School of Mathematics and Statistics
Course Advice for Undergraduates
2022

THE UNIVERSITY OF MELBOURNE

This document is provided to assist students with subject selection, but it is not an official statement of the University of Melbourne's rules and subject descriptions. The official details will be published in the University of Melbourne Handbook for 2022:

handbook.unimelb.edu.au

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A. Ground rules for the BSc Degree

BSc course requirements

The Bachelor of Science requires the successful completion of 300 points comprising:

- 225 points of Science discipline subjects including:
    - At least 62.5 points at Level 1
    - At least 62.5 points at Level 2
    - At least 75 points at Level 3
- 50 points of breadth including:
    - No more than 37.5 points at Level 1
    - At least 12.5 points at Level 2 or 3
- 25 points of free choice subjects at Levels 1 to 3 (science electives or breadth subjects)
- No more than 125 points may be taken at Level 1.

First Year Requirements

Students must complete first year level subjects from at least two different areas of study. A maximum of 37.5 points at first year level from any single area of study may be completed. In particular, students are not permitted to complete all four of MAST10005 Calculus 1, MAST10006 Calculus 2, MAST10007 Linear Algebra and MAST10010 Data Analysis 1. The areas of study available are: Biology; Chemistry; Earth Sciences; Engineering Systems; Geography and Environments; Computer Science; Mathematics and Statistics; Physics; Psychology.

Major Requirements

Students must complete 50 points of a prescribed science major at Level 3 as part of their 75 points of Level 3 Science discipline subjects. Only one major is recorded on the final transcript of results, even if the requirements for two majors have been met.

Special Arrangements

In the case of the study area of History and Philosophy of Science (HPS), students who seek to undertake further subjects in order to complete the equivalent of a major in HPS will be permitted to take up to 100 points of breadth study in HPS, replacing 25 points of the Science requirements of the BSc. These students will be required to satisfy all other completion requirements of the BSc.

Progression

Students must normally complete 50 points of study at one year level before proceeding to the next year level.

Breadth Tracks

The University has developed breadth sequences, or 'tracks', that identify coherent groups of breadth subjects and allow students to extract the maximum benefit from the breadth component of their degree. Students are encouraged to take at least one 37.5 point (three subject) breadth track.

Note: these rules apply to students who started the BSc between 2011 and 2021. Different rules apply to students commencing the Bachelor of Science in 2022 or later. Refer to the University Handbook for the course requirements for students commencing in 2022.

B. Majors within the Bachelor of Science

Students wishing to specialise in mathematics and statistics may choose to complete one of the following majors in the Bachelor of Science, offered by the School of Mathematics and Statistics.

Major in Mathematics and Statistics

Mathematics and Statistics are at the leading edge of knowledge, providing important new insights into nature, technology and business, while drawing on a rich history of ideas as old as civilisation itself. This major will enable you to gain depth of knowledge in a specialised area, as well as equip you with transferable skills related to conceptual understanding, how to analyse and solve problems, and teamwork. These are powerful tools for understanding science and the world of economics and finance, as well as in the study of human behaviour in the fields of psychology, linguistics and the social sciences.

Within this major, students must complete at least one of the following specialisations:

- **Applied Mathematics**
- **Discrete Mathematics and Operations Research**
- **Pure Mathematics**
- **Statistics and Stochastic Processes**

Information about the subjects required for each specialisation is given on pages 2-3.

Major in Data Science

The major in Data Science has an emphasis on statistics and computer science. It provides a strong foundation in the statistical aspects of data analysis (data collection, data mining, modelling and inference), as well as the principles of computer science (algorithms, data structures, data management and machine learning). The major is designed to give students an intellectual understanding of how to integrate and apply statistical and computing principles to solve large scale, real-world data science problems. It is suitable for students interested in a career in government or industry or who wish to pursue specialised graduate study. Information about the Data Science major is given on page 4.

Major in Mathematical Physics

There is also a major in Mathematical Physics, which includes pathways to further study in both physics and mathematics. This major has been developed by the School of Mathematics and Statistics in conjunction with the School of Physics. Information about subject choices for the Mathematical Physics major is given on page 4.

Suggested course plans for each major/specialisation

On the following pages are some suggested course plans leading to the majors and specialisations described above. Only the third year subjects form the requirements for a major. The first and second year subjects are suggestions that will give the pre-requisites for the third year subjects in each area of specialisation. To modify the third year level subjects specified in a specialisation of the Mathematics and Statistics major requires written approval; contact Stop 1 for more information.

Mathematics and Statistics Major

For more information contact the major co-ordinator: Dr Marcy Robertson

Applied Mathematics Specialisation

Can we predict how an ecological system will evolve as a result of changes in environmental conditions? How will a chemical process behave with changing inputs? How does a financial system react to variations in economic or political situations?

All of these real life systems are incredibly complicated. Increasing our understanding of how they operate requires the development of reliable and accurate mathematical models. These can help explain observations in chemical, physical, biological or financial systems allowing us to describe and predict their future behaviour under certain conditions. The discipline of applied mathematics is largely devoted to the development of principles and techniques that will allow us to solve the mathematical problems that arise from the construction of these models.

One of the projects undertaken in the School involved a non-flying moth, Bombyx mori. The moth fans its wings solely to enhance the sampling of chemicals scents in the environment. A mathematical model was developed for the airflow around antennae hairs to understand how insects sample a scent.

First year

One of the first year mathematics and statistics pathways (see page 9)

Second year

Real Analysis *or* Real Analysis: Advanced

Vector Calculus *or* Vector Calculus: Advanced

Differential Equations

Plus one of

COMP20005 Engineering Computation *

PHYC20013 Laboratory and Computational Physics *

COMP10001 Foundations of Computing * †

Third year (major)

Complex Analysis

Numerical Methods and Scientific Computing

Plus two of

Applied Mathematical Modelling

Biological Modelling and Simulation

Methods of Mathematical Physics

Stochastic Modelling

Note:

* Students who can provide evidence of competence in computer programming are not required to take these subjects. Evidence could include passing a relevant Year 12 subject, or a statement of achievement from a relevant MOOC, or passing a programming competency test administered by another University of Melbourne School. For full details see the Handbook entry for MAST30028 Numerical Methods and Scientific Computing.

† COMP10001 may be taken in first year.

Discrete Mathematics and Operations Research Specialisation

Many businesses and large complex organisations face difficult decisions on a daily basis. For example, a manufacturing company may have to decide how much of each product it should be making at each point in time, how many products of each type it should keep in inventory, by what modes of transport and by what routes it should distribute its product, which workers should be rostered on which shifts, when it should replace or repair its equipment and so on. The decisions made may interact with each other and have complex repercussions that are difficult to evaluate. Each decision involves making a trade-off between competing activities, often vying for limited resources.

Operations research and discrete mathematics provide a scientific approach to support this decision-making. Operations research involves formulating mathematical models and developing or applying mathematical tools to obtain the optimal solution. Algorithm development, whereby the most efficient mathematical solutions are programmed on a computer, is a primary topic within discrete mathematics, and also a major area of research in the School. Consulting work is conducted in these fields for business, industry, government and community groups.

First year

One of the first year mathematics and statistics pathways (see page 9)

Second year

Real Analysis *or* Real Analysis: Advanced

Discrete Maths and Operations Research

Plus one of

Probability

Probability for Statistics

Third year (major)

Complex Analysis

Discrete Mathematics

Techniques in Operations Research

Plus one of

Decision Making

Graph Theory

Linear Statistical Models

Stochastic Modelling

Pure Mathematics Specialisation

Mathematics is both an art and a science, and pure mathematics is its foundation. Pure mathematics is the study of the basic concepts that underlie all mathematical applications. Much of pure mathematics was developed to solve practical problems from physics or other sciences. For example, differential geometry was developed in response to the needs of mapmakers. Topology, the study of geometrical structures, was developed to study aspects of physics and today has applications in genetics. Calculus was invented to solve the problems of geometry and mechanics. Algebra has its roots in ancient methods for solving equations.

Of course mathematical theories are also studied for their own sake and some of these have found application much later on. An example of this is number theory, which is now used to ensure the secure transmission of data.

Pure mathematics is as vigorous and lively now as at any time in history. At the University of Melbourne we are involved in developing new methods and techniques for solving theoretical and practical problems in the areas of topology, geometry, analysis and algebra.

First year

One of the first year mathematics and statistics pathways (see page 9)

Second year

Real Analysis *or* Real Analysis: Advanced

Vector Calculus *or* Vector Calculus: Advanced

Group Theory and Linear Algebra

Third year (major)

Complex Analysis

Algebra

Metric and Hilbert Spaces

Plus one of

Graph Theory

Geometry

Discrete Mathematics

Statistics and Stochastic Processes Specialisation

Abstract models cannot capture the full complexity of the environment, the marketplace, or biological entities. So, knowledge about these systems is always uncertain, and decision-making is always risky.

Applied statistics develops, tests, and deploys tools that measure, control, and reduce uncertainty. Fast computers, modern computer languages, and advanced graphics are integral to applied statistics and have led to an explosion in the variety and complexity of techniques that are now used. Applied statistics comprises experimental design, estimation of model parameters, testing of models, testing of hypotheses and the use of models to make predictions about the future. Statistics is applied everywhere, from testing cures for cancer to constructing better models of bushfire behaviour.

Stochastic processes provide models for the random processes that are a crucial part of our environment. They are essential to understanding the behaviour of complex systems such as financial markets, living organisms, populations of individuals, genetics, evolution, the Internet, epidemics, queues, networks, and earthquakes. Researchers in stochastic processes at Melbourne develop new models for these random phenomena and explore their properties.

First year

One of the first year mathematics and statistics pathways (see page 9)

Second year

Real Analysis *or* Real Analysis: Advanced

Statistics

Plus one of

Probability

Probability for Statistics

Third year (major)

Linear Statistical Models

Stochastic Modelling

Plus at least one of

Probability for Inference

Modern Applied Statistics

Plus (if only one of the subjects Probability for Inference and Modern Applied Statistics was chosen)

Any other level-3 MAST subject offered by the School of Mathematics and Statistics

Data Science Major

For more information contact the major co-ordinator: Dr Nathan Ross

The major in Data Science has an emphasis on statistics and computer science. It provides a strong foundation in the statistical aspects of data analysis (data collection, data mining, modelling and inference), as well as the principles of computer science (algorithms, data structures, data management and machine learning). The major is designed to give students an intellectual understanding of how to integrate and apply statistical and computing principles to solve large scale, real-world data science problems. It is suitable for students interested in a career in government or industry or who wish to pursue specialised graduate study.

First year

One of the first year mathematics and statistics pathways (see page 9)

Plus

COMP10001 Foundations of Computing

COMP10002 Foundations of Algorithms

Second year

MAST20005 Statistics

COMP20008 Elements of Data Processing

Plus one of

MAST20004 Probability

MAST20006 Probability for Statistics

Third year (major)

MAST30025 Linear Statistical Models

MAST30027 Modern Applied Statistics

MAST30034 Applied Data Science

COMP30027 Machine Learning

Mathematical Physics Major

For more information contact the major co-ordinator: Dr Thomas Quella

Since before the dawn of science, humankind has strived to understand and predict natural physical phenomena such as the motion of the planets, weather patterns and the melting and freezing of water. Mathematical physics is concerned with describing these natural phenomena in a precise way using abstract mathematical models of the real world. Isaac Newton invented calculus to justify his universal law of gravitation and Albert Einstein used Minkowski and Riemannian geometries to give precise mathematical meaning to his theories of special and general relativity. Remarkably, mathematics is the natural language to describe physics and, just as importantly, the discovery of many of the most beautiful objects in mathematics were inspired by physics.

A common theme within this discipline is statistical mechanics, which describes the thermodynamic behaviour and phase transitions of large complex systems by averaging the behaviour of individual components. Specific projects in the School apply these methods to study the diverse behaviours of fluids, magnets, polymers, percolation, random matrices and random walks.

First year

One of the first year mathematics and statistics pathways (see page 9)

Plus one of

PHYC10001 Physics 1 (Advanced)

PHYC10003 Physics 1

PHYC10005 Physics 1: Fundamentals

Plus one of

PHYC10002 Physics 2 (Advanced)

PHYC10004 Physics 2: Physical Science and Technology

PHYC10006 Physics 2: Life Sciences & Environment

Second year

MAST20026 Real Analysis *or* MAST20033 Real Analysis: Advanced

MAST20009 Vector Calculus *or* MAST20032 Vector Calculus: Advanced

PHYC20012 Quantum and Thermal Physics

PHYC20013 Laboratory and Computational Physics 2

PHYC20015 Special Relativity and Electromagnetism

Plus one of

MAST20022 Group Theory and Linear Algebra

MAST20030 Differential Equations

Third year (major)

MAST30021 Complex Analysis

PHYC30018 Quantum Physics

Plus one of

MAST30026 Metric and Hilbert Spaces

MAST30031 Methods of Mathematical Physics

Plus one of

PHYC30016 Electrodynamics

PHYC30017 Statistical Physics

Computing electives for Mathematics and Statistics majors

In many areas of employment for Mathematics and Statistics majors, as well as further study in many areas of mathematics and statistics, modern computing skills are an important requirement. The Computing and Software Systems (CSS) major offers level-2 subjects as one pathway to a CSS major in third year. Any of these subjects would provide useful computing electives for Mathematics and Statistics majors, whether taken in second or third year.

The pathway starting from level-2 subjects is the combination:

Second year

Semester 1:

COMP20005 Engineering Computation

Note: Engineering Systems Design 2 is given as a recommended background for this subject, but is not required for Mathematics and Statistics majors. This subject satisfies the computing prerequisite for the core Applied Mathematics subject MAST30028 Numerical Methods and Scientific Computing.

*Semester 2**:***

COMP20003 Algorithms and Data Structures

and/or

SWEN20003 Object-oriented Software Development

First year electives

Note that students may do the above subjects without doing first year computer science subjects. If students wish to include first year computing subjects, suitable options are

COMP10001 Foundations of Computing

COMP10002 Foundations of Algorithms

C. Third-year opportunities in Mathematics and Statistics

Outstanding students majoring in Mathematics and Statistics, Data Science or Mathematical Physics or completing a Diploma in Mathematical Sciences may be eligible to undertake an undergraduate research project through the Faculty of Science's general subject SCIE30001 Science Research Project.

These students may also be eligible to take one MAST-coded masters-level subject during their undergraduate degree through the Mathematics and Statistics Graduate Extension Program. This subject may then be credited towards a subsequent Master of Science in Mathematics and Statistics or Data Science.

For more details of these programs and eligibility criteria, see

https://ms.unimelb.edu.au/study/current-students/third-year-opportunities

In addition, there is also the Mathematics and Statistics Vacation Scholarship program that allows second- and third-year students to undertake a paid undergraduate research project during the summer semester. Information about the Vacation Scholarship program is available at

https://ms.unimelb.edu.au/engage/vacation-scholarships

D. Diploma in Mathematical Sciences

The Diploma in Mathematical Sciences provides a way for students to complete the equivalent of a Major in Mathematics and Statistics in a concurrent diploma alongside a major in another area as part of a bachelor degree.

The Diploma in Mathematical Sciences is available in combination with the Bachelor of Science, Commerce, Biomedicine, Arts, Design and Music. Students enrolled in the Bachelor of Science majoring in Mathematics and Statistics, Data Science or Mathematical Physics are not permitted to complete a Diploma in Mathematical Sciences.

Students undertaking a Diploma must complete a minimum of 350 points and a maximum of 400 points for their bachelor degree plus the Diploma including at least 100 points of Mathematics and Statistics subjects.

Within the Diploma, students will complete the requirements of the mathematics and statistics major from the Bachelor of Science. Students must complete one of the four specialisations in the major in Mathematics and Statistics:

- Applied Mathematics
- Discrete Mathematics and Operations Research
- Pure Mathematics
- Statistics and Stochastic Processes

The Diploma may be taken in a variety of 'Fast Track' modes or by adding the full 100 points (i.e. one full year) to their degree. The mode of undertaking the diploma will depend on each student's particular circumstances and study preferences, including whether they meet the criteria for permission to overload. The overload policy requires a particular level of performance/achievement be attained for permission to overload. Fast Track modes will involve cross crediting of up to 50 points and/or overloading in one, two or all three years of the course.

Students may apply for entry at any time from the start of their degree to the commencement of their final semester. The Diploma is subject to a competitive selection process. It is recommended that students complete their first year of study including two subjects from those on which the Diploma is built before applying. These two subjects will be classified as breadth in some degrees and core in others. Performance in these subjects will be considered in the competitive selection process for the Diploma.

Under some degree programs and some areas of major studies it is not possible to do two first year subjects in the mathematics and statistics major in first year. Students in this situation will need to apply for entry at the commencement of first year. In this case, students must have completed VCE Mathematical Methods 3/4 or equivalent. Entry will be competitive, based on achievement in VCE Mathematical Methods 3/4 (or equivalent) and, if taken, VCE Specialist Mathematics 3/4 or equivalent.

Note that in some cases students will be required to complete a total of 125 points of mathematics and statistics study to complete a maths sequence as required by the Diploma. Note that only 100 points of this 125 points of study can be completed in the Diploma and therefore any additional points required must be completed within the bachelors degree or via the Community Access Program.

For sample course pathways, visit

https://ms.unimelb.edu.au/study/mslc/course-advice

E. Mathematics and Statistics to complement major studies in other disciplines

Students planning to major in another discipline will also benefit by taking some mathematics and statistics subjects in their degree to complement their major studies. Mathematics and statistics subjects that complement major studies in other disciplines are shown below.

Enabling mathematics education

Prospective secondary school mathematics teachers must take a minimum of two mathematics and statistics subjects at the Level 1 and two mathematics and statistics subjects at Level 2. However, for greater flexibility of choice in second year and a richer knowledge base, students are advised to take three mathematics and statistics subjects at Level 1, three mathematics and statistics subjects at Level 2, and some subjects at Level 3. Any of the subjects listed below would be very useful for students wishing to teach mathematics.

First year

One of the first year mathematics and statistics pathways (see page 9)

Data Analysis 1

Second year

Real Analysis

Vector Calculus

Discrete Maths and Operations Research

Probability for Statistics

Third year

Graph Theory

Discrete Mathematics

Enhancing biological, environmental and social sciences studies

Students who are interested in the biological, environmental or social sciences are advised to take at least one unit in mathematics and one unit in statistics. The subjects Data Analysis 1 and Analysis of Biological Data are very useful for students who will be involved in designing experiments and collecting and analysing data.

First year

Calculus 1

Calculus 2

Data Analysis 1

Second year

Analysis of Biological Data

Enabling further studies in bioinformatics

Bioinformatics is a multidisciplinary area of study involving mathematics and statistics, computer science and biology. There are increasing research and employment opportunities in this area.

Students with a major in mathematics and statistics are eligible to apply for entry to the Master of Science (Bioinformatics), provided they have completed the equivalent of Probability for Statistics and Statistics. The first year of the Masters degree will then consist of subjects from computer science, genetics and physiology. Mathematics and statistics students that wish to pursue further studies in bioinformatics should take the following subjects.

First year	**Second year**
One of the first year mathematics	Probability for Statistics
and statistics pathways (see page 9)	Statistics

Enhancing computer science applications

Students taking major studies in computer science would benefit from studying subjects that are included in the specialisations of operations research and discrete mathematics. Below is a list of subjects that complement studies in computer science.

First year	**Second year**	**Third year**
One of the first year	Real Analysis	Graph Theory
mathematics and statistics	Probability	Discrete Mathematics
pathways (see page 9)	Discrete Maths and Operations Research	Decision Making

Enhancing studies in the physical sciences

Students who major in physics are required to take the mathematics subjects listed below or equivalent subjects.

Students who are interested in taking further elective subjects in mathematics would benefit from taking more subjects listed in the mathematical physics major.

First year	**Second year**
One of the first year mathematics	Vector Calculus *or* Vector Calculus: Advanced
and statistics pathways (see page 9)	*Plus one of*
	Real Analysis *or* Real Analysis: Advanced
	Differential Equations

Enhancing commerce applications

Students enrolled in a Bachelor of Commerce interested in finance, economic theory, econometrics and business decision-making would benefit from studying any of the subjects listed below.

First year core subjects

One of the first year mathematics and statistics pathways (see page 9)

Second year core subjects

Probability for Statistics

Statistics

Real Analysis

Second and third year electives

The following subjects are useful for economic theory:

Vector Calculus

Group Theory and Linear Algebra

Complex Analysis

Algebra

Metric and Hilbert Spaces

Geometry

The following subjects are useful for econometrics:

Linear Statistical Models

Stochastic Modelling

Probability for Inference

Modern Applied Statistics

The following subjects are useful for business decision-making:

Discrete Maths and Operations Research

Complex Analysis

Decision Making

Discrete Mathematics

Techniques in Operations Research

Mathematics options for engineering systems majors

Students completing one of the engineering systems majors are required to take the core mathematics subjects listed below.

First year core subjects (all streams)

One of the first year mathematics and statistics pathways (see page 9)

Second year core subjects for Bioengineering, Biomedical, Biomolecular, Chemical, Civil, Environmental, Mechanical and Mechatronics Systems

Engineering Mathematics

Or both of

Vector Calculus#

Differential Equations#

Second year core subjects for Electrical Systems

Engineering Mathematics

Or

Real Analysis

Elective subjects for engineering systems majors

Students interested in taking mathematics subjects to complement one of the engineering systems majors would benefit from taking any of the subjects listed below.

Second year

Real Analysis

Vector Calculus#

Discrete Maths and Operations Research

Probability

Differential Equations#

Third year

Complex Analysis

Numerical Methods and Scientific Computing

Applied Mathematical Modelling

Note:

Students who want to get credit for Engineering Mathematics and either or both of Differential Equations and Vector Calculus must take Engineering Mathematics before Differential Equations or Vector Calculus.

Breadth

Mathematics and statistics subjects can be taken as breadth in the Bachelor of Arts, Bachelor of Commerce, Bachelor of Design and Bachelor of Music degrees.

The School offers one first year level University breadth subject UNIB10006 Critical Thinking with Data. Information about this subject can be found on page 18. University Breadth Subjects examine current critical issues using techniques and approaches from multiple disciplines across faculties. University breadth subjects are available to all students in the Bachelors of Science, Commerce, Biomedicine, Design, Arts and Music.

The School has three breadth tracks to assist students with choosing breadth subjects that form a coherent set of study: accelerated mathematics, mathematics and statistics, mathematics for economics. Details about the breadth tracks are available in the 2022 University Handbook.

To find out what breadth subjects are permitted in the Bachelor of Science or any other degree, see the University Handbook website or the direct link:

https://breadth.unimelb.edu.au/

F. First Year Mathematics and Statistics Pathways

Students intending to continue to level-2 (second-year) mathematics and statistics should take one of the first-year mathematics and statistics pathways below. Which pathway(s) you can take depends on the level of mathematics that you completed at school and on your grades.

Completing one of these pathways satisfies the prerequisites for level-2 mathematics and statistics subjects.

The information below is intended for students commencing in semester 1. Students commencing mid-year are recommended to seek individual course advice. Students who have completed secondary school outside Victoria or who have completed the International Baccalaureate should seek advice from a course advisor about what first year level mathematics subjects are appropriate for their background.

MAST10005 Calculus 1 Stream

For students who completed VCE Mathematical Methods 3/4 but not VCE Specialist Mathematics 3/4, or achieved a VCE Specialist Mathematics 3/4 study score ≤ 29, or equivalent.

In this pathway, students take three first-year mathematics subjects:

- MAST10005 Calculus 1 *(semester 1 and 2)*
  MAST10006 Calculus 2 *(semester 1, 2 and summer)*
  MAST10007 Linear Algebra *(semester 1, 2 and summer)*

Note: Students with a study score of 29 may choose to do either Calculus 1 or Calculus 2. Students with a study score of 27 or 28 may choose to do Linear Algebra concurrently with Calculus 1.

Students who achieve a MAST10005 grade ≥ 80 can take MAST10021 Calculus 2: Advanced instead of MAST10006 Calculus 2 and/or MAST10022 Linear Algebra: Advanced instead of MAST10007 Linear Algebra if they wish.

Students who start their mathematics at the level of Calculus 1 are strongly advised to take Calculus 2 in semester 2 of first year and Linear Algebra over summer to retain full choice in the specialisations they can complete in the mathematics and statistics major. If Linear Algebra and/or Calculus 2 are not taken until semester 1 of second year, then it is not possible to complete a specialisation in Applied Mathematics or Pure Mathematics within 3 years.

Bachelor of Science students are permitted to complete a maximum of three level-1 Mathematics and Statistics subjects. They are **not** permitted to complete all four of MAST10005 Calculus 1, MAST10006 Calculus 2, MAST10007 Linear Algebra and MAST10010 Data Analysis 1.

Standard Stream

For students with a study score ≥ 29 in VCE Specialist Mathematics 3/4 or equivalent.

Our flagship first-year subjects cover the essential material with a focus on computation and applications. They are perfect for students who need to know mathematics in their chosen major or who want to broaden their education.

In this pathway, students take two first-year mathematics subjects:

- MAST10006 Calculus 2 (*semester 1, 2 and summer)*
- MAST10007 Linear Algebra (*semester 1, 2 and summer)*

Bachelor of Science students in this stream can also take MAST10010 Data Analysis 1 *(semester 2)* if they wish.

Advanced Stream

For students with a study score ≥ 36 in VCE Specialist Mathematics 3/4 or equivalent.

The advanced stream is for students who want to understand the core first-year material in greater depth than would be possible in MAST10006/10007 or MAST10008/10009. This stream features more emphasis on mathematical proof, formal logic and communication than the accelerated or standard streams. It is designed for strong students interested in the beauty of formal mathematics, particularly those who intend to study higher level mathematics, statistics, physics and mathematical physics.

In this pathway, students take two first-year mathematics subjects:

- MAST10022 Linear Algebra: Advanced *(semester 1)*
- MAST10021 Calculus 2: Advanced *(semester 2)*

Bachelor of Science students in this stream can also take MAST10010 Data Analysis 1 *(semester 2)* if they wish.

Students taking this stream are encouraged to continue to the second-year advanced subjects MAST20032 Vector Calculus: Advanced and/or MAST20033 Real Analysis: Advanced.

Accelerated Stream

For students with a study score ≥ 38 in VCE Specialist Mathematics 3/4 or equivalent.

The accelerated stream is for strong students who want to quickly cover the core first-year mathematics material as well as the equivalent of a second-year subject MAST20026 Real Analysis in two semesters. This rapid treatment also has more emphasis on mathematical proof than MAST10006 and MAST10007. This stream is highly recommended for Bachelor of Commerce students looking to major in Actuarial Studies.

In this pathway, students take two first-year mathematics subjects:

- MAST10008 Accelerated Mathematics 1 *(semester 1)*
- MAST10009 Accelerated Mathematics 2 *(semester 2)*

Bachelor of Science students in this stream can also take MAST10010 Data Analysis 1 *(semester 2)* if they wish.

The subjects in this stream are equivalent, in content, to the standard stream subjects MAST10006 Calculus 2 and MAST10007 Linear Algebra, plus the level-2 subject MAST20026 Real Analysis. Students who complete the accelerated stream do not take MAST20026 Real Analysis in their second year.

Students with a Specialist Mathematics 3/4 study score of 35-37 may apply to sit an additional test, the Advanced Placement Test (APT), to seek entry to the accelerated stream. Potential APT candidates should contact the APT co-ordinator Dr Anthony Morphett for information.

Introductory Stream (Bachelor of Arts, Design and Music only)

Students in the Bachelor of Arts, Bachelor of Design, or Bachelor of Music who have completed VCE Mathematical Methods 1/2 only, or have a study score < 25 in VCE Mathematical Methods 3/4, can take an additional subject MAST10012 Introduction to Mathematics. After completing MAST10012, students can proceed to the MAST10005 Calculus 1 stream and/or MAST10010 Data Analysis 1.

G. Subjects offered by the School of Mathematics and Statistics

Level-1 subject choices

The School of Mathematics and Statistics is offering the following level-1 subjects in 2022.

	Subject	Semester	Entry requirements
Introductory Stream	MAST10012 Introduction to Mathematics	1	VCE Mathematical Methods 1/2 or equivalent
Standard Mathematics Stream	MAST10005 Calculus 1	1, 2	VCE Mathematical Methods 3/4 (study score ≥ 25) or equivalent
	MAST10006 Calculus 2	1, 2, summer	VCE Specialist Maths 3/4 (study score ≥ 29) or equivalent
	MAST10007 Linear Algebra	1, 2, summer	VCE Specialist Maths 3/4 (study score ≥ 27) or equivalent
Advanced Mathematics Stream	MAST10022 Linear Algebra: Advanced	1	VCE Specialist Maths 3/4 (study score ≥ 36) or equivalent
	MAST10021 Calculus 2: Advanced	2	VCE Specialist Maths 3/4 (study score ≥ 36) or equivalent
Accelerated Mathematics Stream	MAST10008 Accelerated Mathematics 1	1	VCE Specialist Maths 3/4 (study score ≥ 38) or equivalent
	MAST10009 Accelerated Mathematics 2	2	VCE Specialist Maths 3/4 (study score ≥ 38) or equivalent
Statistics	MAST10010 Data Analysis 1	2	VCE Mathematical Methods 3/4 (study score ≥ 25) or equivalent
Bachelor of Biomedicine Foundation Subjects	MAST10011 Experimental Design and Data Analysis	1	Entry to BBiomed
	MAST10016 Mathematics for Biomedicine	2	Entry to BBiomed
Breadth	UNIB10006 Critical Thinking with Data	1	

Level-2 subject choices

At level-2, the School of Mathematics and Statistics offers subjects in pure and applied mathematics, probability and statistics, discrete maths and operations research. Students may focus on a single area or pursue interests in several areas. This may be in the form of recommended combinations of subjects at level-2 and level-3 for one of the mathematics and statistics specialisations, or subject choices to support studies in other majors or courses.

The level-2 subjects offered by the School of Mathematics and Statistics in 2022 are listed in the table below. For detailed information on prerequisites and credit exclusions, see the individual subject entries.

Semester 1 only	MAST20006 Probability for Statistics
	MAST20031 Analysis of Biological Data
	MAST20032 Vector Calculus: Advanced
	MAST20033 Real Analysis: Advanced
Semester 1 and 2	MAST20004 Probability
	MAST20009 Vector Calculus
	MAST20026 Real Analysis
Semester 2 only	MAST20018 Discrete Maths and Operations Research
	MAST20022 Group Theory and Linear Algebra
	MAST20030 Differential Equations
Semester 2 and summer	MAST20005 Statistics
Semester 1, 2 and summer	MAST20029 Engineering Mathematics

Brief Subject Descriptions for Second Year

MAST20004 Probability

Almost all real-life processes involve elements of randomness, so it is very important to be able to describe and model such situations. Probability theory is part of mathematics concerned with modeling and analyzing random phenomena. It provides foundation for statistics, which is essential to all human activities involving data analysis, and has numerous applications in sciences and industry, ranging from DNA analysis to telecommunications and stock trading. This subject offers grounding in probability theory and its applications.

MAST20005 Statistics

Statistics concerns the collection and analysis of data to make inferences about the parameters of a probability model. This subject introduces the mathematical theory underlying modern statistical inference. In particular, it demonstrates that many commonly used statistical procedures arise as applications of a common theory. Distribution free and Bayesian statistical methods are also introduced, along with the statistical computing software needed to implement statistical procedures.

MAST20006 Probability for Statistics

This subject develops the probability theory that is necessary to understand statistical inference. Properties of probability are reviewed, random variables are introduced, and probability models are systematically developed. Methods for studying the distributions of functions of random variables are also developed along with techniques to obtain the exact and approximate distributions of sums of random variables.

MAST20009 Vector Calculus

Vector calculus extends the ideas and tools of calculus to apply to scalar and vector fields, which represent quantities such as temperature, velocity fields or magnetic fields. It generalizes derivatives and integrals to vector differential operators, line, surface and volume integrals and relates them by various integral theorems. Curvilinear coordinates are introduced and used to evaluate integrals. Vector calculus is an important tool for many applications in physics and engineering such as electromagnetism, fluid mechanics and quantum mechanics.

MAST20018 Discrete Maths and Operations Research

This subject introduces operations research methods, which are used in business and industry to optimize processes and resource allocation, using mathematical techniques such as linear programming implemented using the simplex method. It also introduces the area of discrete mathematics as applied to social sciences, covering how mathematical reasoning can be used in scheduling, graph theory, matchings and fair division.

MAST20022 Group Theory and Linear Algebra

This subject introduces the theory of groups, which is at the core of modern algebra, and which has applications in many parts of mathematics, chemistry, computer science and theoretical physics. It also develops the theory of linear algebra, building on material in earlier subjects and providing both a basis for later mathematics studies and an introduction to topics that have important applications in science and technology.

MAST20026 Real Analysis

Real analysis is a branch of mathematics that deals with real functions and sequences, including convergence and limits of sequences of real numbers, continuity, smoothness and related properties of real-valued functions, and differential and integral calculus. It is a critically important tool in mathematics and statistics. It is a starting point for areas such as complex analysis and functional analysis. This is a corner-stone subject for students whose studies involve mathematical sciences.

MAST20029 Engineering Mathematics

This subject introduces important mathematical methods required in engineering such as manipulating vector differential operators, computing multiple integrals and using integral theorems. A range of ordinary and partial differential equations are solved by a variety of methods and their solution behaviour is interpreted. The subject also introduces sequences and series including the concepts of convergence and divergence.

MAST20030 Differential Equations

Differential equations arise as common models in the physical, mathematical, biological and engineering sciences. This subject covers linear differential equations, both ordinary and partial, using concepts from linear algebra to understand the structure of the general solutions. It balances basic theory with concrete applications.

MAST20031 Analysis of Biological Data

This subject introduces fundamental concepts in data science for biology, with emphasis on modern statistical methods. Drawing on real biological problems and datasets, as well as drawing on data collected by the class, the lectures cover foundational concepts in experimental design and statistical modelling. The subject emphasises hands-on problem solving. As well as a solid grounding in statistical methodology, students will also develop practical skills, develop capacity to design experiments, collect data, and analyse those data using the R statistical environment.

MAST20032 Vector Calculus: Advanced

This subject covers the material presented in MAST20009 Vector Calculus plus additional material designed to provide deeper insight into interesting areas of calculus and has a greater emphasis on mathematical rigour and proof. This subject studies the fundamental concepts of functions of several variables and vector calculus.

MAST20033 Real Analysis: Advanced

This subject introduces the field of mathematical analysis both with a careful theoretical framework as well as selected applications. Many of the important results are proved rigorously and students are introduced to methods of proof such as mathematical induction and proof by contradiction.

Level-3 subject choices

The level-3 subjects offered by the School of Mathematics and Statistics in 2022 are listed in the table below. For detailed information on prerequisites and credit exclusions, see the individual subject entries.

Semester 1 only	MAST30005 Algebra
	MAST30011 Graph Theory
	MAST30013 Techniques in Operations Research
	MAST30020 Probability for Inference
	MAST30025 Linear Statistical Models
	MAST30030 Applied Mathematical Modelling
	MAST30032 Biological Modelling and Simulation
Semester 1 and 2	MAST30021 Complex Analysis
Semester 2 only	MAST30001 Stochastic Modelling
	MAST30012 Discrete Mathematics
	MAST30022 Decision Making
	MAST30024 Geometry
	MAST30026 Metric and Hilbert Spaces
	MAST30027 Modern Applied Statistics
	MAST30028 Numerical Methods and Scientific Computing
	MAST30031 Methods of Mathematical Physics
	MAST30033 Statistical Genomics
	MAST30034 Applied Data Science

Brief Subject Descriptions for Third Year

MAST30001 Stochastic Modelling

Stochastic processes occur widely in diverse areas such as finance, telecommunications, genetics, chemistry, speech pathology and more. This subject introduces and develops the theory of stochastic processes with an emphasis on Markov chains, and illustrates this theory using a range of examples from the real world.

MAST30005 Algebra

Algebra has a long history of important applications throughout mathematics, science and engineering, and is also studied for its intrinsic beauty. In this subject we study the algebraic laws satisfied by familiar objects such as integers, polynomials and matrices. Abstraction simplifies and unifies our understanding of these structures and enables us to apply our results more broadly. Students will gain experience with abstract algebraic concepts and methods. General structural results are proved and algorithms developed to determine the invariants they describe.

MAST30011 Graph Theory

This subject is an introduction to the modern field of graph theory. It emphasises the relationship between proving theorems in mathematics and the construction of algorithms to find the solutions of mathematical problems, within the context of graph theory. The subject provides material that supplements other areas of study such as operations research and computer science.

MAST30012 Discrete Mathematics

This is a core subject on discrete mathematics and is independent of the second year subject Discrete Maths and Operations Research. The subject consists of five main topics, three of which are bijective aspects of permutations and combinations, recursive structures relating to the Fibonacci sequence, and combinatorics of the Rubik cube. This material is of broad relevance to higher level mathematics, and offers a view of applied mathematics distinct from continuum modelling.

MAST30013 Techniques in Operations Research

This subject introduces a number of basic techniques of operations research. It develops the formulation of operations research models and algorithms with application in production planning, scheduling, inventory management and capital budgeting. Case studies and projects are undertaken and computer packages utilized.

MAST30020 Probability for Inference

This subject provides a bridge between introductory probability and the more rigorous measure theoretic approach. Probability is developed in the framework of measure theory but the emphasis is on the concepts and techniques required for advanced probability, stochastic processes and statistics.

MAST30021 Complex Analysis

Complex analysis is a core subject in pure and applied mathematics, as well as the physical and engineering sciences. While it is true that physical phenomena are given in terms of real numbers and real variables, it is often too difficult and sometimes not possible, to solve the algebraic and differential equations used to model these phenomena without introducing complex numbers and complex variables and applying the powerful techniques of complex analysis.

MAST30022 Decision Making

This subject introduces the essential features of decision-making situations encountered in operations research investigations through the development of basic mathematical approaches. It shows how to construct formal mathematical models for practical decision-making situations such as two-person games, multi-objective optimisation problems and stochastic decision problems. It shows students further uses of linear programming and introduces dynamic programming techniques.

MAST30024 Geometry

This subject introduces three areas of geometry that play a key role in many branches of mathematics and physics. In differential geometry, calculus and the concept of curvature will be used to study the shape of curves and surfaces. In topology, geometric properties that are unchanged by continuous deformations will be studied to find a topological classification of surfaces. In algebraic geometry, curves and surfaces defined by polynomial equations will be explored. Remarkable connections between these areas will be discussed.

MAST30025 Linear Statistical Models

Linear models are central to the theory and practice of modern statistics. They are used to model a response as a linear factor of explanatory variables and are the most widely used statistical models in practice. Starting with examples from a range of application areas this subject develops an elegant unified theory that is illustrated on a variety of common models and experimental designs.

MAST30026 Metric and Hilbert Spaces

This core subject provides a basis for further studies in modern analysis, geometry, topology, differential equations and quantum mechanics. It introduces the idea of a metric space with a general distance function, and the resulting concepts of convergence, continuity, completeness and compactness. The subject also introduces Hilbert spaces: infinite dimensional vector spaces (typically function spaces) equipped with an inner product that allows geometric ideas to be used to study these spaces and the linear maps between them.

MAST30027 Modern Applied Statistics

Modern applied statistics combines the power of modern statistical computing packages and theoretical statistics. It extends linear models to allow responses that are not normally distributed or whose mean is a non-linear function of predictors. It also makes extensive use of computer intensive techniques to explore the sampling distribution of estimators.

MAST30028 Numerical Methods and Scientific Computing

Most mathematical problems arising from the physical sciences, engineering, life sciences and finance are sufficiently complicated to require computational methods for their solution. This subject introduces students to the process of numerical approximation and computer simulation, applied to simple and commonly encountered stochastic or deterministic models. An emphasis is on the development and implementation of algorithms for the solution of continuous problems including aspects of their efficiency, accuracy and stability.

MAST30030 Applied Mathematical Modelling

This subject demonstrates how the mathematical modelling process naturally gives rise to certain classes of ordinary and partial differential equations in many contexts. This includes the modelling of infectious diseases, the flow of traffic and the dynamics of fluids. It advances the student's knowledge of the modelling process, as well as addressing important mathematical ideas in deterministic modelling and the challenges of system non-linearity.

MAST30031 Methods of Mathematical Physics

This subject builds on, and extends earlier, related undergraduate subjects with topics that are useful to applied mathematics, mathematical physics and physics students, as well as pure mathematics students interested in applied mathematics and mathematical physics. These include special functions, such as Legendre and Bessel functions, more general formulations of vector calculus using differential forms, Hilbert spaces, and Lie groups and algebras.

MAST30032 Biological Modelling and Simulation

This subject introduces the concepts of mathematical and computational modelling of biological systems, and how they are applied to data in order to study the underlying drivers of observed behaviour. The subject emphasises the role of abstraction and simplification of biological systems and requires an understanding of the underlying biological mechanisms. Combined with an introduction to sampling-based methods for statistical inference, students will learn how to identify common patterns in the rich and diverse nature of biological phenomena and appreciate how the modelling process leads to new insight into biological phenomena.

MAST30033 Statistical Genomics

This subject introduces the biology and technology underlying modern genomics data, features of the resulting data types including the frequency and patterns of error and missingness, and the statistical methods used to analyse them. It will include hands-on data analysis using R software. The material covered will span the following four areas: introduction to genomics technology and the resulting data, population genetics including stochastic models and statistical inference, association analysis including tests of association and major sources of confounding, and heritability and prediction both in human genetics and for animal and plant breeding.

MAST30034 Applied Data Science

This subject is the capstone subject for the data science major. The subject combines statistical reasoning and practical computing skills to solve challenging problems with big data. Students work in groups to formulate and implement a major project in data science.

Detailed Subject Descriptions

Please refer to the University handbook for further information about these subjects, including contact persons and recommended texts.

Level-1 subjects

MAST10005 Calculus 1

Credit points: 12.5

Prerequisites: A study score of 25 or more in VCE Mathematical Methods 3/4 or equivalent, or MAST10012 Introduction to Mathematics, or both of MAST10014 Foundation Mathematics 1 and MAST10015 Foundation Mathematics 2.

Note: Students with a study score of 30 or more in VCE Specialist Mathematics 3/4 or equivalent may not enrol in this subject for credit. Such students should enrol in one of MAST10006 Calculus 2, MAST10007 Linear Algebra, MAST10008 Accelerated Mathematics 1, MAST10009 Accelerated Mathematics 2, MAST10021 Calculus 2: Advanced or MAST10022 Linear Algebra: Advanced.

Students with a study score of 29 in VCE Specialist Mathematics 3/4 or equivalent, are eligible to enrol in MAST10005 Calculus 1, MAST10006 Calculus 2 or MAST10007 Linear Algebra. Such students should seek course advice before completing their enrolment.

Credit Exclusions: Students who have completed any of the following may not enrol in this subject for credit:

- MAST10006 Calculus 2
- MAST10008 Accelerated Mathematics 1
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced
- MAST10022 Linear Algebra: Advanced

Students may not enrol in MAST10005 Calculus 1 and MAST10006 Calculus 2 concurrently.

Bachelor of Science students are permitted to complete a maximum of three first year level Mathematics and Statistics subjects. They are not permitted to complete all of MAST10005, MAST10006, MAST10007 and MAST10010.

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week, 1 x one hour workshop per week. *(Semester 1 and 2)*

Description: This subject extends students' knowledge of functions and calculus and introduces them to the topics of vectors and complex numbers. Students will be introduced to new functions such as the inverse trigonometric functions and learn how to extend the techniques of differentiation to these. Integration techniques will be applied to solving first order differential equations.

Differential calculus: graphs of functions of one variable, trigonometric functions and their inverses, derivatives of inverse trigonometric functions, implicit differentiation, related rates. Integral calculus: integration by trigonometric and algebraic substitutions and partial fractions with application to areas and volumes. Ordinary differential equations: solution of simple first order differential equations arising from applications such as population modelling. Vectors: dot product, scalar and vector projections, plane curves specified by vector equations. Complex numbers: arithmetic of complex numbers, sketching regions in the complex plane, De Moivre's Theorem, roots of polynomials, the Fundamental Theorem of Algebra.

Assessment: Eight to ten assignments (written or online) due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%). Up to one third of the assignment based assessment will be completed online.

MAST10006 Calculus 2

Credit points: 12.5

Prerequisites: A study score of at least 29 in VCE Specialist Mathematics 3/4, or equivalent, or one of

- MAST10005 Calculus 1
- MAST10007 Linear Algebra

Note: Students with a study score of 40 or more in VCE Specialist Mathematics 3/4 are strongly encouraged to enrol in both of MAST10008 Accelerated Mathematics 1 and MAST10009 Accelerated Mathematics 2 or both of MAST10021 Calculus 2: Advanced and MAST10022 Linear Algebra: Advanced instead of MAST10006 Calculus 2 and MAST10007 Linear Algebra.

Students with a study score of 29 in VCE Specialist Mathematics 3/4 or equivalent, are eligible to enrol in MAST10005 Calculus 1, MAST10006 Calculus 2 or MAST10007 Linear Algebra. Such students should seek course advice before completing their enrolment.

Credit Exclusions: Students may only gain credit for one of

- MAST10006 Calculus 2
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Students may not enrol in MAST10005 Calculus 1 and MAST10006 Calculus 2 concurrently.

Bachelor of Science students are permitted to complete a maximum of three first year level Mathematics and Statistics subjects. They are not permitted to complete all of MAST10005, MAST10006, MAST10007 and MAST10010.

Contact Hours: Semester 1 and 2: 3 x one hour lectures per week, 1 x one hour practice class per week.

Summer semester: 6 x one hour lectures per week, 2 x one hour practice classes per week

Description: This subject will extend knowledge of calculus from school. Students are introduced to hyperbolic functions and their inverses, the complex exponential and functions of two variables. Techniques of differentiation and integration will be extended to these cases. Students will be exposed to a wider class of differential equation models, both first and second order, to describe systems such as population models, electrical circuits and mechanical oscillators. The subject also introduces sequences and series including the concepts of convergence and divergence.

Calculus topics include: intuitive idea of limits and continuity of functions of one variable, sequences, series, hyperbolic functions and their inverses, level curves, partial derivatives, chain rules for partial derivatives, directional derivative, tangent planes and extrema for functions of several variables. Complex exponential topics include: definition, derivative, integral and applications. Integration topics include: techniques of integration and double integrals. Ordinary differential equations topics include: first order (separable, linear via integrating factor) and applications, second order constant coefficient (particular solutions, complementary functions) and applications.

Assessment: Semester 1 and 2: Eight to ten assignments (written or online) due at regular intervals during semester (approximately 30 hours total, worth 20%), and a 3-hour written examination in the examination period (80%). Up to one third of the assignment based assessment will be completed online.

Summer semester: 4 to 5 assignments (written or online) due at regular intervals during semester (approximately 30 hours total, worth 20%), and a 3-hour written examination in the examination period (80%). Up to one third of the assignment based assessment will be completed online.

MAST10007 Linear Algebra

Credit points: 12.5

Prerequisites: A study score of at least 27 in VCE Specialist Mathematics 3/4, or equivalent, or one of

- MAST10005 Calculus 1
- MAST10006 Calculus 2

Note: Students with a study score of 40 or more in VCE Specialist Mathematics 3/4 are strongly encouraged to enrol in both of MAST10008 Accelerated Mathematics 1 and MAST10009 Accelerated Mathematics 2 or both of MAST10021 Calculus 2: Advanced and MAST10022 Linear Algebra: Advanced instead of MAST10006 Calculus 2 and MAST10007 Linear Algebra.

Students with a study score of 29 in VCE Specialist Mathematics 3/4 or equivalent, are eligible to enrol in MAST10005 Calculus 1, MAST10006 Calculus 2 or MAST10007 Linear Algebra. Such students should seek course advice before completing their enrolment.

Credit Exclusions: Students may only gain credit for one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Bachelor of Science students are permitted to complete a maximum of three first year level Mathematics and Statistics subjects. They are not permitted to complete all of MAST10005, MAST10006, MAST10007 and MAST10010.

Contact Hours: Summer Semester: 6 x one hour lectures per week, 2 x one hour practice classes per week, 2 x one hour computer laboratory classes per week.

Semester 1 and 2: 3 x one hour lectures per week, 1 x one hour practice class per week, 1 x one hour computer laboratory class per week *(Semester 1, 2 and summer)*

Description: This subject gives a solid grounding in key areas of modern mathematics needed in science and technology. It develops the concepts of vectors, matrices and the methods of linear algebra. Students should develop the ability to use the methods of linear algebra and gain an appreciation of mathematical proof. Little of the material here has been seen at school and the level of understanding required represents an advance on previous studies.

Systems of linear equations, matrices and determinants; vectors in real n-space, cross product, scalar triple product, lines and planes; vector spaces, linear independence, basis, dimension; linear transformations, eigenvalues, eigenvectors; inner products, least squares estimation, symmetric and orthogonal matrices.

Assessment: Semester 1 and 2: Eight to ten assignments (written or online) due at regular intervals during semester amounting to a total of up to 25 pages (20%), one 45-minute computer laboratory test held at the end of semester (10%), and a 3-hour written examination in the examination period (70%). To pass the subject a mark of at least 40% is required on the written examination. Up to one third of the assignment based assessment will be completed online.

Summer semester: Five assignments, either written or online, due at weekly intervals during semester amounting to a total of up to 25 pages (20%), one 45-minute computer laboratory test held at the end of semester (10%), and a 3-hour written examination in the examination period (70%). To pass the subject a mark of at least 40% is required on the written examination. Up to two of the five assignment based assessments will be completed online.

MAST10008 Accelerated Mathematics 1

Note: This subject, along with MAST10009 Accelerated Mathematics 2, forms the accelerated stream of first-year mathematics. The accelerated stream is suitable for students with a high level of achievement in VCE Specialist Mathematics 3/4 or equivalent who want to quickly cover the core first-year mathematics material as well as the equivalent of a second-year subject MAST20026 Real Analysis in two semesters. This rapid treatment also has more emphasis on mathematical proof than MAST10006 and MAST10007. This stream is highly recommended for Bachelor of Commerce students looking to major in Actuarial Studies.

This subject, together with MAST10009 Accelerated Mathematics 2 is equivalent in content to the three subjects

- MAST10006 Calculus 2
- MAST10007 Linear Algebra
- MAST20026 Real Analysis

Credit points: 12.5

Prerequisites: A study score of at least 38 in VCE Specialist Mathematics 3/4 or equivalent, or

- MAST10009 Accelerated Mathematics 2 or
- permission from the Director of the Mathematics and Statistics Learning Centre

Credit Exclusions: Students may only gain credit for one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Contact Hours: 4 x one hour lectures per week, 1 x one hour practice class per week, 1 x one hour computer laboratory class per week *(Semester 1)*

Description: This subject develops the concepts of vectors, matrices and the methods of linear algebra and introduces students to differentiation and integration of functions of two variables. Students will be exposed to methods of mathematical proof. Little of the material here has been seen at school and the level of understanding required represents an advance on previous studies. Underlying concepts developed in lectures will be reinforced in computer laboratory classes.

Topics covered include systems of linear equations, matrices and determinants, vector geometry, lines and planes, vector spaces, subspaces, linear independence, bases, dimension, inner products, linear transformations, eigenvalues and eigenvectors, complex eigenvalues and exponentials as well as techniques of proof, partial derivatives, chain rule for partial derivatives, directional derivatives, tangent planes, extrema for functions of several variables and double integrals.

Assessment: Six assignments, either written or online, due at regular intervals during semester amounting to a total of up to 25 pages (15%, equally weighted), a 45-minute computer laboratory test held at the end of semester (5%), and a 3-hour written examination in the examination period (80%)

MAST10009 Accelerated Mathematics 2

Note: This subject, along with MAST10008 Accelerated Mathematics 1, forms the accelerated stream of first-year mathematics. The accelerated stream is suitable for students with a high level of achievement in VCE Specialist Mathematics 3/4 or equivalent who want to quickly cover the core first-year mathematics material as well as the equivalent of a second-year subject MAST20026 Real Analysis in two semesters. This rapid treatment also has more emphasis on mathematical proof than MAST10006 and MAST10007. This stream is highly recommended for Bachelor of Commerce students looking to major in Actuarial Studies.

This subject, together with MAST10008 Accelerated Mathematics 1 is equivalent in content to the three subjects

- MAST10006 Calculus 2
- MAST10007 Linear Algebra
- MAST20026 Real Analysis

Credit points: 12.5

Prerequisites: A study score of at least 38 in VCE Specialist Mathematics 3/4 or equivalent, or MAST10008 Accelerated Mathematics 1, or permission from the Director of the Mathematics and Statistics Learning Centre

Credit Exclusions: Students may only gain credit for one of

- MAST10006 Calculus 2
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Students may only gain credit for one of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Contact Hours: 4 x one hour lectures per week, 1 x one hour practice class per week. *(Semester 2)*

Description: This subject develops fundamental concepts and principles in mathematical analysis. Students should gain skills in the practical techniques of differential calculus, integral calculus and infinite series, and study selected applications of these techniques in mathematical modelling.

Topics covered: rigorous discussion of limits of sequences and of real-valued functions, continuity and differentiability; Mean Value Theorem and applications; Taylor polynomials; Riemann integration, techniques of integration and applications, improper integrals; infinite series, with applications to power series representations of elementary functions and their generation by Taylor series and to the representation of periodic functions by Fourier series; first order differential equations, second order linear differential equations with constant coefficients and selected applications.

Assessment: Two or three written assignments due at regular intervals during semester amounting to a total of up to 25 pages (10%), a 45-minute written test held mid-semester (10%), and a 3-hour written examination in the examination period (80%).

MAST10010 Data Analysis 1

Credit points: 12.5

Prerequisites: A study score of 25 or more in VCE Mathematical Methods 3/4 or equivalent, or MAST10012 Introduction to Mathematics, or both of MAST10014 Foundation Mathematics 1 and MAST10015 Foundation Mathematics 2.

Credit Exclusions: Students may only gain credit for one of

- MAST10010 Data Analysis 1
- MAST10011 Experimental Design and Data Analysis
- ECON10005 Quantitative Methods 1

Students who have completed the following may not enrol in this subject for credit

- MAST20005 Statistics

Note: Bachelor of Science students are permitted to complete a maximum of three first year level Mathematics and Statistics subjects. They are not permitted to complete all of MAST10005, MAST10006, MAST10007 and MAST10010.

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week, 1 x one hour computer laboratory class per week. *(Semester 2)*

Description: This subject lays the foundations for an understanding of the fundamental concepts of probability and statistics required for data analysis. Students should develop expertise in some of the statistical techniques commonly used in the design and analysis of experiments, and will gain experience in the use of a major statistical computing package. They should develop skills in collecting random samples, data description, basic statistical inference including parametric and nonparametric tests to compare population proportions and means, data manipulation and statistical computing. The methods will be illustrated using applications from science, engineering and commerce. Descriptive statistics, data manipulation and the implementation of the statistical procedures covered in lectures will be reinforced in the computer laboratory classes.

Sampling; introduction to experimental design; review of simple probability; estimation; confidence intervals; hypothesis testing including types of errors and power; inferences about means and proportions based on single and independent samples; matched pairs designs; introduction to nonparametric methods; contingency tables; regression; and analysis of variance.

Assessment: Ten online quizzes due at weekly intervals during semester (10%), two written assignments due during semester amounting to a total of up to 25 pages (10%), one 45-minute computer based test at the end of semester (10%), and a 3-hour written examination in the examination period (70%).

MAST10021 Calculus 2: Advanced

Note: This subject, along with MAST10022 Linear Algebra: Advanced, forms the advanced stream of first-year mathematics. The advanced stream is suitable for students with a high level of achievement in VCE Specialist Mathematics 3/4 or equivalent and who want to understand the core first-year material in greater depth than would be possible in MAST10006/10007 or MAST10008/10009. This stream features more emphasis on mathematical proof, formal logic and communication than the accelerated or standard streams. It is designed for strong students interested in the beauty of formal mathematics, particularly those who intend to study higher level mathematics, statistics, physics and mathematical physics.

Credit Points: 12.5

Prerequisites: One of:

- A study score of at least 36 in VCE Specialist Mathematics 3/4, or equivalent
- MAST10005 Calculus 1 with a mark of at least 80%
- MAST10007 Linear Algebra with a mark of at least 75%
- MAST10018 Linear Algebra Extension Studies with a mark of at least 75%
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST10006 Calculus 2
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: This subject covers the same material as MAST10006 Calculus 2, but to a greater depth including a greater emphasis on mathematical rigour and proof.

Students are introduced to the complex exponential function, even and odd functions and functions of two or more variables. Techniques of differentiation and integration will be extended to these cases. Students will be exposed to a wider class of differential equation models, both first and second order, to describe systems such as population models, electrical circuits and mechanical oscillators. The subject also introduces sequences and series including the concepts of convergence and divergence. In addition to the intuitive understanding of convergence, students will see the mathematical definition of convergence.

Calculus topics include: limits and continuity of functions of one variable, sequences, series, hyperbolic functions and their inverses, level curves, partial derivatives, chain rules for partial derivatives, directional derivative, tangent planes and extrema for functions of several variables. Complex exponential topics include: definition, derivative, integral and applications. Integration topics include: techniques of integration and double integrals. Ordinary differential equations topics include: first order (separable, linear via integrating factor) and applications, second order constant coefficient (particular solutions, complementary functions) and applications.

Assessment: Eight to ten assignments (written or online) due at regular intervals during semester (approximately 30 hours in total, worth 20%), and a 3-hour written examination in the examination period (80%). Up to one third of the assignment based assessment will be completed online.

MAST10022 Linear Algebra: Advanced

Note: This subject, along with MAST10021 Calculus 2: Advanced, forms the advanced stream of first-year mathematics. The advanced stream is suitable for students with a high level of achievement in VCE Specialist Mathematics 3/4 or equivalent and who want to understand the core first-year material in greater depth than would be possible in MAST10006/10007 or MAST10008/10009. This stream features more emphasis on mathematical proof, formal logic and communication than the accelerated or standard streams. It is designed for strong students interested in the beauty of formal mathematics, particularly those who intend to study higher level mathematics, statistics, physics and mathematical physics.

Credit Points: 12.5

Prerequisites: One of:

- A study score of at least 36 in VCE Specialist Mathematics 3/4, or equivalent
- MAST10005 Calculus 1 with a mark of at least 80%
- MAST10006 Calculus 2 with a mark of at least 75%
- MAST10019 Calculus Extension Studies with a mark of at least 75%
- MAST10021 Calculus 2: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week, 1 x one hour computer laboratory class per week *(Semester 1)*

Description: This subject covers the same material as MAST10007 Linear Algebra, but to a greater depth including a greater emphasis on mathematical rigour and proof.

This subject gives a solid grounding in key areas of modern mathematics needed in science and technology. It develops the concept of a vector space, including linear transformations, matrices and the methods of linear algebra. There will be an emphasis on the axiomatic treatment of vector spaces, linear transformations, and inner product spaces.

Students will develop the ability to use the methods of linear algebra and gain an appreciation of mathematical proof including the ability to prove results about vector spaces.

Topics covered include: systems of linear equations; matrices and determinants; vectors in real n-space, cross product, lines and planes; general vector spaces; linear independence; bases and dimension; linear transformations; eigenvalues and eigenvectors; inner product spaces; symmetric and orthogonal matrices; diagonalisation of linear transformations and matrices.

Assessment: Eight to ten assignments (written or online) due at regular intervals during semester (approximately 15 hours in total, 20%), one 45-minute computer laboratory test held at the end of semester (10%), and a 3-hour written examination in the examination period (70%). Up to one third of the assignment based assessment will be completed online. To pass the subject a mark of at least 40% is required on the written examination.

UNIB10006 Critical Thinking with Data

Credit points: 12.5

Prerequisites: None

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week. *(Semester 1)*

Description: This subject teaches students to become critical users of data-based evidence. Future journalists, political scientists, sociologists, lawyers, health professionals, psychologists, environmental scientists, business people, engineers, scientists and teachers will develop skills in identifying the strengths and weaknesses of arguments and reports based on quantitative evidence, and learn to evaluate reasoning that uses probabilistic ideas.

Data-based evidence is found in the media, in academic research and in many aspects of everyday life. The subject examines ways of judging the quality of quantitative information, and the strength of conclusions drawn from it, including concerns in establishing causality. It discusses how variability may be characterised and modelled in a wide variety of settings including public opinion, health, sport, legal disputes, and the environment. It covers good and bad ways of examining evidence in data. The subject deals with judging the likelihood of events, common pitfalls in thinking about probability, measuring risk in medical contexts and quantifying uncertainty in conclusions. It describes how data-based evidence can contribute to the accumulation of knowledge.

Assessment: Six short assignments due at regular intervals during semester: three written amounting to a total of up to 600 words and three assessed on-line (30%), 10 weekly on-line revision quizzes (5%), a group project involving production of a poster and a 4-minute oral presentation due after mid-semester (10%), one 1200 word written assignment due at the end of semester (15%), and a 2 hour written examination in the examination period (40%).

Level-2 subjects

MAST20004 Probability

Note: Students undertaking Actuarial Studies should take MAST20004 Probability in semester 1, instead of MAST20006 Probability for Statistics.

Credit Points: 12.5

Prerequisites: One of

- MAST10006 Calculus 2 (with a mark of at least 60)
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies (with a mark of at least 60)
- MAST10021 Calculus 2: Advanced (with a mark of at least 60)

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST20004 Probability
- MAST20006 Probability for Statistics

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week, and 1 x one hour computer laboratory class per week *(Semester 1 and 2)*

Description: This subject offers a thorough grounding in the basic concepts of mathematical probability and probabilistic modelling. Topics covered include random experiments and sample spaces, probability axioms and theorems, discrete and continuous random variables/distributions (including measures of location, spread and shape), expectations and generating functions, independence of random variables and measures of dependence (covariance and correlation), methods for deriving the distributions of transformations of random variables or approximations for them (including the central limit theorem).

The probability distributions and models discussed in the subject arise frequently in real world applications. These include a number of widely used one- and two-dimensional (particularly the bivariate normal) distributions and also fundamental probability models such as Poisson processes and Markov chains.

Assessment: Four written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST20005 Statistics

Credit Points: 12.5

Prerequisites: One of

- MAST20004 Probability
- MAST20006 Probability for Statistics

Credit Exclusions: Passing MAST20005 Statistics precludes subsequent credit for either of

- MAST10010 Data Analysis 1
- MAST10011 Experimental Design and Data Analysis

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week, and 1 x one-hour computer laboratory class per week *(Semester 2)*

6 x 1 hour lectures per week, 2 x one hour practice classes per week, and 2 x one hour computer laboratory classes per week. *(Summer semester)*

Description: This subject introduces the basic elements of statistical modelling, computation and data analysis. It is an entry point to further study of both mathematical and applied statistics, as well as broader data science.

Students will develop the ability to fit statistical models to data, estimate parameters of interest and test hypotheses. Both classical and Bayesian approaches will be covered. The importance of the underlying mathematical theory of statistics and the use of modern statistical software will be emphasised.

Concepts covered include: descriptive statistics, random sample, statistical inference, point estimation, interval estimation, properties of estimators, maximum likelihood, confidence intervals, hypothesis testing and Bayesian inference. Applications covered include: exploratory data analysis, inference for samples from univariate distributions, simple linear regression, correlation, goodness-of-fit tests and analysis of variance.

Assessment: Semester 2: Three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), a 45-minute computer laboratory test held at the end of semester (10%), and a 3-hour written examination in the examination period (70%).

Summer semester: Two written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), a 45-minute computer laboratory test held at the end of semester (10%), and a 3-hour written examination in the examination period (70%).

MAST20006 Probability for Statistics

Note: Students undertaking Actuarial Studies should take MAST20004 Probability instead of MAST20006 Probability for Statistics.

Credit Points: 12.5

Prerequisites: One of

- MAST10006 Calculus 2
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10010 Data Analysis 1
- MAST10011 Experimental Design and Data Analysis
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST20004 Probability
- MAST20006 Probability for Statistics

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week, and 1 x one hour computer laboratory class per week *(Semester 1)*

Description: This subject develops the probability theory that is necessary to understand statistical inference. Properties of probability are reviewed, random variables are introduced, and their properties are developed and illustrated through common univariate probability models. Models for the joint behaviour of random variables are introduced, along with conditional probability and Markov chains. Methods for obtaining the distributions of functions of random variables are considered along with techniques to obtain the exact and approximate distributions of sums of random variables. These methods will be illustrated through some well known normal approximations to discrete distributions and by obtaining the exact and approximate distributions of some commonly used statistics. Computer packages are used for numerical and theoretical calculations but no programming skills are required.

Assessment: Five written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), a 45-minute computer laboratory test held at the end of semester (10%), and a 3-hour written examination in the examination period (70%).

MAST20009 Vector Calculus

Note: Vector Calculus can be taken after passing Engineering Mathematics. Vector Calculus cannot be taken in the same semester as Engineering Mathematics. Students cannot take Engineering Mathematics after passing Vector Calculus.

Credit Points: 12.5

Prerequisites: One of

- MAST10006 Calculus 2
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST20009 Vector Calculus
- MAST20032 Vector Calculus: Advanced

Passing MAST20009 Vector Calculus precludes subsequent credit for MAST20029 Engineering Mathematics.

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 1 and 2*)

Description: This subject studies the fundamental concepts of functions of several variables and vector calculus. It develops the manipulation of partial derivatives and vector differential operators. The gradient vector is used to obtain constrained extrema of functions of several variables. Line, surface and volume integrals are evaluated and related by various integral theorems. Vector differential operators are also studied using curvilinear coordinates.

Functions of several variables topics include limits, continuity, differentiability, the chain rule, Jacobian, Taylor polynomials and Lagrange multipliers. Vector calculus topics include vector fields, flow lines, curvature, torsion, gradient, divergence, curl and Laplacian. Integrals over paths and surfaces topics include line, surface and volume integrals; change of variables; applications including averages, moments of inertia, centre of mass; Green's theorem, Divergence theorem in the plane, Gauss' divergence theorem, Stokes' theorem; and curvilinear coordinates.

Assessment: Three to five written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST20018 Discrete Maths and Operations Research

Credit Points: 12.5

Prerequisites: One of

- MAST10006 Calculus 2
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: This subject introduces the essential features of Operations Research methods, and also introduces the area of Discrete Mathematics with a focus on applications. Operations Research topics include mathematical modelling, linear programming, simplex methods, and duality theory. Discrete mathematics topics include scheduling, graph theory, assignments and matchings, and fair division. The subject material has a common theme of applications of mathematics in realistic settings encountered in the business world, industry and day-to-day life.

Assessment: Four written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST20022 Group Theory and Linear Algebra

Credit Points: 12.5

Prerequisites:

MAST10008 Accelerated Mathematics 1

Or

one of

- MAST10007 Linear Algebra
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

and one of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: This subject introduces the theory of groups, which is at the core of modern algebra, and which has applications in many parts of mathematics, chemistry, computer science and theoretical physics. It also develops the theory of linear algebra, building on material in earlier subjects and providing both a basis for later mathematics studies and an introduction to topics that have important applications in science and technology.

Topics include: modular arithmetic and RSA cryptography; abstract groups, homomorphisms, normal subgroups, quotient groups, group actions, symmetry groups, permutation groups and matrix groups; theory of general vector spaces, inner products, linear transformations, spectral theorem for normal matrices, Jordan normal form.

Assessment: Three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST20026 Real Analysis

Note: The subject was previously known as MAST20026 Real Analysis with Applications.

Credit Points: 12.5

Prerequisites: One of

- MAST10006 Calculus 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Contact Hours: 3 x one hour lectures per week, 2 x one hour practice classes per week *(Semester 1 and 2)*

Description: This subject introduces the field of mathematical analysis both with a careful theoretical framework as well as selected applications. Many of the important results are proved rigorously and students are introduced to methods of proof such as mathematical induction and proof by contradiction.

The important distinction between the real numbers and the rational numbers is emphasized and used to motivate rigorous notions of convergence and divergence of sequences, including the Cauchy criterion. These ideas are extended to cover the theory of infinite series, including common tests for convergence and divergence. A similar treatment of continuity and differentiability of functions of a single variable leads to applications such as the Mean Value Theorem and Taylor's theorem. The definitions and properties of the Riemann integral allow rigorous proof of the Fundamental Theorem of Calculus. The convergence properties of sequences and series are explored, to power series representations of elementary functions and their generation by Taylor series. Fourier series are introduced as a way to represent periodic functions.

Assessment: Four to six written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST20029 Engineering Mathematics

Note: This subject is intended only for students pursuing an Engineering Systems major, who do not wish to take any further study in Mathematics and Statistics or Physics. Other students, including those wanting to supplement their Engineering Systems major with further study in Mathematics and Statistics or Physics, should seek advice.

Credit Points: 12.5

Prerequisites: One of

- MAST10006 Calculus 2
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Or

- Enrolment in the Master of Engineering

Credit Exclusions:

Students who have completed MAST20009 Vector Calculus may not enrol in MAST20029 Engineering Mathematics for credit.

Concurrent enrolment in both MAST20029 Engineering Mathematics and MAST20009 Vector Calculus is not permitted.

Students who have completed MAST20030 Differential Equations may not enrol in MAST20029 Engineering Mathematics for credit.

Concurrent enrolment in both MAST20029 Engineering Mathematics and MAST20030 Differential Equations is not permitted.

Vector Calculus can be taken after passing Engineering Mathematics.

Contact Hours: Summer: 6 x 1 hours lectures per week, 2 x one hour practice classes per week. Semester 1 and 2: 3 x one hour lectures per week, 1 x one hour practice class per week.

Description: This subject introduces important mathematical methods required in engineering such as manipulating vector differential operators, computing multiple integrals and using integral theorems. A range of ordinary and partial differential equations are solved by a variety of methods and their solution behaviour is interpreted. The subject also introduces sequences and series including the concepts of convergence and divergence.

Topics include: Vector calculus, including Gauss' and Stokes' Theorems; sequences and series; Fourier series, Laplace transforms; systems of homogeneous ordinary differential equations, including phase plane and linearization for nonlinear systems; second order partial differential equations and separation of variables.

Assessment:

Semester 1 and 2: Three written assignments due at regular intervals during semester amounting to a total of up to 40 pages (15%), a 45 minute written test held mid-semester (15%), and a 3-hour written examination in the examination period (70%).

Summer semester: Two written assignments due at regular intervals during semester amounting to a total of up to 40 pages (15%), a 45 minute written test held mid-semester (15%), and a 3-hour written examination in the examination period (70%).
Students must pass the assessment during semester to pass the subject. That is, students must obtain a mark of at least 15% out of 30% for the combined assignment and mid semester test mark to pass the subject. *(Semesters 1, 2 and summer)*

MAST20030 Differential Equations

Credit Points: 12.5

Prerequisites: One of

- MAST20009 Vector Calculus
- MAST20022 Vector Calculus: Advanced

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Plus one of

- MAST10006 Calculus 2
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies
- MAST10021 Calculus 2: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST20030 Differential Equations,
- MAST30029 Partial Differential Equations (prior to 2014)

Students may not enrol in MAST20009 Vector Calculus and MAST20030 Differential Equations concurrently.

Passing MAST20030 Differential Equations precludes subsequent credit for MAST20029 Engineering Mathematics.

Concurrent enrolment in both MAST20030 Differential Equations and MAST20029 Engineering Mathematics is not permitted.

Differential Equations can be taken after passing Engineering Mathematics.

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: Differential equations arise as common models in the physical, mathematical, biological and engineering sciences. This subject covers linear differential equations, both ordinary and partial, using concepts from linear algebra to understand the structure of the general solutions. It balances basic theory with concrete applications. Topics include:

- linear ordinary differential equations and initial-value problems, including systems of first-order linear ordinary differential equations;

- Taylor series solutions of linear ordinary differential equations;

- Laplace transform methods for solving dynamical models with discontinuous inputs;

- boundary-value problems for linear ordinary differential equations and their interpretation in terms of eigenvalues and eigenfunctions;

- Fourier series solutions of certain linear partial differential equations on spatially bounded domains using separation of variables and eigenfunction expansion;

- Fourier transform solutions of certain linear partial differential equations on unbounded spatial domains.

Assessment: Two or three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (30%), and a 3-hour written examination in the examination period (70%).

MAST20031 Analysis of Biological Data

Credit Points: 12.5

Prerequisites: One of the following level-1 biology or biomedicine subjects:

BIOL10001, BIOL10002, BIOL10006, BIOL10008, BIOL10009, BIOL10010, BIOL10011, BIOM10002, BIOL10003 (prior to 2021), BIOL10004 (prior to 2021), BIOL10005 (prior to 2021),

Or selection of the Environmental specialisation (formal) in the MC-ENG Master of Engineering

Recommended background knowledge: 25 points of first year Biology subjects

Credit Exclusions: None

Contact Hours: 2 x one hour online lectures per week, 1 x one hour interactive lecture per week, 1 x one hour tutorial per week, 1 x one hour computer laboratory class per week *(Semester 1)*

Description: A capacity to interpret data is fundamental to making informed decisions in everyday life. The design of experiments, analysis, and interpretation of biological data also lie at the very heart of the scientific enterprise. You cannot be a scientist without an understanding of data and design. This subject introduces you to fundamental concepts in data science for biology, with emphasis on modern statistical methods. Drawing on real biological problems and datasets, as well as drawing on data collected by the class, the lectures cover foundational concepts in experimental design and statistical modelling. The subject emphasises hands-on problem solving. As well as a solid grounding in statistical methodology, you will also develop practical skills, developing your capacity to design experiments, collect data, and analyse those data using the R statistical environment.

Assessment: Weekly online review quizzes, 15 minutes each, of which only 10 need to be completed (5%); six online tests, 45 minutes each, held fortnightly throughout semester (15%); three assignments, 400 words each, due in weeks 5, 9 and 11 (25%); and a 2-hour examination in the examination period (55%).

MAST20032 Vector Calculus: Advanced

Credit Points: 12.5

Prerequisites: One of

- MAST10006 Calculus 2 (with a mark of at least 75)
- MAST10009 Accelerated Mathematics 2
- MAST10019 Calculus Extension Studies (with a mark of at least 75)
- MAST10021 Calculus 2: Advanced

Plus one of

- MAST10007 Linear Algebra (with a mark of at least 75)
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies (with a mark of at least 75)
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST20009 Vector Calculus
- MAST20032 Vector Calculus: Advanced

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 1)*

Description: This subject covers the material presented in MAST20009 Vector Calculus plus additional material designed to provide deeper insight into interesting areas of calculus and has a greater emphasis on mathematical rigour and proof.

This subject studies the fundamental concepts of functions of several variables and vector calculus. It develops the manipulation of partial derivatives and vector differential operators. The gradient vector is used to obtain constrained extrema of functions of several variables. Line, surface and volume integrals are evaluated and related by various integral theorems. Vector differential operators are also studied using curvilinear coordinates.

Functions of several variables topics include: limits, continuity, differentiability, the chain rule, Jacobian, implicit and inverse function theorems, Taylor polynomials and Lagrange multipliers. Vector calculus topics include: vector fields, flow lines, curvature, torsion, gradient, divergence, curl and Laplacian. Integrals over paths and surfaces topics include line, surface and volume integrals; change of variables; applications including moments of inertia, centre of mass; Green's theorem, Divergence theorem in the plane, Gauss' divergence theorem, Stokes' theorem; and curvilinear coordinates. Possible additional topics include differential geometry of surfaces.

Assessment: Three to five written assignments due at regular intervals during semester amounting to a total of up to 30 hours (20%), and a 3-hour written examination in the examination period (80%).

MAST20033 Real Analysis: Advanced

Credit Points: 12.5

Prerequisites: One of

- MAST10006 Calculus 2 (with a mark of at least 75)
- MAST10019 Calculus Extension Studies (with a mark of at least 75)
- MAST10021 Calculus 2: Advanced

Plus one of

- MAST10007 Linear Algebra (with a mark of at least 75)
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies (with a mark of at least 75)
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: Students may only gain credit for one of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Contact Hours: 3 x one hour lectures per week, 2 x one hour practice classes per week *(Semester 1)*

Description: This subject introduces the field of mathematical analysis both with a careful theoretical framework as well as selected applications. Many of the important results are proved rigorously and students are introduced to methods of proof such as mathematical induction and proof by contradiction.

The important distinction between the real numbers and the rational numbers is emphasised and used to motivate rigorous notions of convergence and divergence of sequences, including the Cauchy criterion. Various constructions of the real numbers, for example using Dedekind cuts or by completion, are discussed and shown to be equivalent. These ideas are extended to cover the theory of infinite series, including common tests for convergence and divergence. Compactness of the unit interval is established and various consequences of compactness, such as the Extreme Value Theorem, are discussed. A similar treatment of continuity and differentiability of functions of a single variable leads to applications such as the Mean Value Theorem and Taylor's theorem. We define and compare both the Lebesgue and Riemann integral, establish basic properties of both, and discuss the proof of the Fundamental Theorem of Calculus. The convergence properties of sequences and series are explored, with applications to power series representations of elementary functions and their generation by Taylor series. Fourier series are introduced as a way to represent periodic functions. Further topics may include: uniform continuity, equicontinuity, the Arzela-Ascoli theorem, and the Stone-Weierstrass theorem.

Assessment: Five written assignments due at regular intervals during semester amounting to a total of up to 30 hours (20%), and a 3-hour written examination in the examination period (80%).

Level-3 subjects

MAST30001 Stochastic Modelling

Credit Points: 12.5

Prerequisites: One of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Plus one of

- MAST20004 Probability
- MAST20006 Probability for Statistics

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: Stochastic processes occur in finance as models for asset prices, in telecommunications as models for data traffic, in computational biology as hidden Markov models for gene structure, in chemistry as models for reactions, in manufacturing as models for assembly and inventory processes, in biology as models for the growth and dispersion of plant and animal populations, in speech pathology and speech recognition and many other areas.

This course introduces the theory of stochastic processes including Poisson processes, Markov chains in discrete and continuous time, and renewal processes. These processes are illustrated using examples from real-life situations. It then considers in more detail important applications in areas such as queues and networks (the foundation of telecommunication models), finance, and genetics.

Assessment: Two written assignments due mid-semester and at the end of semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30005 Algebra

Credit Points: 12.5

Prerequisites: MAST20022 Group Theory and Linear Algebra

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 1)*

Description: Algebra has a long history of important applications throughout mathematics, science and engineering, and is also studied for its intrinsic beauty. In this subject we study the algebraic laws satisfied by familiar objects such as integers, polynomials and matrices. This abstraction simplifies and unifies our understanding of these structures and enables us to apply our results to interesting new cases. Students will gain further experience with abstract algebraic concepts and methods. General structural results are proved and algorithms developed to determine the invariants they describe.

Assessment: Two or three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30011 Graph Theory

Credit Points: 12.5

Prerequisites: One of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

And any other second year level subject from the School of Mathematics and Statistics

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 1)*

Description: Graphs model networks of all types such as telecommunication, transport, computer and social networks. They also model physical structures such as crystals and abstract structures within computer algorithms.

This subject is an introduction to the modern field of graph theory. It emphasises the relationship between proving theorems in mathematics and the construction of algorithms to find the solutions of mathematical problems within the context of graph theory. The subject provides material that supplements other areas of study such as operations research, computer science and discrete mathematics.

Assessment: Two written assignments due mid-semester and at the end of semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30012 Discrete Mathematics

Credit Points: 12.5

Prerequisites: One of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

And any other second year level subject from the School of Mathematics and Statistics

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: This subject is concerned with the study of objects, which are finite in number and typically computable. At a computational level one seeks efficient algorithms and methods for construction and counting of the objects.

The main topics to be covered are: enumeration, permutations, designs, finite geometry, words, Ramsey theory and physical combinatorics. Designs are relevant to statistics, Ramsey theory to computer science, and physical combinatorics to mathematical physics. Words are useful for representing and constructing objects and relating combinatorial objects to algebraic structures.

Assessment: Three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30013 Techniques in Operations Research

Credit Points: 12.5

Prerequisites: MAST20018 Discrete Maths and Operations Research

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 1)*

Description: This subject introduces some major techniques and algorithms for solving nonlinear optimisation problems. Unconstrained and constrained systems will be considered, for both convex and non-convex problems. The methods covered include: interval search techniques, Newton and quasi-Newton methods, penalty methods for nonlinear programs, and methods based on duality. The emphasis is both on being able to apply and implement the techniques discussed, and on understanding the underlying mathematical principles. Examples involve the formulation of operations research models for linear regression, multi-facility location analysis and network flow optimisation.

A significant part of the subject is the project, where students work in groups on a practical operations research problem.

Assessment: Three written assignments (due in weeks 4,7, and 10) amounting to a total of up to the equivalent of 800 words (20%), a group project involving a written report of up to 20 pages due at the end of semester (25%) and a 15-minute oral presentation at the end of semester (5%), and a 2-hour written examination in the examination period (50%).

MAST30020 Probability for Inference

Credit Points: 12.5

Prerequisites: One of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Plus one of

- MAST20004 Probability
- MAST20006 Probability for Statistics with a grade of H2B or above

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 1)*

Description: This subject introduces a measure-theoretic approach to probability theory and presents its fundamental concepts and results.

Topics covered include: probability spaces and random variables, expectation, conditional expectation and distributions, elements of multivariate distribution theory, modes of convergence in probability theory, characteristic functions and their application in key limit theorems.

Assessment: Ten written assignments due at weekly intervals during semester amounting to a total of up to 40 pages (15%), a 45-minute written test held mid-semester (15%), and a 3-hour written examination in the examination period (70%).

MAST30021 Complex Analysis

Credit Points: 12.5

Prerequisites: One of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

And any other second year level subject from the School of Mathematics and Statistics.

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 1 and 2)*

Description: Complex analysis is a core subject in pure and applied mathematics, as well as the physical and engineering sciences. While it is true that physical phenomena are given in terms of real numbers and real variables, it is often too difficult and sometimes not possible, to solve the algebraic and differential equations used to model these phenomena without introducing complex numbers and complex variables and applying the powerful techniques of complex analysis.

Topics include: the topology of the complex plane; convergence of complex sequences and series; holomorphic functions, the Cauchy-Riemann equations, harmonic functions and applications; contour integrals and the Cauchy Integral Theorem; singularities, Laurent series, the Residue Theorem, evaluation of integrals using contour integration, conformal mapping; and aspects of the gamma function.

Assessment: Three or four written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30022 Decision Making

Credit Points: 12.5

Prerequisites: MAST20018 Discrete Maths and Operations Research

Plus one of

- MAST20004 Probability
- MAST20006 Probability for Statistics

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: This subject introduces the essential features of decision-making techniques encountered in operations research, management, industry, business and economics. It shows how to construct formal mathematical models for practical decision-making as encountered in two-person games, multi-objective optimisation problems, stochastic decision problems, group decision and social choice, and decision-making under uncertainty. It shows students further uses of linear programming and introduces dynamic programming techniques.

Assessment: Three or four written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30024 Geometry

Credit Points: 12.5

Prerequisites: One of

- MAST20009 Vector Calculus
- MAST20032 Vector Calculus: Advanced

Plus one of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: This subject introduces three areas of geometry that play a key role in many branches of mathematics and physics. In differential geometry, calculus and the concept of curvature will be used to study the shape of curves and surfaces. In topology, geometric properties that are unchanged by continuous deformations will be studied to find a topological classification of surfaces. In algebraic geometry, curves defined by polynomial equations will be explored. Remarkable connections between these areas will be discussed.

Topics include: Topological classification of surfaces, Euler characteristic, orientability. Introduction to the differential geometry of surfaces in Euclidean space: smooth surfaces, tangent planes, length of curves, Riemannian metrics, Gaussian curvature, minimal surfaces, Gauss-Bonnet theorem. Complex algebraic curves, including conics and cubics, genus.

Assessment: Two or three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30025 Linear Statistical Models

Credit Points: 12.5

Prerequisites: MAST20005 Statistics

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour computer laboratory class per week *(Semester 1)*

Description: Linear models are central to the theory and practice of modern statistics. They are used to model a response as a linear combination of explanatory variables and are the most widely used statistical models in practice. Starting with examples from a range of application areas this subject develops an elegant unified theory that includes the estimation of model parameters, quadratic forms, hypothesis testing using analysis of variance, model selection, diagnostics on model assumptions, and prediction. Both full rank models and models that are not of full rank are considered. The theory is illustrated using common models and experimental designs.

Assessment: Two or three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30026 Metric and Hilbert Spaces

Credit Points: 12.5

Prerequisites: MAST20022 Group Theory and Linear Algebra

Plus one of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: This subject provides a basis for further studies in modern analysis, geometry, topology, differential equations and quantum mechanics. It introduces the idea of a metric space with a general distance function, and the resulting concepts of convergence, continuity, completeness, compactness and connectedness. The subject also introduces Hilbert spaces: infinite dimensional vector spaces (typically function spaces) equipped with an inner product that allows geometric ideas to be used to study these spaces and linear maps between them.

Topics include: metric and normed spaces, limits of sequences, open and closed sets, continuity, topological properties, compactness, connectedness; Cauchy sequences, completeness, contraction mapping theorem; Hilbert spaces, orthonormal systems, bounded linear operators and functionals, applications.

Assessment: Two or three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%).

MAST30027 Modern Applied Statistics

Credit Points: 12.5

Prerequisites:

- MAST30025 Linear Statistical Models

Credit Exclusions: Students who gain credit for both ACTL30001 Actuarial Modelling 1 and ACTL30004 Actuarial Statistics cannot also gain credit for MAST30027 Modern Applied Statistics.

Contact Hours: 3 x one hour lectures per week, 1 x one hour computer laboratory class per week *(Semester 2)*

Description: Modern applied statistics combines the power of modern computing and theoretical statistics. This subject considers the computational techniques required for the practical implementation of statistical theory, and includes Bayes and Monte-Carlo methods. The subject focuses on the application of these techniques to generalised linear models, which are commonly used in the analysis of categorical data

Assessment: Four written assignments due at regular intervals during semester amounting to a total of up to 70 pages (50%), and a 2-hour written examination in the examination period (50%).

There is a hurdle requirement of a minimum 50% mark on the examination for satisfactory completion.

MAST30028 Numerical Methods and Scientific Computing

Credit Points: 12.5

Prerequisites: One of

- MAST10009 Accelerated Mathematics 2
- MAST20026 Real Analysis
- MAST20033 Real Analysis: Advanced

Plus one of

- MAST10007 Linear Algebra
- MAST10008 Accelerated Mathematics 1
- MAST10018 Linear Algebra Extension Studies
- MAST10022 Linear Algebra: Advanced

Plus one of

- COMP10001 Foundations of Computing
- COMP20005 Engineering Computation
- PHYC20013 Laboratory and Computational Physics 2
- Other evidence of competence in computer programming

Other evidence could include passing a relevant Year 12 school subject, or a statement of achievement from a relevant MOOC, or passing a programming competency test administered by another University of Melbourne School.

Credit Exclusions: None

Contact Hours: 2 x one hour lectures and 1 x two hour computer laboratory class per week. *(Semester 2)*

Description: Most mathematical problems arising from the physical sciences, engineering, life sciences and finance are sufficiently complicated to require computational methods for their solution. This subject introduces students to the process of numerical approximation and computer simulation, applied to simple and commonly encountered stochastic or deterministic models. An emphasis is on the development and implementation of algorithms for the solution of continuous problems including aspects of their efficiency, accuracy and stability. Topics covered will include simple stochastic simulation, direct methods for linear systems, data fitting of linear and nonlinear models, and time-stepping methods for initial value problems.

Assessment: Two programming assignments of 20 pages each, worth 20% each (one due mid-semester and one due late in semester) and a 3-hour computer laboratory examination worth 60% (held in final examination period).

MAST30030 Applied Mathematical Modelling

Credit Points: 12.5

Prerequisites: MAST20030 Differential Equations

Plus one of

- MAST20009 Vector Calculus
- MAST20032 Vector Calculus: Advanced

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 1)*

Description: This subject demonstrates how the mathematical modelling process naturally gives rise to certain classes of ordinary and partial differential equations in many contexts, including the infectious diseases, the flow of traffic and the dynamics of particles and of fluids. It advances the student's knowledge of the modelling process, as well addressing important mathematical ideas in deterministic modelling and the challenges raised by system nonlinearity.

- Infectious disease models and other contexts leading to systems of autonomous first-order differential equations; initial value problem, phase space, critical points, local linearization and stability; qualitative behaviour of plane autonomous systems, structural stability; formulation, interpretation and critique of models.
- Conservation laws and flux functions leading to first-order quasilinear-linear partial differential equations; characteristics, fans, shocks and applications including modelling traffic flow.
- Introduction to continuum mechanics: basic principles; tensor algebra and tensor calculus; the ideal fluid model and potential flow; the Newtonian fluid, Navier-Stokes equations and simple solutions.

Assessment: Three written assignments due at regular intervals during semester amounting to a total of up to 50 pages (30%), and a 3-hour written examination in the examination period (70%).

MAST30031 Methods of Mathematical Physics

Credit Points: 12.5

Prerequisites: Both of

- MAST20030 Differential Equations
- MAST30021 Complex Analysis

MAST30021 Complex Analysis may be taken concurrently with MAST30031 Methods of Mathematical Physics

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week *(Semester 2)*

Description: This subject gives an example-oriented overview of various advanced topics that are important for mathematical physics and physics students, as well as being of interest to students of pure and applied mathematics. These topics include:

- Further differential equations: Bessel functions, Legendre polynomials, spherical harmonics and applications such as the Laplace/Schrodinger equation in polar/spherical coordinates;
- Further vector calculus: Differential forms, integration, Stokes' theorem and applications such as Maxwell's equations, charge conservation and Dirac monopoles;
- Hilbert spaces: L2 spaces, bounded and unbounded operators, normalisable and non-normalisable eigenfunctions, distributions and applications to quantum theory;
- Group theory: Lie groups and algebras, representations and applications such as quantum spin and particle physics.

Assessment: Three written assignments due at regular intervals during semester amounting to a total of up to 60 pages (30%), and a 3-hour written examination in the examination period (70%).

MAST30032 Biological Modelling and Simulation

Credit Points: 12.5

Prerequisites: See the University handbook for prerequisites for this subject.

Credit Exclusions: None

Contact Hours: 2 x one hour lectures per week, 1 x two hour practice class per week *(Semester 1)*

Description: This subject introduces the concepts of mathematical and computational modelling of biological systems, and how they are applied to data in order to study the underlying drivers of observed behaviour. The subject emphasises the role of abstraction and simplification of biological systems and requires an understanding of the underlying biological mechanisms. Combined with an introduction to sampling-based methods for statistical inference, students will learn how to identify common patterns in the rich and diverse nature of biological phenomena and appreciate how the modelling process leads to new insight into biological phenomena.

- Modelling: Deterministic and stochastic population-level dynamic models; agent-based computational models; and geospatial statistical models will be introduced and studied. Indicative examples will be drawn from health (e.g. infectious diseases, cell tumour growth, developmental biology), ecology (e.g. predator-prey systems, sustainable harvesting, environmental decision making) and biotechnology (e.g. biochemical and metabolic models).
- Simulation: Sampling based methods (e.g Monte Carlo simulation, Approximate Bayesian Computation) for parameter estimation and hypothesis testing will be introduced, and their importance in modern computational biology discussed.

Assessment: One x 1,000 word written assignment due in week 8 (20%). Four laboratory exercises completed during practice classes, held at regular intervals during semester due in weeks 4, 6, 10, 12 (10% for each exercise). A 2-hour written examination in the examination period (40%).

MAST30033 Statistical Genomics

Credit Points: 12.5

Prerequisites:

- GENE20001 Principles of Genetics, or equivalent knowledge of genetics.

And either both of

- MAST10006 Calculus 2
- MAST20031 Analysis of Biological Data

Or one of

- MAST30032 Biological Modelling and Simulation
- MAST20005 Statistics

Credit Exclusions: None

Contact Hours: 2 x one hour lectures per week, 1 x two hour practice class per week *(Semester 2)*

Description: This subject introduces the biology and technology underlying modern genomics data, features of the resulting data types including the frequency and patterns of error and missingness, and the statistical methods used to analyse them. It will include hands-on data analysis using R software. The material covered will evolve as genomics technology and practice change, and will span the following four areas: introduction to genomics technology and the resulting data, population genetics, association analysis including tests of association and major sources of confounding, heritability and prediction both in human genetics and for animal and plant breeding, and analysis of expression quantitative trait loci.

Assessment: Four computer-based assignments (12.5% per assignment) due at regular intervals during the semester (week 3, 6, 9 and 12). Submissions will include computer code, results generated (numerical and graphical) plus sections of text interpreting the results (total 10 pages per assignment). A 2-hour written exam due during the examination period (50%).

MAST30034 Applied Data Science

Credit Points: 12.5

Prerequisites: Both of

- COMP30027 Machine Learning
- MAST30025 Linear Statistical Models

Credit Exclusions: None

Contact Hours: 1 x one hour lecture per week, 1 x two hour workshop per week *(Semester 2)*

Description: This capstone subject for the Data Science major combines statistical reasoning and practical computing skills to solve challenging problems with big data. Students will learn about communication of quantitative information and insights; presentation skills; report writing; project management; problem formulation using case studies; data collection and measurement protocols; data from surveys and experiments; issues in capturing and dealing with “big data”; dimension reduction; data visualisation; fitting formulated models to data to infer insightful information about populations; ethics in quantitative research; working effectively in teams

Assessment: Two individual assignments (up to 15 pages each) due in weeks 3-4 and 6-7 (20% each). A group assignment (written component, up to 50 pages), to proceed in two phases: formulation followed by a review in weeks 9-10, then implementation, due in week 12 (50%). An individual self-reflection report that also outlines the individual's contribution to the group assignment, due during the examination period (10%). The individual's contribution to the project will be measured using change logs from document and source-code repositories.

Mathematics and Statistics subjects available in the Bachelors of Arts, Design and Music only

MAST10012 Introduction to Mathematics

Notes: This subject is not available for science credit or commerce credit in any course.

This subject is equivalent for pre-requisite purposes to VCE Mathematical Methods 3/4.

Students with a study score of 25 or more in VCE Mathematical Methods 3/4 or equivalent, will not be permitted to enrol in this subject for credit.

Credit points: 12.5

Prerequisites: Successful completion of VCE Mathematical Methods 1/2 or equivalent

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 2 x one hour practice classes per week (*Semester 1)*

Description: Students will strengthen and develop algebraic and conceptual skills, building a firm mathematical base for MAST10005 Calculus 1. Fundamental concepts about number systems and set theory will be followed by introductory counting principles and techniques. These will be applied to the laws of probability, leading to the study of discrete and continuous random variables. Basic ideas about functions and their inverses will be introduced using examples such as the logarithmic, exponential and trigonometric functions. Differential and integral calculus will be studied to graph sketching and optimization problems. Students will also learn integration techniques, to areas between curves.

Assessment:

8-10 assignments (written or online) due at regular intervals amounting to a total of up to 50 pages (20%), and a 3-hour written examination in the examination period (80%). Up to one third of the assignment based assessment will be completed online.

Mathematics and Statistics subjects available in the Bachelor of Biomedicine only

Note: The following subjects are only available to students enrolled in the Bachelor of Biomedicine.

MAST10011 Experimental Design and Data Analysis

Credit points: 12.5

Prerequisites: None

Credit Exclusions: Students may only gain credit for one of

- MAST10010 Data Analysis 1
- MAST10011 Experimental Design and Data Analysis
- ECON10005 Quantitative Methods 1

Students who have completed the following may not enrol in this subject for credit:

- MAST20005 Statistics

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week, 1 x one hour computer laboratory class per week (*Semester 1)*

Description: This subject provides an understanding of the fundamental concepts of probability and statistics required for experimental design and data analysis in the health sciences. Initially the subject introduces common study designs, random sampling and randomised trials as well as numerical and visual methods of summarising data. It then focuses on understanding population characteristics such as means, variances, proportions, risk ratios, odds ratios, rates, prevalence, and measures used to assess the diagnostic value of a clinical test. Finally, after determining the sampling distributions of some common statistics, confidence intervals will be used to estimate these population characteristics and statistical tests of hypotheses will be developed. The presentation and interpretation of the results from statistical analyses of typical health research studies will be emphasised. The statistical methods will be implemented using a standard statistical computing package and illustrated on applications from the health sciences.

Assessment: Ten online quizzes due at weekly intervals during semester (10%); two written assignments due during semester amounting to a total of up to 25 pages (10%); one 45-minue computer based test at the end of semester (10%); and a 3-hour written examination conducted during the examination period (70%).

MAST10016 Mathematics for Biomedicine

Credit Points: 12.5

Prerequisites: VCE Mathematical Methods 3/4 or equivalent

Credit Exclusions: None

Contact Hours: 3 x one hour lectures per week, 1 x one hour practice class per week (*Semester 2)*

Description: This subject will introduce mathematical techniques to illustrate the importance of quantitative modelling in biomedicine. Quantitative models will be explored in a variety of biomedical contexts. Emphasis will be placed on understanding how biological principles can give rise to quantitative models. Topics to be explored in a quantitative context include genetic variation over many generations, dynamic processes at the cellular level and the modeling of the spread of infectious diseases among populations.

Assessment: Ten written assignments due at weekly intervals throughout the semester amounting to a total of up to 50 pages of written work (25%); an oral presentation during the semester (5%); and a 3-hour written examination conducted during the examination period (70%).