Summer School subjects will be approved for credit in a given year. You are allowed to take at most one such subject for credit during your program.

To participate in an AMSI Summer School, you will need to register and pay the registration fee. That can be done from the Summer School webpage.[7] Look out for any earlybird registration discount and registration deadlines!

The School of Mathematics and Statistics may reimburse part of the registration fee if you are taking a subject from the AMSI Summer School for credit and formally enrol in the specially created subject MAST90079 AMSI Summer School.

If the AMSI Summer School is being held outside of Melbourne, you can apply for a Travel Grant from AMSI (see the Summer School webpage). The School of Mathematics and Statistics does not cover any associated travel expenses or accommodation costs.

7 How to Find a Supervisor

Every MSc student must find a supervisor, normally an academic staff member in the School of Mathematics and Statistics. You are not required to have found or confirmed a supervisor at the time when you submit your application, but you will have to have a confirmed supervisor prior to commencing the first component of the Research Project.

It is wise to actively consider your choice of specialisation and supervisor well in advance. Meeting with potential supervisors to discuss the type of projects they offer is an excellent strategy and it is recommended to start as early as possible.

Information about the School of Mathematics and Statistics can be found on the School web site:

https://www.ms.unimelb.edu.au

In particular, the research activities of the School's research groups can be found, along with information about research seminars, at

https://ms.unimelb.edu.au/research/groups
and
https://ms.unimelb.edu.au/events

Research interests for individual academic staff members in the School can be found online at

https://ms.unimelb.edu.au/study/supervisors-list

while academic staff's webpages can be found here:

https://ms.unimelb.edu.au/people/academic-staff

[7] https://ss.amsi.org.au/

Enrolled Mathematics and Statistics students can find more information on MS Prime.

Once a supervisor has been found, the student must inform the MSc coordinator of the supervision arrangement. This is usually facilitated by an online form that students will receive access to at induction.

The role of the supervisor is to suggest the content and aim of the research project, discuss relevant sources including textbooks, papers, reports, industry materials, etc., oversee the timeline for completing the project, and advise on which coursework will best support the research project. Over the course of the research project, the supervisor should regularly meet with the student to discuss progress, provide advice and give feedback (see also Section 16 below).

The student is expected to provide a final draft of the thesis in good time for the supervisor to read and give feedback (**at least two weeks** prior to the thesis submission date would be appropriate). The student is also responsible for submitting an electronic copy of their thesis by the deadline specified in this Guide. The supervisor and a second examiner appointed by the MSc coordinator will be responsible for marking the thesis.

GDA students do not have supervisors. To assist them with coursework planning, the School has several specialist advisors whose names will be communicated to newly enrolled students at induction. These advisors will also be able to assist MSc students with coursework planning and, if necessary, with finding a suitable supervisor.

8 The Research Project Component

During the first semester of their MSc program, students must finalise their choice of Research Project supervisor and research topic. The Research Project starts at the beginning of the second semester of study and should be conducted in three consecutive semesters. Typically, work on the project, including the thesis and presentation, is conducted in 60 of the next 66 weeks. An indicative total time commitment of **800 hours** for the duration of the project is expected.

Note that any leave of absence taken during enrolment in a Research Project, outside of the University's holidays, requires formal approval.

Assessment. The research project has three components, which run over successive semesters.

Research 1: The first research subject includes a *Research Methods Minicourse*, consisting of four hour-long sessions at the start of the semester: please consult the LMS for MAST90116 for more information.

At the end of Week 8 of their first semester of research, students must submit a preliminary *literature survey and research plan* (of at least 2 pages) to their supervisor (**hurdle: pass/fail**).

Research 2: At the end of Week 8 of their second semester of research, students must submit an *intermediate progress report* (of at least 2 pages) on their progress in the Research Project to their supervisor (**hurdle: pass/fail**).

Research 3: A thesis (90% of assessment) is due two weeks prior to the end of the teaching period in the final semester of enrolment in the Research Project. This is to be submitted electronically to the School following the instructions given to students at induction.

Students also have to give a 30 minute presentation (10% of assessment) on their Research Project in the last week of this semester, on a date to be announced by the School of Mathematics and Statistics in the middle of the semester.

Students will also have the opportunity to present a summary of their research report at a poster session. **This is voluntary and not assessed.** The poster session is held once per year with the 2022 dates yet to be announced.

Thesis. It is expected that the thesis will be prepared to a professional standard using a typesetting program such as LaTeX. They are expected to be around 40–60 pages in length, excluding references, appendices, figures and tables. Some recent theses can be found on the LMS for the Research Project subjects. For more information concerning research projects, see Section 16.

The thesis will be assessed on criteria which take into account the expectations of the School's diverse research areas and the many different forms (surveys, new research, biological or industrial applications, modelling, etc.) that a thesis may take. These criteria will include

- clarity of exposition,
- mathematical/statistical accuracy,
- mathematical/statistical insight displayed,
- coverage of the field and references

and may be complemented by one or more of the following:

- the description of the application and/or business context,
- details of any mathematical/statistical modelling,
- the presentation and analysis of numerical results.

The weights given to these components will take into account the nature of the project.

Student Seminars. During their candidature, MSc students **must give at least two talks**. The first could be a progress talk on their project or on another related topic; it may be given before their research group. The second will be a 30 minute presentation (including question time) to be given by students at a special "miniconference" at the end of the semester in which they complete the Research Project Component. This presentation is assessed (see above).

MSc and GDA students should consider themselves as an integral part of the the School and are strongly encouraged to attend a wide variety of school seminars as a means to broadening their knowledge. It is moreover expected that students will attend research seminars in the broader area of their chosen specialisation.

9 Extensions and Special Consideration

The University's policy on extensions and special consideration (MPF1326) apply to coursework programs and to coursework subjects in our MSc and GDA programs. This includes the Research Project Component of the MSc.

As such, students who are unable to meet a submission deadline will need to apply for an extension. Applications for extensions of up to two weeks should be made to either the subject coordinator (for coursework) or the MSc program coordinator (for the Research Project Component). If an extension of more than two weeks is required, the student will need to apply to the University's special consideration unit. For further details, visit

https://policy.unimelb.edu.au/MPF1326
https://students.unimelb.edu.au/your-course/manage-your-course/exams-assessments-and-results/special-consideration

A student may ask their supervisor for a letter of support whenever an extension for the Research Project Component is sought.

10 Computer Literacy

There are many useful mathematics and statistics resources that can be found online. One of the most valuable is the research publications database **MathSciNet** published by the American Mathematical Society. The database provides BibTeX entries with all reviews and its abbreviations of journal titles have become a *de facto* standard in mathematical publishing. An alternative (and bigger) major international reviewing service that covers the entire field of mathematics is **Zentralblatt MATH**, which is edited by the European Mathematical Society. Both databases can be accessed via the University Library Web site.

Modern computational hardware and software have tremendously enhanced research in the areas of applied mathematics and statistics; it has had a serious effect on theoretical research as well. Perhaps the most powerful and popular symbolic and/or numerical mathematics software packages available today are **Maple**, **Mathematica** and **Matlab**. The School has licenses for all three that cover all School computers, meaning that students will be able to use the software on the desktop machines in the Peter Hall building. Student standalone licenses are also available at a reasonable price.[8] Alternatively, students who are experienced with **python** may wish to check out the free software system **SageMath**:

https://www.sagemath.org/

Even if you will not need any symbolic or numerical computation packages for your own research project and/or coursework subjects, it is highly recommended for your future professional life that you learn how to work with at least one of the above packages. The same applies to **LaTeX**, the standard high-level typesetting system for mathematical (and scientific) document preparation. It is **strongly recommended** for thesis preparation. The School has a collection of useful (but slightly out-of-date) LaTeX-related links here:

https://ms.unimelb.edu.au/study/current-masters-and-pgdip-students/latex

A user-friendly interface for beginners is provided by **Overleaf**:

https://www.overleaf.com/

Other useful sources for beginners (and experts) include the **LaTeX WikiBook** and the **TeX - LaTeX Stack Exchange**:

https://en.wikibooks.org/wiki/Category:Book:LaTeX
https://tex.stackexchange.com/

Statistics students will in all likelihood be familiar with **R**, a freely available programming language and environment which provides a wide variety of statistical and graphical techniques. It has become a *de facto* standard among statisticians for developing statistical software, see

https://cran.r-project.org/

for more information. Due to its rich capabilities and efficient syntax, **R** is becoming an increasingly popular programming tool in areas other than statistics.

It is important to realise that many (if not all) quantitative jobs in industry (and academia) require a certain facility with programming. Quite often, successful candidates are expected to have experience with a number of programming languages. Aside from general-purpose languages, very often the "wish list" includes such items as SAS, SPSS and SQL. There are a few opportunities to gain experience with these languages during your postgraduate coursework degree:

SAS (Statistical Analysis System): This is a comprehensive and powerful software system for data management and data analysis. It consists of the *Base SAS module* and a number of separate add-on modules. As a student of this University, you will have free access to both SAS itself and eight *eLearning SAS courses*. For more information, please visit

https://unimelb.libguides.com/c.php?g=402784&p=2740902
https://www.sas.com

SPSS (Statistical Package for the Social Sciences): This is a relatively basic computer program used for statistical analysis. One possibility to learn how to work with it is to take part in an SPSS-based version of the course "Statistics for Research Workers" run by our Statistical Consulting Centre, see

https://www.scc.ms.unimelb.edu.au/statistics-courses

[8] These licenses are restricted to only be used by students enrolled in a course offered by a degree-granting institution or in a continuing education course.

for more information. The course is unfortunately not free, unless it's taken for credit (which is not currently an option for our MSc students).

SQL (Structured Query Language): This is a database computer language designed for managing data in relational database management systems. Elements of SQL are covered in the master's-level subject SINF90001 Database Systems & Information Modelling which is offered in both semesters. However, because of the overall content of this subject, it is not on the Handbook's list of approved master's-level subjects from other Schools.

11 Key Contact Details

- Dr James Osborne, MSc and GDA Coordinator (Mathematics and Statistics);
  Room: 3215 in Old Geology South, email: jmosborne@unimelb.edu.au
- Ms Tina Soundias, Academic Support Coordinator;
  phone: (03) 8344 9153, email: tinas@unimelb.edu.au

12 Key Dates

To find the due dates for applications from students planning to commence studies in 2022, please check the University website referred to in Section 4. Applications may be accepted after these dates, at the University's discretion.

MSc/GDA Commencement/orientation: Usually, this takes place in Orientation Week ("O-week"), the week before the start of teaching in semester 1 or 2. Successful applicants will be contacted in advance by the University via email.

MSc Thesis Submission Deadline: 2:00pm on Friday, two weeks prior to the end of teaching in the final semester of enrolment in the Research Project. In 2022, the deadline will be on May 13 in Semester 1, and on October 7 in Semester 2.

Research Project Seminars: In the last week of teaching, in the final semester of enrolment in the Research Project. The exact date will be announced approximately one month in advance.

13 Some Useful Web Sites

The School of Mathematics and Statistics:

https://www.ms.unimelb.edu.au

The University's website for prospective MSc students:

https://study.unimelb.edu.au/find/courses/graduate/master-of-science-mathematics-and-statistics/

The University's website for prospective GDA students:

https://study.unimelb.edu.au/find/courses/graduate/graduate-diploma-in-science-advanced/

The University's Handbook entry for the MSc in Mathematics and Statistics:

https://handbook.unimelb.edu.au/courses/mc-scimat

The University's Handbook entry for the GDA:

https://handbook.unimelb.edu.au/courses/gda-sci

The University's Scholarships website:

https://scholarships.unimelb.edu.au/

The University's Careers website:

https://students.unimelb.edu.au/careers

The School's MS Prime Graduate Studies pages:

All MSc and GDA students will be given access to **MS Prime**, an online Canvas community, where the Graduate Studies pages include a summary of this guide and other useful information.

14 Discipline Subjects in 2022–2023: Semester Allocations

The tables below show the year/semester allocation of master's-level discipline subjects in Mathematics and Statistics for 2022–2023. Some subjects are taught each year, while some subjects alternate. Those that appear in the 2022 half of the table will be offered in even years, whereas those in the 2023 half will be offered in odd years. The names of the compulsory subjects within the five specialisations are typeset in **boldface**.

2022		2023	
Semester 1	**Semester 2**	**Semester 1**	**Semester 2**
Applied Mathematics and Mathematical Biology (AMMB)			
MAST90067 **Advanced Methods: Transforms**	MAST90125 Bayesian Statistical Learning	MAST90064 **Advanced Methods: Differential Equations**	MAST90125 Bayesian Statistical Learning
MAST90026 Computational Differential Equations	MAST90011 Mathematical Biology	MAST90060 Mathematical Statistical Mechanics	MAST90113 Continuum Mechanics
MAST90103 Random Matrix Theory			MAST90129 Infectious Disease Dynamics
MAST90127 Advanced Biological Modelling: Dynamics			
Mathematical Physics and Physical Combinatorics (MPPC)			
MAST90067 **Advanced Methods: Transforms**	MAST90031 Enumerative Combinatorics	MAST90060 **Mathematical Statistical Mechanics**	MAST90030 **Advanced Discrete Mathematics**
MAST90103 Random Matrix Theory	MAST90069 Introduction to String Theory	MAST90064 Advanced Methods: Differential Equations	MAST90065 Exactly Solvable Models
		MAST90132 Lie Algebras	
Operations Research and Industrial Optimisation (ORIO)			
MAST90014 **Optimisation for Industry**	MAST90098 **Approximation, Algorithms & Heuristics**	MAST90014 **Optimisation for Industry**	MAST90098 **Approximation, Algorithms & Heuristics**
MAST90142 Advanced Nonlinear Programming	MAST90013 Network Optimisation	MAST90137 Mathematical Game Theory	MAST90050 Scheduling and Optimisation
Pure Mathematics (PURE)			
MAST90023 **Algebraic Topology**	MAST90068 Groups, Categories & Homological Algebra	MAST90012 **Measure Theory**	MAST90017 Representation Theory
MAST90020 Functional Analysis	MAST90097 Algebraic Geometry	MAST90029 Differential Topology	MAST90056 Riemann Surfaces & Complex Analysis
MAST90136 Algebraic Number Theory	MAST90143 Differential Geometry	MAST90132 Lie Algebras	MAST90133 Partial Differential Equations

2022		2023	
Semester 1	**Semester 2**	**Semester 1**	**Semester 2**
Statistics and Stochastic Processes (SASP)			
MAST90082 **Mathematical Statistics**	MAST90081 **Advanced Probability****	MAST90082 **Mathematical Statistics**	MAST90081 **Advanced Probability****
MAST90019 Random Processes*	MAST90083 Computational Statistics & Data Science	MAST90019 Random Processes*	MAST90083 Computational Statistics & Data Science
MAST90084 Statistical Modelling	MAST90125 Bayesian Statistical Learning	MAST90084 Statistical Modelling	MAST90125 Bayesian Statistical Learning
MAST90122 Inference for Spatio-temporal Processes	MAST90138 Multivariate Statistics for Data Science	MAST90122 Inference for Spatio-temporal Processes	MAST90138 Multivariate Statistics for Data Science
MAST90112 Advanced Topics in Stochastic Models	MAST90027 Practice of Statistics and Data Science	MAST90059 Stochastic Calculus with Applications	
	MAST90051 Mathematics of Risk		
	MAST90111 Advanced Statistical Modelling		

* MAST90019 Random Processes ceased being a core subject in the SASP specialisation at the end of 2020. Students who started their MSc in Semester 2 of 2020 or earlier can count MAST90019 as a core subject in the SASP specialisation.

** MAST90081 Advanced Probability became a core subject in the SASP Specialisation at the beginning of 2021. Students completing their MSc 2022 or later can count MAST90081 as a core subject in the SASP specialisation.

15 Discipline Subjects: Brief Descriptions

Here, the master's-level discipline subjects are listed, ordered alphabetically by title. Some subjects are only offered in either odd or even years. These subjects are indicated below with an (o) or (e), respectively, after the subject code. For semester allocation of the subjects, see the table on p.18–19.

The subject coordinator names listed below are tentative and subject to change. Prerequisite subjects may be exchanged for equivalent subjects, with subject coordinator approval. The italicised text in the prerequisite sections describes the "*recommended background knowledge*" for the subject. Be advised that all discipline subjects are described in the University's Handbook. In the event of a disagreement between this Guide and the Handbook, the Handbook prevails.

A First Course In Statistical Learning MAST90104
Subject Coordinator: Khue-Dung Dang
Supervised statistical learning is based on the widely used linear models that model a response as a linear combination of explanatory variables. Initially, this subject develops an elegant unified theory for a quantitative response that includes the estimation of model parameters, hypothesis testing using analysis of variance, model selection, diagnostics on model assumptions, and prediction. Some classification methods for qualitative responses are then developed. This subject then considers

computational techniques, including the EM algorithm. Bayes and Monte-Carlo methods are also considered. The subject concludes by considering some unsupervised learning techniques.
Prerequisites: MAST90105 Methods of Mathematical Statistics.

Advanced Biological Modelling: Dynamics MAST90127 (e)
Subject Coordinator: Pengxing Cao
This subject builds on the knowledge of how biological modelling provides insight into complex biological phenomena. With a focus on mechanistic modelling and viewing biological systems as dynamic in nature, students will learn how to develop and implement "real-world" models, applicable to current open problems in computational biology. Advanced approaches to the model-based analysis of data will be introduced, including Bayesian hierarchical modelling. Software languages and packages for modelling and statistical analysis (e.g. SBML and STAN) will be introduced. Motivating problems will be drawn from across the spectrum of biology from genetics to ecology.
Prerequisites: One of MAST20029, MAST20030, MAST30030 or PHYC20014, as well as either MAST30032 Biological Modelling and Simulation or one of COMP10001, COMP90059 and MAST30028.

Advanced Discrete Mathematics MAST90030 (o)
Subject Coordinator: Trevor Welsh
This subject consists of three main topics: The bijective principle with applications to maps, permutations, lattice paths, trees and partitions; Algebraic combinatorics with applications to rings, symmetric functions and tableaux; Ordered sets with applications to generating functions and the structure of combinatorial objects.
Prerequisites: MAST30021 Complex Analysis. *It is recommended that students have completed third-year subjects in graph theory and/or discrete mathematics equivalent to one of the following: MAST30011 Graph Theory, MAST30012 Discrete Mathematics.*

Advanced Methods: Differential Equations MAST90064 (o)
Subject Coordinator: Hailong Guo
This subject develops the mathematical methods of applied mathematics and mathematical physics with an emphasis on ordinary differential equations. Both analytical and approximate techniques are used to determine solutions of ordinary differential equations. Exact solutions by localised series expansion techniques of second-order linear ordinary differential equations and Sturm–Liouville boundary value problems are explored. Special functions are introduced here. Regular and singular perturbation expansion techniques, asymptotic series solutions, dominant balance, and WKB theory are used to determine approximate solutions of linear and nonlinear differential equations. Throughout, the theory is set in the context of examples from applied mathematics and mathematical physics such as nonlinear oscillators, boundary layers and dispersive phenomena.
Prerequisites: MAST20030 Differential Equations. *It is recommended that students have completed MAST20026 Real Analysis. Completion of, or concurrent enrolment in, MAST30021 Complex Analysis will also be helpful.*

Advanced Methods: Transforms MAST90067 (e)
Subject Coordinator: Nick Beaton
This subject develops the mathematical methods of applied mathematics and mathematical physics with an emphasis on integral transforms and related techniques. An introduction is given to the calculus of variations and the Euler–Lagrange equation. Advanced complex contour integration techniques are used to evaluate and invert Fourier and Laplace transforms. The general theory includes convolutions, Green functions and generalised functions. The methods of Laplace, stationary phase, steepest descent and Watson's lemma are used to asymptotically approximate integrals. Throughout, the theory is set in the context of examples from applied mathematics and mathematical physics such as the brachistochrone problem, Fraunhofer diffraction, Dirac delta function, heat equation and diffusion.
Prerequisites: MAST20030 Differential Equations and MAST30021 Complex Analysis. *It is recommended that students have completed at least one of MAST30030 Applied Mathematical Modelling or MAST30031 Methods of Mathematical Physics.*

Advanced Nonlinear Optimisation MAST90142
Subject Coordinator: Charl Ras
Many optimisation problems in the real world are inherently nonlinear. A variety of industries, including telecommunications networks, underground mining, microchip design, computer vision, facility location and supply chain management, depend on the efficient solution of nonlinear programs. This subject introduces the foundational mathematical concepts behind nonlinear optimisation. Some of the concepts covered include convex analysis, optimality conditions, conic programming and duality. Various methods to solve nonlinear programs are covered, including iterative methods such as conjugate gradient methods, barrier methods and subgradient methods. This subject also explores the application of geometric methods such as perturbation and variational approaches to problems in facility location and network design.
Prerequisites: MAST30013 Techniques in Operations Research.

Advanced Probability MAST90081
Subject Coordinator: Malwina Luczak
This subject mostly explores the key concept of probability Theory: the convergence of probability distributions. This is fundamental for mathematical statistics and is widely used in other applications. We study in depth the classical method of characteristic functions and discuss alternative approaches to proving the limit theorems of probability theory.
Prerequisites: MAST30020 Probability for Inference.

Advanced Statistical Genomics MAST90126
Subject Coordinator: Kim-Anh Lê Cao and Heejung Shim
This subject will cover the statistical analysis of data arising from modern genomics and their practical application using R and specialist software. RNA-seq, epigenomics and metagenomics assays will be introduced, together with properties of the resulting data, appropriate pre-analyses and advanced statistical methods and algorithms. Methods for biomarker discovery, including supervised learning and multivariate analysis techniques, will also be covered, as will statistical models and techniques for phylogenetics.
Prerequisites: MAST30033 Statistical Genomics.

Advanced Statistical Modelling MAST90111 (e)
Subject Coordinator: Guoqi Qian
Complex data consisting of dependent measurements, collected at different times and locations, are increasingly important in a wide range of disciplines, including environmental science, biomedical science, engineering and economics. This subject will introduce you to advanced statistical methods and probability models that have been developed to address complex data structures, such as functional data, geostatistical data, lattice data, and point process data. A unifying theme of this subject will be the development of inference, classification and prediction methods able to cope with the dependencies that often arise in these data.
Prerequisites: MAST30025 Linear Statistical Models and MAST90082 Mathematical Statistics. *It is recommended that students have completed MAST90083 Computational Statistics & Data Science, MAST90084 Statistical Modelling, MAST90085 Multivariate Statistical Techniques, MAST90138 Multivariate Statistics for Data Science.*

Advanced Topics in Stochastic Models MAST90112 (e)
Subject Coordinator: Mark Holmes
This subject develops some advanced topics and methods of stochastic processes, while discussing possible applications of the models covered in the course. It serves to prepare students for research in Probability Theory.
Prerequisites: MAST30020 Probability for Inference.

Algebraic Geometry MAST90097 (e)
Subject Coordinator: Jack Hall
This course is an introduction to algebraic geometry. Algebraic geometry is the study of zero sets of polynomials. It exploits the interplay between rings of functions and the underlying geometric objects on which they are defined. It is a fundamental tool in many areas of mathematics including number theory and differential geometry. There are also many applications in physics. The syllabus includes affine and projective varieties, coordinate rings of functions, the Nullstellensatz, Zariski

topology, regular morphisms, dimension, smoothness and singularities, sheaves, and schemes.
Prerequisites: MAST30005 Algebra.

<u>**Algebraic Number Theory**</u> MAST90136 (e)
Subject Coordinator: Alex Ghitza
This course is an introduction to algebraic number theory. Algebraic number theory studies the structure of the integers and algebraic numbers, combining methods from commutative algebra, complex analysis, and Galois theory. This subject covers the basic theory of number fields, rings of integers and Dedekind domains, zeta functions, decomposition of primes in number fields and ramification, the ideal class group, and local fields. Additional topics may include Dirichlet L-functions and Dirichlet's theorem; quadratic forms and the theorem of Hasse–Minkowski; local and global class field theory; adeles; and other topics of interest.
Prerequisites: MAST30005 Algebra.

<u>**Algebraic Topology**</u> MAST90023 (e)
Subject Coordinator: Nora Ganter
This subject studies topological spaces and maps between them. It shows how topology can be applied to many areas, including geometry, analysis, group theory and physics. The aim is to reduce questions in topology to problems in algebra by introducing algebraic invariants associated to spaces and maps. Important classes of spaces studied are manifolds (locally Euclidean spaces) and CW-complexes, built by gluing together cells of various dimensions. Topics include: homotopy of maps and homotopy equivalence of spaces, homotopy groups of spaces, the fundamental group, covering spaces, homology theory (including singular homology theory), the axiomatic approach of Eilenberg and Steenrod, and cellular homology.
Prerequisites: MAST30005 Algebra and MAST30026 Metric and Hilbert Spaces.

<u>**Approximation, Algorithms and Heuristics**</u> MAST90098
Subject Coordinator: Charl Ras
Many discrete optimisation problems encountered in practice are too difficult to solve exactly in a reasonable time frame. Approximation algorithms and heuristics are the most widely used approaches for obtaining reasonably accurate solutions to such hard problems. This subject introduces the basic concepts and techniques underlying these "inexact" approaches. We will address the following fundamental questions in the subject: How difficult is the problem under consideration? How closely can an optimal solution be approximated? How can we go about finding near-optimal solutions in an efficient way? We will discuss methodologies for analysing the complexity and approximability of some important optimisation problems, including the travelling salesman problem, knapsack problem, bin packing, scheduling, network design, covering problems and facility location. We will also learn about various metaheuristics (simulated annealing, Tabu search, GRASP, genetic algorithms) and matheuristics (relax-and-fix, fix-and-optimise, local branching) that are widely used in solving real-world optimisation problems.
Prerequisites: MAST30013 Techniques in Operations Research.

<u>**Bayesian Statistical Learning**</u> MAST90125
Subject Coordinator: John Holmes
Bayesian inference treats all unknowns as random variables and the core task is to update the probability distribution for each unknown as new data is observed. After introducing Bayes' Theorem to transform prior probabilities into posterior probabilities, the first part of this subject introduces theory and methodological aspects underlying Bayesian statistical learning including credible regions, comparisons of means and proportions, multimodel inference and model selection. The second part of the subject focuses on advanced supervised and unsupervised Bayesian machine learning methods in the context of Gaussian processes and Dirichlet processes. The subject will also cover practical implementations of Bayesian methods through Markov Chain Monte Carlo computing and real data applications.
Prerequisites: MAST20005 Statistics and one of MAST30001 Stochastic Modelling, MAST30020 Probability for Inference, MAST30025 Linear Statistical Models and MAST30027 Modern Applied Statistics.

Computational Differential Equations MAST90026 (e)
Subject Coordinator: Hailong Guo
Many processes in the natural sciences, engineering and finance are described mathematically using ordinary or partial differential equations. Only the simplest of these, or those with special structure, can be solved exactly. This subject discusses common techniques to computing numerical solutions to differential equations and introduces the major themes of accuracy, stability and efficiency. Understanding these basic properties of scientific computing algorithms should prevent the unwary from using software packages inappropriately or uncritically, whilst providing the foundation for devising methods for nonstandard problems. We cover both time-independent problems, in one and higher space dimensions, and evolution equations of hyperbolic or parabolic type.
Prerequisites: Students should be able to program in one of: C, Matlab, Mathematica, Perl, Fortran, Python etc. *Students are required to write programs in MATLAB so previous experience in writing and debugging procedural computer programs is expected. It is recommended that students have completed a subject in differential equations.*

Computational Statistics & Data Science MAST90083
Subject Coordinator: Karim Seghouane
Computing techniques and data mining methods are indispensable in modern statistical research and applications, where "Big Data" problems are often involved. This subject will introduce a number of recently developed statistical data mining methods that are scalable to large datasets and high-performance computing. These include regularised regression such as the Lasso; tree based methods such as bagging, boosting and random forests; and support vector machines. Important statistical computing algorithms and techniques used in data mining will be explained in detail. These include the bootstrap, cross-validation, the EM algorithm, and Markov chain Monte Carlo methods including the Gibbs sampler and Metropolis–Hastings algorithm.
Prerequisites: MAST30025 Linear Statistical Models or MAST30027 Modern Applied Statistics.

Continuum Mechanics MAST90113 (o)
Subject Coordinator: Douglas Brumley
This subject develops mathematical methods for the study of the mechanics of fluids and solids and illustrates their use in several contexts. Topics covered include Newtonian fluids at low and at high Reynolds number and the linear theory of elasticity. Applications may be drawn from biological, earth sciences, engineering or physical contexts.
Prerequisites: MAST30030 Applied Mathematical Modelling.

Differential Geometry MAST90143 (e)
Subject Coordinator: Volker Schlue
This subject extends notions from calculus, linear algebra and differential equations to study spaces with geometric structures. The concepts introduced are of great importance in mathematics, physics, and all areas in which local properties of spaces are used to model systems. Topics include smooth manifolds, vector bundles, multilinear algebra, Frobenius' theorem, exterior differentiation, Lie differentiation, flows of vector fields, connections and curvature, bilinear forms, metrics, length, volume, the Levi–Civita connection, parallel transport, geodesics, holonomy, connections on principal bundles, examples including Lie groups, hyperbolic geometry and homogeneous spaces. Additional topics may include the second fundamental form and minimal submanifolds; Jacobi fields and applications to topology; constant curvature and Einstein metrics; the Hodge star operator, the Laplacian and harmonic forms; Lorentzian geometry and Einstein's equations; Kähler geometry; symplectic geometry; and gauge theory.
Prerequisites: MAST20009 Vector Calculus and MAST30026 Metric and Hilbert Spaces.

Differential Topology MAST90029 (o)
Subject Coordinator: Craig Hodgson
This subject extends the methods of calculus and linear algebra to study the topology of higher-dimensional spaces. The ideas introduced are of great importance throughout mathematics, physics and engineering. This subject will cover basic material on the differential topology of manifolds. Topics include smooth manifolds; tangent spaces; inverse and implicit function theorems; differential forms; integration on manifolds and de Rham cohomology; submersions and fibre bundles; immersions and transversality; examples coming from Lie groups and homogeneous spaces. Additional topics may include Morse theory; intersection theory; characteristic classes and Chern–Weil

theory; the Thom isomorphism; bordism theory.
Prerequisites: MAST20009 Vector Calculus and MAST30026 Metric and Hilbert Spaces.

Enumerative Combinatorics MAST90031 (e)
Subject Coordinator: Aleks Owczarek
This subject uses generating functions to enumerate combinatorial structures, including partitions of numbers, partitions of sets, permutations with restricted cycle structure, connected graphs, and other types of graph. The subject covers the solution of recurrence relations, methods of asymptotic enumeration, and some applications to statistical mechanics. The methods covered have widespread applicability in areas including pure and applied mathematics, physics and computer science.
Prerequisites: MAST30021 Complex Analysis. *Familiarity with mathematical symbolic computation packages such as Mathematica and Maple is encouraged.*

Exactly Solvable Models MAST90065 (o)
Subject Coordinator: Paul Zinn-Justin
In mathematical physics, a wealth of information comes from the exact, non-perturbative, solution of quantum models in one-dimension and classical models in two-dimensions. This subject is an introduction to Yang–Baxter and Bethe-Ansatz integrability, and the orthogonal polynomial method of random matrix theory. Transfer matrices, the Yang–Baxter equation and the Bethe Ansatz are developed in the context of the 6-vertex model, quantum spin chains and other examples. As a solvable model, random matrix theory aims to first identify the explicit eigenvalue distributions for a given matrix distribution. The method of orthogonal polynomials is then used to compute eigenvalue correlation functions that can be compared against (numerical) experiments.
Prerequisites: MAST30021 Complex Analysis. *No prior knowledge of physics is assumed.*

Experimental Mathematics MAST90053 (e)
Subject Coordinator: Paul Zinn-Justin
Modern computers have developed far beyond being great devices for numerical simulations or tedious but straightforward algebra. In 1990, the first mathematical research paper was published whose sole author was a thinking machine known as Shalosh B Ekhad. This course will discuss some of the great advances made in using computers to purely algorithmically discover (and prove) nontrivial mathematical theorems in, for example, number theory and algebraic combinatorics. Topics include automated hypergeometric summation, Gröbner bases, chaos theory, number guessing, recurrence relations and BBP formulas.
Prerequisites: One of MAST30028 Numerical Methods and Scientific Computing, MAST30005 Algebra or MAST30012 Discrete Mathematics. *MAST30028 Numerical Methods and Scientific Computing or a similar subject is recommended.*

Functional Analysis MAST90020 (e)
Subject Coordinator: Jesse Gell-Redman
Functional analysis is a fundamental area of pure mathematics, with countless applications to the theory of differential equations, engineering, and physics. The students will be exposed to the theory of Banach spaces, the concept of dual spaces, the weak-star topology, the Hahn–Banach theorem, the axiom of choice and Zorn's lemma, the Krein–Milman theorem, operators on Hilbert space, the Peter–Weyl theorem for compact topological groups, the spectral theorem for infinite dimensional normal operators, and connections with harmonic analysis.
Prerequisites: MAST20022 Group Theory and Linear Algebra and MAST30026 Metric and Hilbert Spaces.

Groups, Categories and Homological Algebra MAST90068 (e)
Subject Coordinator: Christian Haesemeyer
As well as being beautiful in its own right, algebra is used in many areas of mathematics, computer science and physics. This subject provides a grounding in several fundamental areas of modern advanced algebra including Lie groups, combinatorial group theory, category theory and homological algebra.
Prerequisites: MAST30005 Algebra.

Infectious Disease Dynamics MAST90129 (o)
Subject Coordinator: Jennifer Flegg
This subject introduces the fundamental mathematical models used to study infectious diseases at both the epidemiological and within-host scale. The emphasis is on: 1) how models are developed, from conceptualisation through to implementation in software; and 2) how to apply models to questions of epidemiological, public health and biological importance. Statistical techniques for the model-based analysis of relevant data resources will be introduced, including the following.
Epidemiology: epidemic/endemic behaviour and intervention strategies to reduce transmission, the SIR model, including demography, threshold behaviour, phase-plane analysis.
Viral dynamics: host-pathogen interactions, the mediating influences of immunomodulatory agents and antimicrobials, the TIV model, including the immune response, pharmacokinetic-pharmacodynamic models.
Additional topics include model sensitivity and uncertainty analysis, scenario analysis, parameter estimation, and model comparison.
Prerequisites: One of COMP10001, COMP90059, MAST30032 or MAST30028 and one of MAST20030, MAST20029, MAST30030 or PHYC20014.

Inference for Spatio-temporal Processes MAST90122
Subject Coordinator: Tingjin Chu
Modern data collection technologies are creating unprecedented challenges in statistics and data science related to the analysis and interpretation of massive data sets where observations exhibit patterns through time and space. This subject introduces probability models and advanced statistical inference methods for the analysis of temporal and spatio-temporal data. The subject balances rigorous theoretical development of the methods and their properties with real-data applications. Topics include inference methods for univariate and multivariate time series models, spatial models, lattice models, and inference methods for spatio-temporal processes. The subject will also address aspects related to computational and statistical tradeoffs and the use of statistical software.
Prerequisites: MAST90082 Mathematical Statistics.

Introduction to String Theory MAST90069 (e)
Subject Coordinator: Johanna Knapp
The first half of this subject is an introduction to two-dimensional conformal field theory with emphasis on the operator formalism and explicit calculations. The second half is an introduction to string theory based on the first half. For concreteness, the representation theory of Virasoro algebra and bosonic strings will be emphasised.
Prerequisites: MAST20009 Vector Calculus and MAST30021 Complex Analysis. *No prior knowledge of physics is assumed.*

Lie Algebras MAST90132 (o)
Subject Coordinator: Daniel Murfet
The theory of Lie algebras is fundamental to the study of groups of continuous symmetries acting on vector spaces, with applications to diverse areas including geometry, number theory and the theory of differential equations. Moreover, since quantum mechanical systems are described by Hilbert spaces acted on by continuous symmetries, Lie algebras and their representations are also fundamental to modern mathematical physics. This subject develops the basic theory in a way accessible to both pure mathematics and mathematical physics students, with an emphasis on examples. The main theorems are the classification of complex semisimple Lie algebras in terms of Cartan matrices and Dynkin diagrams, and the classification of finite-dimensional representations of these algebras in terms of highest weight theory.
Prerequisites: MAST30021 Complex Analysis

Mathematical Biology MAST90011 (e)
Subject Coordinator: Jennifer Flegg
Modern techniques have revolutionised biology and medicine, but interpretative and predictive tools are needed. Mathematical modelling is such a tool, providing explanations for counterintuitive results and predictions leading to new experimental directions. The broad flavour of the area and the modelling process will be discussed. Applications will be drawn from many areas including

population growth, epidemic modelling, biological invasion, pattern formation, tumour modelling, developmental biology and tissue engineering. A large range of mathematical techniques will be discussed, for example discrete time models, ordinary differential equations, partial differential equations, stochastic models and cellular automata.
Prerequisites: MAST20030 Differential Equations.

<u>**Mathematical Game Theory**</u> MAST90137 (o)
Subject Coordinator: Mark Fackrell
This subject provides a rigorous mathematical treatment of game theory and will include applications selected from queueing theory, biology, population dynamics, resource allocation, auction theory, political science, and military applications.
Prerequisites: MAST30022 Decision Making.

<u>**Mathematical Statistical Mechanics**</u> MAST90060 (o)
Subject Coordinator: Thomas Quella
The goal of statistical mechanics is to describe the behaviour of bulk matter starting from a physical description of the interactions between its microscopic constituents. This subject introduces the Gibbs probability distributions of classical statistical mechanics, the relation to thermodynamics, and the modern theory of phase transitions and critical phenomena. The central concepts of critical exponents, universality and scaling are emphasised throughout. Applications include the ideal gases, magnets, fluids, the one-dimensional Ising and Potts lattice spin models, random walks and percolation, as well as approximate methods of solution.
Prerequisites: MAST20009 Vector Calculus. *It is recommended that students have completed MAST20026 Real Analysis.*

<u>**Mathematical Statistics**</u> MAST90082
Subject Coordinator: Liuhua Peng
The theory of statistical inference is important for applied statistics and as a discipline in its own right. After reviewing random samples and related probability techniques including inequalities and convergence concepts, the theory of statistical inference is developed. The principles of data reduction are discussed and related to model development. Methods of finding estimators are given, with an emphasis on multiparameter models, along with the theory of hypothesis testing and interval estimation. Both finite and large sample properties of estimators are considered. Applications may include robust and distribution-free methods, quasi-likelihood and generalised estimating equations. It is expected that students completing this course will have the tools to be able to develop inference procedures in novel settings.
Prerequisites: MAST20005 Statistics and any third-year subject in statistics or stochastic processes. *It is recommended that students have completed MAST30020 Probability for Inference, MAST30025 Linear Statistical Models and MAST30027 Modern Applied Statistics.*

<u>**Mathematics of Risk**</u> MAST90051 (e)
Subject Coordinator: Kostya Borovkov
Mathematical modelling of various types of risk has become an important component of the modern financial industry. This subject discusses the key aspects of the mathematics of market risk. Main concepts include loss distributions, risk and dependence measures, copulas, risk aggregation and allocation principles, and elements of extreme value theory. The main theme is the need to satisfactorily address extreme outcomes and the dependence of key risk drivers.
Prerequisites: MAST30020 Probability for Inference and one of MAST20026 Real Analysis or MAST20033 Real Analysis: Advanced.

<u>**Measure Theory**</u> MAST90012 (o)
Subject Coordinator: Lawrence Reeves
Measure Theory formalises and generalises the notion of integration. It is fundamental to many areas of mathematics and probability and has applications in other fields such as physics and economics. Students will be introduced to Lebesgue measure and integration, signed measures, the Hahn–Jordan decomposition, the Radon–Nikodym derivative, conditional expectation, Borel sets and standard Borel spaces, product measures, and the Riesz representation theorem.
Prerequisites: MAST20022 Group Theory and Linear Algebra and MAST30026 Metric and Hilbert Spaces.

Multivariate Statistics for Data Science MAST90138
Subject Coordinator: Dennis Leung
Modern statistics and data science deals with data having multiple dimensions. Multivariate methods are used to handle these types of data. Approaches to supervised and unsupervised learning with multivariate data are discussed. In particular, methods for classification, clustering, and dimension reduction are introduced, which are particularly suited to high-dimensional data. Both parametric and nonparametric approaches are discussed.
Prerequisites: MAST30025 Linear Statistical Models and MAST90082 Mathematical Statistics

Network Optimisation MAST90013 (e)
Subject Coordinator: Sanming Zhou
Many practical problems in management, operations research, telecommunication and computer networking can be modelled as optimisation problems on networks. Here, the underlying structure is a graph. This subject is an introduction to optimisation problems on networks with a focus on theoretical results and efficient algorithms. It covers classical problems that can be solved in polynomial time, such as shortest paths, maximum matchings, maximum flows, and minimum cost flows. Other topics include complexity and NP-completeness, matroids and greedy algorithms, approximation algorithms, multicommodity flows, and network design. This course is beneficial for all students of discrete mathematics, operations research, and computer science.
Prerequisites: MAST30011 Graph Theory. *MAST20018 Discrete Maths and Operations Research is recommended.*

Optimisation for Industry MAST90014
Subject Coordinator: Alysson Costa
The use of mathematical optimisation is widespread in business, where it is a key analytical tool for managing and planning business operations. It is also required in many industrial processes and is useful to government and community organisations. This subject will expose students to operations research techniques as used in industry. A heavy emphasis will be placed on the modelling process that turns an industrial problem into a mathematical formulation. The focus will then be on how to solve the resulting mathematical problem. Mathematical programming and (meta)-heuristic techniques will be reviewed and applied to selected problems.
Prerequisites: MAST10007 Linear Algebra or MAST10008 Accelerated Mathematics 1. *It is recommended that students have completed either MAST30013 Techniques in Operations Research or MAST30022 Decision Making.*

Partial Differential Equations MAST90133 (o)
Subject Coordinator: Volker Schlue
This subject offers a wide ranging introduction to the modern theory of partial differential equations in pure mathematics. A starting point is the discussion of the classical equations (Laplace's equation, the heat equation, and the wave equation) which will lead us to the broader theory of elliptic, parabolic, and hyperbolic equations. The course covers mostly linear equations, but also exposes the student to some of the most interesting non-linear equations arising in physics and geometry. Further topics may include the calculus of variations, Hamilton–Jacobi equations, systems of conservation laws, non-linear elliptic equations, Schauder theory, quasi-linear hyperbolic equations, propagation of singularities, and blow-up phenomena.
Prerequisites: MAST20030 Differential Equations and MAST30021 Complex Analysis.

Practice of Statistics and Data Science MAST90027 (e)
Subject Coordinator: Ian Gordon
This subject builds on methods and techniques learned in theoretical subjects by studying the application of statistics in real contexts. Emphasis is on the skills needed for a practising statistician, including the development of mature statistical thinking, organising the structure of a statistical problem, the contribution to the design of research from a statistical point of view, measurement issues, and data processing. The subject deals with thinking about data in a broad context, and skills required in statistical consulting.
Prerequisites: Either MAST30025 Linear Statistical Models or MAST30027 Modern Applied Statistics.

Random Matrix Theory MAST90103 (e)
Subject Coordinator: Mario Kieburg
Random matrix theory is a diverse topic in mathematics. It draws together ideas from linear algebra, multivariate calculus, analysis, probability theory and mathematical physics, amongst other topics. It also enjoys a wide number of applications, ranging from wireless communication in engineering, to quantum chaos in physics, to the Riemann zeta function zeroes in pure mathematics. A self-contained development of random matrix theory will be undertaken in this course from a mathematical physics viewpoint. Topics to be covered include Jacobians for matrix transformations, matrix ensembles and their eigenvalue probability density functions, equilibrium measures, global and local statistical quantities, determinantal point processes, products of random matrices, and Dyson Brownian motion.
Prerequisites: MAST30021 Complex Analysis. *It is recommended that students have completed MAST20004 Probability and MAST30031 Methods of Mathematical Physics.*

Random Processes MAST90019
Subject Coordinator: Nathan Ross
This subject covers the key aspects of the theory of stochastic processes that play a central role in modern probability and have numerous applications in the natural sciences and industry. It begins with a discussion of ways to construct and specify random processes, then proceeds to distributional convergence of processes, the functional central limit theorem and its counterpart for empirical processes, and finally discusses Levy processes and more general continuous-time Markov processes. Applications to modelling random phenomena evolving in time are discussed throughout the course.
Prerequisites: MAST90081 Advanced Probability.

Representation Theory MAST90017 (o)
Subject Coordinator: Chenyan Wu
Symmetries arise in mathematics as groups and representation theory is the study of groups via their actions on vector spaces. It has important applications in many fields including physics, chemistry, economics and biology. This subject will provide the basic tools for studying actions on vector spaces. The course will focus on learning the basics of representation theory through some favourite examples: symmetric groups, diagram algebras, matrix groups and reflection groups. In each case the irreducible characters and irreducible modules for the group (or algebra) will be analysed, developing more and more powerful tools as the course proceeds. Examples that will form the core of the material for the course include SL_2, cyclic and dihedral groups, the Temperley–Lieb algebra, symmetric groups and Hecke algebras, Brauer and BMW algebras, and compact Lie groups. Among the tools and motivation that will play a role in the study are characters and character formulas, induction, restriction and tensor products, and connections to statistical mechanics, mathematical physics and geometry. If time permits, there may be some treatment of loop groups, affine Lie algebras and Dynkin diagrams.
Prerequisites: MAST30005 Algebra.

Riemann Surfaces and Complex Analysis MAST90056 (o)
Subject Coordinator: Paul Norbury
Riemann surfaces arise from complex analysis. They are central in mathematics, appearing in seemingly diverse areas such as differential and algebraic geometry, number theory, integrable systems, statistical mechanics and string theory.
The first part of the course studies complex analysis. It assumes students have completed a first course in complex analysis so begins with a quick review of analytic functions and Cauchy's theorem, emphasising topological aspects such as the argument principle and Rouche's theorem. Topics also include Schwarz's lemma, limits of analytic functions, normal families, the Riemann mapping theorem, multiple-valued functions, differential equations and Riemann surfaces.
The second part of the course studies Riemann surfaces and natural objects on them such as holomorphic differentials and quadratic differentials. Topics may also include divisors, the Riemann–Roch theorem, the moduli space of Riemann surfaces, Teichmüller space, and integrable systems.
Prerequisites: MAST30021 Complex Analysis.

<u>Scheduling and Optimisation</u> MAST90050 (o)
Subject Coordinator: Joyce Zhang
Scheduling is critical to manufacturing, mining, and logistics, and is of increasing importance in the healthcare and service industries. Most automated systems, ranging from elevators to industrial robots, embed some kind of scheduling algorithms. Building on the optimisation background provided by MAST90014 Optimisation for Industry, this subject teaches students how to solve more advanced problems. A particular focus will be scheduling problems, but other more general assignment problems will be discussed.
Prerequisites: MAST90014 Optimisation for Industry.

<u>Statistical Modelling</u> MAST90084
Subject Coordinator: Dennis Leung
Statistical models are central to applications of statistics and their development motivates new statistical theories and methodologies. Commencing with a review of linear and generalised linear models, analysis of variance and experimental design, the theory of linear mixed models is developed and model selection techniques are introduced. Approaches to non- and semi-parametric inference, including generalised additive models, are considered. Specific applications may include longitudinal data, survival analysis and time series modelling.
Prerequisites: MAST30025 Linear Statistical Models and MAST90082 Mathematical Statistics.

<u>Stochastic Calculus with Applications</u> MAST90059 (o)
Subject Coordinator: Xi Geng
This subject provides an introduction to stochastic calculus and the mathematics of financial derivatives. Stochastic calculus is essentially a theory of integration of a stochastic process with respect to another stochastic process, created for situations where conventional integration will not be possible. Apart from being an interesting and deep mathematical theory, stochastic calculus has been used with great success in numerous applications, from engineering and control theory to mathematical biology, the theory of cognition and financial mathematics.
Prerequisites: MAST30001 Stochastic Modelling and MAST30020 Probability for Inference.

16 Research Project: Thesis and Oral Presentation

16.1 Your Supervisor

It is expected that MSc students will have chosen a supervisor and the topic of their research project by the end of the first semester of their program at the latest. The School formally appoints a supervisor and a second examiner to each MSc student; any changes in supervisory arrangements must be reported to the Academic Support Officer within a week.

Most students see their supervisor about once a week, although this may vary and is negotiable between the student and the supervisor. Even if the student has not made substantial progress between visits, it is still a good idea to have regular meetings as that makes it possible for the supervisor to keep track of how the student is going.

The supervisor's role includes:

- Giving general course advice, including assistance with coursework subject selection and approval thereof.
- Helping the student with topic selection and/or modification.
- Directing the student to useful references on the project topic.
- Explaining difficult points.
- Providing students with feedback on the direction and progress of their research.
- Reading and commenting on thesis drafts (provided they are submitted sufficiently early; giving your supervisor a couple of weeks for reading your first draft is reasonable — the sooner your supervisor sees your work, the better).

- Giving students general advice on talk preparation.

The second examiner's only role is to prepare a short report justifying the mark they've awarded for the student's thesis and final presentation.

16.2 Your Thesis: General Advice

Although an MSc thesis in mathematics and statistics is not necessarily an original contribution to mathematical/statistical research, students are encouraged to make efforts towards making independent advances whenever possible. In any case, originality in the presentation of the thesis is certainly expected.

MSc students should be enrolled in the Research Project Component for three consecutive semesters. It is expected that during such a long time period, they will be able to produce well written theses on well researched topics. The students should study several sources (which are usually research papers and/or monographs) until it is thoroughly assimilated. Theses that are drawn from a single source are not acceptable.

The acquired knowledge and understanding of the area will form the basis of writing the thesis. In a good MSc research project, the student's own well written presentation of the subject is often complemented by independent advances in the direction of the study. Such original contributions are certainly more than welcome, but a student is ill-advised to start out determined to solve some outstanding classical problem. Progress in research is usually made by acquiring a good grasp of existing knowledge and answering successive small questions. If you do discover something new, be sure to consult with your supervisor and other staff members. They may be able to help you to go further or to save you from the embarrassment of a serious mistake.

The mathematical sciences are a very diverse research area and so MSc research projects can differ significantly in their nature. Some are essentially surveys of a particular advanced area of mathematics, others may include numerical investigations of particular problems, and some might fill in gaps in published papers. Accordingly, projects are assessed on criteria which take into account the general expectations of the research area being investigated and the different forms that a thesis may take. The general assessment criteria are listed in Section 8 and the weighting given to each of them will take into account the nature of the project. Note that in the final mark for the Research Project Component, the written thesis has a weight of 90%, while the mark for the final oral presentation contributes the remaining 10%.

MSc theses are expected to be around 40–60 pages in length, excluding references, appendices, figures and tables (the format of the thesis is discussed below, in Section 16.3). Please note that theses exceeding 60 typewritten pages put a considerable strain on the examiners and rarely get as much attention as they may deserve. Theses are not judged by their volume, but rather by their content.

The thesis must be prepared electronically as a PDF that may be printed on A4 size (297×210 mm) paper. The typing should be 1–1.5 spaced (not double spaced) and presented in a clear and legible 12pt font. All the margins should be 30 mm and page numbers should appear inside the margins. Pages should be numbered consecutively and clearly.

A thesis must be preceded by a title page. The title page of the thesis should show:

- The name of the School and the University.
- The title of the thesis.
- The full name of the author (as it appears on their enrolment record).
- The degree for which the thesis is being submitted.
- The month and year of submission.

The use of the University logo in the thesis is not permitted.

Before producing the final version of their thesis for submission, the student should ensure that all spelling, grammar, punctuation and choice of language are of an appropriate standard and that the bibliography is complete, exact and correctly formatted.

It is necessary to plan your work on the Research Project Component so that you will be able to submit it by the due date (see Section 12). If your progress has been significantly affected by circumstances outside your control, you can follow the standard procedures to apply for an extension to the Research Project submission due date. Extensions for up to two weeks can be granted by our MSc program coordinator, whereas requests for extensions for longer time periods require the student to apply for special consideration, see Section 9.

16.3 Your Thesis: How to Write It

Your thesis is an overview of what you have been exploring whilst working on your research project. Write it as if you were trying to explain the research topic to a fellow student. This does not mean that you should write a textbook or set of lecture notes. In particular, you may assume that the reader has a solid background equivalent to what is covered in the discipline subjects offered by the School.

The thesis should be a coherent, self-contained piece of work. Your writing should conform to a high standard of formal English. Aim at clarity, precision and correct grammar. Start sentences with capital letters and end them with fullstops. Never use contractions, i.e. write "do not" rather than "don't". Think hard about notation prior to writing up the thesis: it will save you a lot of time and help the reader to understand what you are trying to say. LaTeX macros are an excellent way to enforce good notation and have the advantage that they are easy to change if you find halfway through that your notational choice wasn't the best.

Your thesis should start with an introduction, preferably a couple of pages long, that explains what the project is about and what its contents are. Wise people always leave writing this part to the end, when you will know what needs explaining here. Often, including a short conclusion or summary is appropriate (again, a couple of pages). The introduction is usually followed by a literature review or background chapter, presenting the key results concerning the topic of your thesis that are already well known. What follows after that will depend on the nature of your project. If in doubt, ask your supervisor!

Be careful not to plagiarise: it is expected that the thesis will be written in your own words. Most importantly, for any fact, idea and result that appears in your thesis, the reader must be able to easily figure out if it is your own original result and, if not, then where you got it from. This means that good bibliographic referencing is a must: wherever some material has an external source, this should be clear to the reader. On the other hand, the list of references in your thesis should contain no items that are not referred to in the text.

There are many texts that try to explain (or demystify) the art of effective mathematical writing. This is completely subjective of course, but here are some favourites for your bedtime reading:

- A nice *Guide to Writing MSc Dissertations* by Bernhard von Stengel (Dept. of Mathematics, London School of Economics) can be found at

  http://www.maths.lse.ac.uk/Personal/stengel/TEXTE/diss-how-final.pdf

  It contains a lot of useful recommendations, including how to write mathematics and helpful LaTeX hints. In particular, you can use the format for bibliographic entries that is used in that paper.

- Another very useful (and interesting) resource is *Mathematical Writing* by Donald E. Knuth, Tracy Larrabee and Paul M. Roberts that can be found at

  https://tex.loria.fr/typographie/mathwriting.pdf

  In particular, their § 1 is an excellent "minicourse on technical writing".

- Yet one more instructive essay on the topic is *How to Write Mathematics* by Paul R. Halmos. It was published in *L'Enseignement Math.* 16 (1970), pp.123–152, and can be accessed at

  https://www.math.washington.edu/~lind/Resources/Halmos.pdf

Halmos also has an essay entitled *How to Talk Mathematics*, which appeared in the *Notices of the AMS* 21 (1974), pp.155–158, and can be accessed at

https://faculty.washington.edu/heagerty/Courses/b572/public/HalmosHowToTalk.pdf

Of course, a master like Halmos can get away with such a grammatically questionable title...

- Finally, for the *Ten Simple Rules For Mathematical Writing* by Dimitri Bertsekas (M.I.T.), see

  https://mit.edu/dimitrib/www/Ten_Rules.pdf

16.4 Your Final Presentation

In the last week of the last semester of your enrolment in the Research Project Component, you will have to give an oral talk at a student "miniconference" organised by the School. The exact date of the event will be announced around the middle of the semester.

About two weeks prior to the miniconference, you will be asked to submit the title and abstract of your talk (and possibly some further necessary information). The title should be the same as the thesis title, the abstract should not exceed 150 words. The standard policy of international conferences and research journals in mathematics and statistics is that the formulae usage in one's abstract should be reduced to an absolute minimum; the School asks you to comply with that policy as well. If you cannot avoid using formulae in your abstract, please use LaTeX commands for them in the body of your email (no attachments, no PDF files, etc. please).

Each talk will be assigned a fixed time slot (usually 30 or 40 minutes), which also includes time for questions. The exact amount of time given to speak will be communicated to you in the middle of semester. Please note that the final presentation is worth 10% of the Research Project mark. Criteria to be used to assess the presentation will include:

- Clarity of the presentation (both verbal and slides/writing).
- Knowledge displayed.
- Description of the main goal of the research project.
- Description of results and achievements.
- Keeping on time.
- Responses to questions.

As with the thesis, your talk must be aimed at an audience of your peers (and not at your supervisor). It should be self-contained as much as possible. Note that it is easy to overestimate what the audience understands — just because you (and/or your supervisor) understand everything in your presentation, it does not necessarily mean that the audience will. You should have attended sufficiently many research seminars during your MSc to know this.

The general advice is to start the talk with an accessible low-tech introduction, to make sure that everybody understands what your project is about. One is usually forced to pitch the talk at a higher level later on, but try to avoid situations where there is only one person in the room who understands what the speaker is talking about. It would be great if everybody in the audience could take something home from your talk.

Try to speak facing the audience and avoid spending too much time looking at the screen/board with your back to the audience (especially if you are writing on it). Make eye contact and, above all, never read verbatim from slides! If appropriate, you may wish to liven up your presentation with pictures that illustrate the concepts you are explaining. Remember that giving a presentation of any kind is putting you on a stage — your aim is to engage your audience (though it is not necessarily to entertain them).

There are two common methods for giving talks — writing on a board and preparing slides. Writing on a board is generally much slower, but this can be advantageous. Preparing slides takes a lot of time, but leaves you to tell your story unencumbered by the constraints of writing legibly (and at the pace you this is appropriate). Before deciding, discuss with your supervisor and perhaps try both when practising.

If you do decide to prepare slides for your presentation, there exist several LaTeX document classes that you can use for that purpose (**beamer** is perhaps the *de facto* standard at present). Using powerpoint is not recommended for some fields — ask your supervisor! In any case, it is very important to avoid overcrowding slides with text and, especially, formulae. The general recommendation is to have at most 10–12 lines of text/formulae on a slide, using a reasonably large font. Of course, one can pack much more material onto any given slide, but that would make it much harder for the audience to follow.

You are certainly encouraged to discuss with your supervisor which parts of the project should be covered in your talk. Moreover, some students give practice talks to their supervisors and fellow students a few days prior to the miniconference. An excellent way to improve your presentation skills is to go to the talks of other completing students. During your MSc studies, there will be multiple occasions for you to do that and see for yourself what works (and maybe what doesn't).

As a rule, a few questions are asked at the end of each talk. They are usually asked because the questioner wants to know the answer, not because somebody is trying to catch you out. Don't panic if you don't know the answer, just say frankly that you don't know (it may happen that nobody knows). Thanking the questioner for an instructive question/comment is always a good idea.

And don't be too nervous, everybody understands that it's likely to be your first important talk.

So good luck!!

Appendix A: Master of Science in Mathematics and Statistics Course Planning Form

Make sure you include this record in all email correspondence with the course coordinator regarding subject approvals and your study plan. This form is best completed using Adobe Acrobat.

Family name:	
Given names:	
Student number:	
Starting semester:	
Email address(es):	
Status:	☐ Part time ☐ Full time
Undergraduate:	☐ UoM ☐ non UoM
Specialisation:	☐ Applied Mathematics and Mathematical Biology (AMMB)
	☐ Mathematical Physics and Physical Combinatorics (MPPC)
	☐ Operations Research and Industrial Optimisation (ORIO)
	☐ Pure Mathematics (PURE)
	☐ Statistics and Stochastic Processes (SASP)
Supervisor:	
Research area(s):	

Program

Students must complete a total of 200 points comprising:

1. Discipline Subjects (137.5 points);
2. Professional Skills Subject (12.5 points);
3. Research Project Component (50 points over three consecutive semesters).

Each MSc candidate must complete eleven 12.5 point subjects as indicated in the following table.

Number of Subjects	Total Points	Chosen from...
Two	25	Compulsory master's-level subjects from the student's selected specialisation
Three	37.5	Elective master's-level subjects from the student's selected specialisation
Two	25	Any master's-level subjects from a single specialisation that is **not** the student's selected specialisation
Four	50	Any master's-level discipline subjects (see below). These four subjects may include up to two further discipline subjects offered by other schools.[a] Moreover, up to two of these subjects may be replaced by approved undergraduate subjects.[b]

Many of the discipline subjects are offered each year, but others are offered in alternate years. In the MSc Guide, subjects offered in odd years are labelled with (o), while those offered in even years are labelled with (e).

Full details can be found in Section 2.

Instructions for enrolling in courses

Step 1: Approval from the subject co-ordinator

If you have not taken the University of Melbourne (UoM) prerequisites for a subject, you will need to send an email the subject coordinator for their approval. In this case you should write a polite email to the subject coordinator requesting to enrol in their class. The email should include:

1. a copy of your academic transcript(s); and
2. a short explanation of which subjects you have taken which you believe are equivalent to the UoM prerequisites.

The names of subject coordinators for master's-level maths and stats subjects can be found in the MSc Guide. Contact information for faculty in maths and stats can be found here:

https://ms.unimelb.edu.au/people/academic-staff.

Step 2: Approval of the course coordinator

For undergraduate subjects and for subjects not taught by the School of Mathematics and Statistics (including the AMSI Summer School subject), you also need the approval of the course coordinator. In this case, you should first obtain the approval of the subject coordinator and then forward their approval email to the course coordinator with your request to enrol in the subject.

Step 3: Submit a Course Variation to Stop1, along with the relevant approval email(s)

The approved course plan with its variations will be recorded in the Student Portal.

[a]This may also include at most one **approved** AMSI Summer School subject; fees and enrolment rules apply to that subject (see Section 6 and https://ss.amsi.org.au/ for more detail).

[b]If it is necessary for the student to acquire the required knowledge for master's-level Mathematics and Statistics discipline subjects, up to two further master's-level subjects can be replaced with approved undergraduate subjects.

Plan

This is your course plan as well as your personal academic record. It is your responsibility to keep this record up to date. It is reasonable for it to be incomplete, especially early in your MSc.

Subject Category	**Passed**	**Name, semester, coordinator**	**Name, semester, coordinator**	**Name, semester, coordinator**	**Name, semester, coordinator**
Core					
Major elective					
Minor elective					
Professional Tools					
Other					

Schedule

1st Semester, date

Subject code and name	**Subject category**	**Prerequisites**	**Subject Coordinator approval**		**Course Coordinator approval**	
			Y	N	Y	N
			Y	N	Y	N
			Y	N	Y	N
			Y	N	Y	N

2nd Semester, date

Subject code and name	Subject category	Prerequisites	Subject Coordinator approval				Course Coordinator approval			
				Y		N		Y		N
				Y		N		Y		N
				Y		N		Y		N
				Y		N		Y		N

3rd Semester, date

Subject code and name	Subject category	Prerequisites	Subject Coordinator approval				Course Coordinator approval			
				Y		N		Y		N
				Y		N		Y		N
				Y		N		Y		N
				Y		N		Y		N

4th Semester, date

Subject code and name	**Subject category**	**Prerequisites**	**Subject Coordinator approval**		**Course Coordinator approval**	
			Y	N	Y	N
			Y	N	Y	N
			Y	N	Y	N
			Y	N	Y	N

5th Semester, date **(if required)**

Subject code and name	**Subject category**	**Prerequisites**	**Subject Coordinator approval**		**Course Coordinator approval**	
			Y	N	Y	N
			Y	N	Y	N
			Y	N	Y	N
			Y	N	Y	N

6th Semester, date (if required)

Subject code and name	**Subject category**	**Prerequisites**	**Subject Coordinator approval**		**Course Coordinator approval**	
			Y	N	Y	N
			Y	N	Y	N
			Y	N	Y	N
			Y	N	Y	N

Appendix B: Graduate Diploma (Advanced) in Mathematics and Statistics
Course Planning Form

Make sure you include this record in all email correspondence with the course coordinator regarding subject approvals and your study plan. This form is best completed using Adobe Acrobat.

Family name:

Given names:

Student number:

Starting semester:

Email address(es):

Status: ☐ Part time ☐ Full time

Undergraduate: ☐ UoM ☐ non UoM

Specialisation:
- ☐ Applied Mathematics and Mathematical Biology (AMMB)
- ☐ Mathematical Physics and Physical Combinatorics (MPPC)
- ☐ Operations Research and Industrial Optimisation (ORIO)
- ☐ Pure Mathematics (PURE)
- ☐ Statistics and Stochastic Processes (SASP)

Research area(s):

Program

Students must complete a total of 100 points comprising:

1. Master's-level discipline subjects from a single specialisation in the Mathematics and Statistics MSc ($\geq$37.5 points);
2. Additional master's-level subjects in the Mathematics and Statistics MSc ($\geq$12.5 points);
3. Undergraduate-level subjects in Mathematics and Statistics ($\leq$50 points).

Many of the discipline subjects are offered each year, but others are offered in alternate years. In the MSc Guide, subjects offered in odd years are labelled with (o), while those offered in even years are labelled with (e).

Not all subjects with a MAST90xxx code are master's-level elective subjects. You must consult the Handbook and Guide to be sure the subject you are choosing is part of the GDA program.

Full details can be found in Section 2.2.

Instructions for enrolling in courses

Step 1: Approval from the subject co-ordinator

If you have not taken the University of Melbourne (UoM) prerequisites for a subject, you will need to send an email the subject coordinator for their approval. In this case you should write a polite email to the subject coordinator requesting to enrol in their class. The email should include:

1. a copy of your academic transcript(s); and
2. a short explanation of which subjects you have taken which you believe are equivalent to the UoM prerequisites.

The names of subject coordinators for master's-level maths and stats subjects can be found in the MSc Guide. Contact information for faculty in maths and stats can be found here:

https://ms.unimelb.edu.au/people/academic-staff.

Step 2: Approval of the course coordinator

For undergraduate subjects and for subjects not taught by the School of Mathematics and Statistics (including the AMSI Summer School subject), you also need the approval of the course coordinator. In this case, you should first obtain the approval of the subject coordinator and then forward their approval email to the course coordinator with your request to enrol in the subject.

Step 3: Submit a Course Variation to Stop1, along with the relevant approval email(s)

The approved course plan with its variations will be recorded in the Student Portal.

Plan

This is your course plan as well as your personal academic record. It is your responsibility to keep this record up to date. It is reasonable for it to be incomplete, especially early in your GDA.

Subject Category	**Passed**	**Name, semester, coordinator**	**Name, semester, coordinator**	**Name, semester, coordinator**	**Name, semester, coordinator**
Major					
MSc elective					
Undergraduate					

Schedule

1st Semester, date

Subject code and name	**Subject category**	**Prerequisites**	**Subject Coordinator approval**	**Course Coordinator approval**
			Y N	Y N
			Y N	Y N
			Y N	Y N
			Y N	Y N

2nd Semester, date

Subject code and name	Subject category	Prerequisites	Subject Coordinator approval				Course Coordinator approval			
				Y		N		Y		N
				Y		N		Y		N
				Y		N		Y		N
				Y		N		Y		N

3rd Semester, date

Subject code and name	Subject category	Prerequisites	Subject Coordinator approval				Course Coordinator approval			
				Y		N		Y		N
				Y		N		Y		N
				Y		N		Y		N
				Y		N		Y		N