Mathematics and statistics

The Department of Mathematics and Statistics offers a variety of subjects at first, second and third-year levels that are designed to prepare students for professional careers in mathematics and statistics, the pure and applied sciences, commerce, education, engineering, industry and technology, and the social sciences. Our subjects provide training in generic skills such as logical reasoning, problem-solving, oral and written communication and working together as a team. These skills are invaluable for professional life in any discipline.

The department is responsible for the major in mathematics and statistics, which includes the specialisations of applied mathematics, pure mathematics, statistics, operations research, financial mathematics, discrete mathematics and mathematical physics. Students wishing to choose one or more such specialisations can find the appropriate subject choices in the Faculty of Science entry, page 14. Statistics is required in the environmental science major. Subjects in mathematics or statistics are also valuable for students pursuing many other majors and courses.

Subject choices

100-level subjects

Coordinator: K Baker (Director of Mathematics and Statistics Learning Centre)

The Department of Mathematics and Statistics offers a number of subjects at 100-level. The department has a Mathematics and Statistics Learning Centre through which the teaching and administration of first-year subjects is coordinated. This centre is located on the ground floor of the Richard Berry Building. Within the centre are the office of the Department of Mathematics and Statistics Director of First Year Studies, offices of tutors in mathematics and statistics, tutorial rooms, and a student workroom.

The two most important factors in determining subject choice at 100-level are the subjects taken and performance in secondary school mathematics and the likely choice of career or major.

Choice by background

An assumed VCE background for most but not all 100-level subjects is VCE Mathematical Methods 3/4. Table 1 provides a list of 100-level subjects with their normal entry requirements.

Table 1: Mathematics and statistics 100-level subjects

	subject	semester	normal entry requirements
Statistics	620-160 Experimental Design & Data Analysis *(p.5)*	1, 2	VCE Mathematical Methods 3/4
	620-131 Scientific Programming & Simulation *(p.4)*	1	Corequisites: one of 620-121, 620-141
Mathematics	620-161 Introductory Mathematics *(p.6)*	1	VCE Mathematical Methods 3/4
	620-140 Intermediate Mathematics *(p.4)*	2	620-161
	620-141 Mathematics A *(p.5)*	1, 2	VCE Specialist Mathematics 3/4 is recommended
	620-142 Mathematics B *(p.5)*	1, 2	620-141
	620-143 Applied Mathematics *(p.5)*	Sum, 1, 2	620-141
Advanced mathematics	620-121 Mathematics A (Advanced) *(p.4)*	1	A high level of achievement in VCE Specialist Mathematics 3/4
	620-122 Mathematics B (Advanced) *(p.4)*	1, 2	Either 620-121, or a grade of H1 in 620-141
	620-123 Applied Mathematics (Advanced) *(p.4)*	2	Either 620-121, or a grade of H1 in 620-141
Advanced plus mathematics	620-113 Applied Mathematics (Advanced Plus) *(p.3)*	2	A very high level of achievement in 620-121
For detailed prerequisites, see individual subject descriptions.			

Where subject offerings are marked as *Semester 1, repeat 2* this means that the subject is offered in both semesters, and a student may take the subject in either semester. However, for a natural progression into 200-level mathematics and statistics subjects, students are advised to take 620-121 or 620-141 in Semester 1, followed by 620-122 or 620-142 and/or 620-123 or 620-143 in Semester 2.

Students without VCE Specialist Mathematics 3/4 (or equivalent) are normally advised to select mathematics 620-161 and/or statistics 620-160. Students who wish to take more mathematics subjects after completing 620-161 are advised to take 620-140 in Semester 2 instead of 620-141. This enables entry into 620-142 and/or 620-143 in later years.

Students who wish to progress to 200-level mathematics, and who have a high level of achievement in VCE Mathematical Methods 3/4, should discuss the possibility of taking 620-141 in Semester 1 (and 620-142 and 620-143 in Semester 2) with the department's Director of First Year Studies.

Students with VCE Specialist Mathematics 3/4 should enrol in 620-121 or 620-141 in their first semester: they are not normally permitted to enrol in 620-161. Each of the subjects 620-121 and 620-141 has a linear algebra and analysis sequel in Semester 2 (620-122, 620-142) and an applied calculus sequel in Semester 2 (620-123, 620-143).

To open options for the study of probability and statistics in later years, students should select in their first year one of 620-131 (available in Semester 1 only) or 620-160 (available in both semesters). Since 620-131 contains a scientific programming component, it is particularly suitable for students who require hands-on programming experience but are not taking either of the computer science subjects 433-151 or 433-171. Taking 620-131 enables students to take 620-381 Computational Mathematics in a later year, which is a recommended subject for students interested in applied mathematics or financial mathematics.

Standard and advanced subjects

620-121 Mathematics A (Advanced) requires a very high level of achievement in VCE Specialist Mathematics 3/4 - at least a study score of 37 in Specialist Mathematics 3/4. Students eligible for the advanced subjects 620-121, 620-122 and 620-123 are strongly advised to take these subjects since they deal with the subject material in a deeper and more intellectually challenging way. The advanced subjects have considerable assessment in common with the standard subjects 620-141, 620-142 and 620-143, so that students are not disadvantaged regarding marks by choosing the advanced subjects.

One advanced mathematics plus subject 620-113 is also available. Selected students will be invited to enrol in this subject by the Head of Department.

VCE extensions studies students (UMEP)

Students who have studied university-level mathematics at school via the University of Melbourne Extension Program (620-120 UMEP Maths for High Achieving Students) or equivalent, may be permitted direct entry into the 200-level subjects 620-201 Probability, 620-211 Mathematics 2 (Advanced) and 620-231 Vector Analysis. The recommended (minimum) mathematics and statistics enrolment for students who obtained a grade of H3 or better in UMEP mathematics is 620-211 in Semester 1, and 620-123 in Semester 2. All UMEP students should discuss their subject selection with the department's UMEP coordinator.

Credit exclusions for 100-level subjects

Credit exclusions for 620 (mathematics and statistics) subjects are as follows. Students cannot gain credit for:

- more than one of 620-121, 620-140, 620-141;
- more than one of 620-122, 620-142, [05]620-192, [05]620-194, 620-211;
- more than one of 620-113, 620-123, 620-143, [05]620-193;
- more than one of 620-152, 620-160;
- more than one of 620-151, 620-161, [02]620-163.

Students enrolled in mathematics and statistics subjects prior to 2002 should discuss their course plans with a Department of Mathematics and Statistics course adviser.

200-level subjects

At 200-level, the Department of Mathematics and Statistics offers subjects in several areas of pure and applied mathematics and several areas of probability and statistics. Students may focus on a single area (pure mathematics, applied mathematics, operations research, probability, applied statistics), or pursue interests in several areas. This may be in the form of recommended combinations of subjects at the 200-level and 300-level for one of the mathematics and statistics specialisations (see page 1), or subject choices to support studies in other majors or courses. Students may take any combination of subjects if the prerequisites and conditions prescribed are satisfied.

The 200-level subjects offered by the Department of Mathematics and Statistics are listed below in Table 2. For detailed information on prerequisites and credit exclusions, see the individual subject entries.

Table 2: Mathematics and statistics 200-level subjects	
Semester 1	620-201 Probability *(p.6)*
	620-205 Probability for Statistics *(p.6)*
	620-211 Mathematics 2 (Advanced) *(p.6)*
	620-221 Real and Complex Analysis *(p.7)*
	620-231 Vector Analysis *(p.7)*
	620-233 Vector Analysis (Advanced) *(p.7)*
	620-261 Introduction to Operations Research *(p.8)*
Semester 2	620-202 Statistics *(p.6)*
	620-222 Linear and Abstract Algebra *(p.7)*
	620-231 Vector Analysis *(p.7)*
	620-232 Mathematical Methods *(p.7)*
	620-234 Mathematical Methods (Advanced) *(p.8)*
	620-252 Analysis *(p.8)*
	620-262 Decision Making *(p.8)*
	620-270 Applied Statistics *(p.8)*

For 200-level studies in pure or applied mathematics to ensure a reasonable choice of options, one of the following combinations is recommended for first year:

- 620-121, 620-122, 620-123; or
- 620-141, 620-142, 620-143.

If one of 620-142 or 620-143 (or their advanced versions) is not taken in first year, then unless that subject is taken in the Semester 1 of second year, enrolment in 620-232 is not possible in second year. High-achieving students from 620-142 may be allowed entry into the subjects 620-221 or 620-222. The subject 620-143 Applied Mathematics will be available in the Summer Semester.

Probability and statistics: 620-201, 620-202, 620-205 and 620-270. The subject 620-270 is an applied statistics subject which can be taken by students majoring in other disciplines and is required for students in environmental sciences: the emphasis is on applications and methods. The subjects 620-201 (or 620-205) and 620-202 constitute the basic second-year course for students intending 300-level studies in probability and statistics. These subjects are a core part of the statistics specialisation. Students in engineering degrees, especially those combined with science or commerce, may be better advised to select 620-201 and 620-202, which earn science points and are core subjects in the actuarial studies program, instead of the subjects 620-370 Statistics for Mechanical Engineers or 431-325 Stochastic Signals and Systems.

Analysis and algebra: 620-221, 620-222 and 620-252. These subjects are a core part of the pure mathematics specialisation.

Methods and applications: 620-231 and 620-232. These subjects are a core part of the applied mathematics and mathematical physics specialisations. 620-233 and 620-234 are advanced versions of 620-231 and 620-232 respectively.

Operations research: 620-261 and 620-262. These subjects are a core part of the operations research specialisation.

300-level subjects

The 300-level subjects offered by the Department of Mathematics and Statistics are listed below in Table 3.

Table 3: Mathematics and statistics 300-level subjects	
Semester 1	620-301 Stochastic Modelling *(p.9)*
	620-311 Metric Spaces *(p.9)*
	620-321 Algebra *(p.9)*
	620-331 Applied Partial Differential Equations *(p.10)*
	620-352 Graph Theory *(p.10)*
	620-361 Operations Research: Techniques *(p.11)*
	620-371 Linear Models *(p.11)*
	620-381 Computational Mathematics *(p.12)*
	600-311 Research Project A *(p.1)*
Semester 2	620-302 Chance and Options Pricing *(p.9)*
	620-312 Linear Analysis *(p.9)*
	620-322 Topology *(p.9)*
	620-332 Integral Transforms & Asymptotics *(p.10)*
	620-342 Industrial & Applied Mathematics *(p.10)*
	620-351 Number Theory *(p.10)*
	620-353 Discrete Mathematics *(p.11)*
	620-362 Applied Operations Research *(p.11)*
	620-372 Applied Statistical Inference *(p.11)*
	620-374 Sampling and Forecasting *(p.12)*
	600-312 Research Project B *(p.1)*

Students may take any combination of subjects provided prerequisites and conditions are satisfied. Suggested combinations are given under each specialisation for the mathematics and statistics major. The subjects shown in Table 3 may be classified as follows.

Analysis, algebra and topology: 620-311, 620-312, 620-321 and 620-322. These subjects give the necessary background for students who wish to study fourth-year subjects in pure mathematics as part of an honours degree.

Applied statistics: 620-371, 620-372 and 620-374. These subjects teach useful strategies in the analysis and interpretation of data, modelling, and the design of experiments. They give the necessary background for students who wish to study fourth-year subjects in applied statistics as part of an honours degree.

Methods and applications: 620-331, 620-332, 620-342 and 620-381. These subjects are particularly suited to students of engineering, physics and other areas of physical science and technology. They give the necessary background for students who wish to study fourth-year subjects in the applications of mathematics in science and technology as part of an honours degree.

Operations research: 620-361 and 620-362. These subjects offer an introduction to the application of mathematics to problems arising in industry and commerce. They give the necessary background for students who wish to study fourth-year subjects in operations research as part of an honours degree.

Probability and stochastic processes: 620-301 and 620-302. These subjects deal with the modern theory of probability and its applications in science, engineering and economics. They give the necessary background for students who wish to study fourth-year subjects in probability and stochastic processes as part of an honours degree.

Discrete mathematics: 620-352 and 620-353. Discrete mathematics units are standard for students with interests in computing and software engineering. They are also electives for the pure and applied mathematics specialisations.

Additional subject: 620-351 Number Theory is supplementary to the subjects above and is designed to broaden the scope of studies in mathematics and statistics.

Generic skills: The subjects 620-361, 620-362 and 620-371 are designed to emphasise the development of generic skills. These subjects will involve group projects, where teams will work on unfamiliar problems, plan their project and deliver oral and written presentations.

Projects: Students with excellent results, or with interests not served by the standard subject selections, may consider taking one or both of the research project subjects 600-311 and 600-312. Enrolment in these subjects, the content of which varies from year to year, requires the permission of the Head of the Department of Mathematics and Statistics. These units are not a substitute for the standard offerings.

Students proposing to take an honours degree should take careful note of the requirements for entry into the various honours schools as set out in this Handbook (see *Bachelor of Science (Degree with Honours) and Bachelor of Information Systems (Degree with Honours) (p.1)*). In particular, students wishing to take mathematics and statistics honours should ensure that all prerequisites for 400-level subjects are satisfied. Honours entry is possible from an appropriate selection of four 300-level mathematics and statistics subjects. For a wider choice of honours options, additional mathematics and statistics subjects may be included.

Double major in mathematics and statistics and computer science

Completion of the following subjects will lead to a major in mathematics and statistics with a specialisation in discrete mathematics and a separate major in computer science. The recommended subject sequence has been endorsed by both Departments.

First year

620-141 Mathematics A (or advanced version 620-121)

620-142 Mathematics B (or advanced version 620-122)

620-143 Applied Mathematics (or advanced version 620-123)
620-131 Scientific Programming and Simulation
433-171 Introduction to Programming (or advanced version 433-151)
433-172 Algorithmic Problem Solving (or advanced version 433-152)
Plus two additional subjects

Second year

620-201 Probability (or 620-205 Probability for Statistics)
620-222 Linear and Abstract Algebra (or 620-202 Statistics)
620-261 Introduction to Operations Research
620-262 Decision Making
433-252 Software Engineering Principles and Tools
433-253 Algorithms and Data Structures
433-254 Software Design
433-255 Logic and Computation

Third year

620-352 Graph Theory
620-353 Discrete Mathematics
620-381 Computational Mathematics
433-303 Artificial Intelligence
433-330 Theory of Computation
433-385 Modelling, Analysis and Visualisation
Plus one other 300-level Mathematics and Statistics subject and one other 300-level Computer Science subject. Suggestions include 620-301, 620-351, 620-361, 620-362, 620-374, 433-361, 433-380.

Subjects to complement major studies in other disciplines

Typical course plans for students wishing to major in mathematics and statistics are available from the Department of Mathematics and Statistics. 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 100 level and three mathematics and statistics subjects at the 200 level. However, for greater flexibility of choice in second year and a richer knowledge base, students are advised to take at least three mathematics and statistics subjects at the 100 level, at least three mathematics and statistics subjects at the 200 level, and some subjects at the 300 level. Any of the subjects listed below would be very useful for students wishing to teach mathematics.

First year

620-141 Mathematics A (or advanced version 620-121)
620-142 Mathematics B (or advanced version 620-122)
620-143 Applied Mathematics (or advanced version 620-123)
620-160 Experimental Design and Data Analysis

Second year

620-231 Vector Analysis
620-232 Mathematical Methods
620-261 Introduction to Operations Research
620-262 Decision Making
620-270 Applied Statistics

Third year

620-351 Number Theory
620-352 Graph Theory
620-353 Discrete Mathematics
620-361 Operations Research: Techniques
620-371 Linear Models

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 at the 100 level. Any of the subjects listed below would be very useful for students who will be involved in designing experiments and collecting and analysing data.

First year

620-141 Mathematics A (or advanced version 620-121)
620-143 Applied Mathematics (or advanced version 620-123)
620-160 Experimental Design and Data Analysis

Second year

620-270 Applied Statistics

Third year

620-371 Linear Models

Enhancing commerce applications

Students enrolled in a BCom or the combined degree BCom/BSc would benefit from studying subjects that are included in the specialisations of financial mathematics or statistics. Any of the subjects listed below would be particularly useful for students who wish to pursue careers in finance.

First year

620-131 Scientific Programming and Simulation
620-141 Mathematics A (or advanced version 620-121)
620-142 Mathematics B (or advanced version 620-122)
620-143 Applied Mathematics (or advanced version 620-123)

Second year

620-201 Probability (or 620-205 Probability for Statistics)
620-202 Statistics
620-261 Introduction to Operations Research

Third year

620-301 Stochastic Modelling
620-302 Chance and Options Pricing
620-371 Linear Models
620-374 Sampling and Forecasting
Note that actuarial studies students should take 620-121, 620-123 and 620-131 at 100 level before proceeding to 620-201 and 620-202.

Enhancing computer science applications

Students taking major studies in computer science would benefit from the subjects 620-141 and 620-142, which lead on to the specialisation of operations research and subjects involving discrete mathematics. Below is a list of subjects that complement studies in computer science.

First year

620-141 Mathematics A (or advanced version 620-121)
620-142 Mathematics B (or advanced version 620-122)

Second year

620-222 Linear and Abstract Algebra
620-261 Introduction to Operations Research
620-262 Decision Making

Third year

620-352 Graph Theory
620-353 Discrete Mathematics

Bachelor of Science (Degree with Honours)

For information about the faculty and departmental entry requirements for honours, please refer to *Bachelor of Science (Degree with Honours) and Bachelor of Information Systems (Degree with Honours) (p.1)* for details. These requirements should be considered when planning your course.

Further information

Department of Mathematics and Statistics
The University of Melbourne
Victoria 3010
Tel: +61 3 8344 5550
Fax: +61 3 8344 4599
Web: http://www.ms.unimelb.edu.au

Subject descriptions

100-level subjects

620-113 Applied Mathematics (Advanced Plus)

Note: Students may only gain credit for one of 620-113, 620-123, 620-143 and [05]620-193.

Eligible students will be invited by the Director of First Year Studies.

Credit points: 12.5

Coordinator: K Baker

Prerequisites: A very high level of achievement in 620-120 (UMEP Maths for High Achieving Students) or 620-121.

Contact: 36 lectures (three per week), 11 1-hour tutorials (one per week) plus 12 1-hour extensions classes *(Semester 2).*

Description: This subject consists of the material presented in 620-123 Applied Mathematics (Advanced) *(p.4)* plus extensions material designed to provide deeper insight into interesting areas of mathematics.

Assessment: Up to 24 pages of written assignments due during the semester (8%); a 50-minute written test held mid semester (12%); up to 24 pages of written assignments due during the semester on material from the extension classes (10%); a 3-hour written examination in the examination period (70%).

620-121 Mathematics A (Advanced)

Note: Students may only gain credit for one of 620-121, 620-140 and 620-141.

Credit points: 12.5

Coordinator: A/Prof P Pearce

Prerequisites: A high level of achievement in VCE Specialist Mathematics 3/4, or equivalent, or special permission of the Director of First Year Studies.

Contact: 36 lectures (three per week), 11 1-hour tutorials (one per week) and 11 1-hour practice classes (one per week) *(Semester 1).*

Description: This subject prepares students for later studies in mathematics and statistics, or other disciplines in which mathematical concepts of calculus and linear algebra are needed, introducing important topics not previously studied at school, and giving a fresh perspective on familiar topics.

Linear algebra topics include the solution of systems of linear equations by row operations, row echelon form and reduced row echelon form; matrices, rank of a matrix, inverses and applications to solving systems of linear equations; determinants and applications; vectors in two and three dimensions; dot and cross products; triple products; and problems involving lines and planes. Foundations of analysis topics include number systems, methods of proof, mathematical induction; functions, sequences, limits, continuity and differentiability. Calculus topics include hyperbolic functions and their inverses; implicit differentiation; applications to graph sketching; level curves, partial derivatives, chain rules for partial derivatives and directional derivative; tangent planes; and extrema for functions of several variables. Complex numbers topics include Cartesian and polar form, De Moivre's theorem, powers, roots of equations and complex exponential; conversions between powers and multiple angles; and derivatives and integrals of complex exponentials and applications. Riemann integration topics include the integral as the limit of a sum; the fundamental theorem of calculus, Leibniz's theorem; and improper integrals.

Assessment: A 45-minute written test held mid semester (0% or 15%); a 3-hour written examination in the examination period (85% or 100%). The relative weighting of the examination and mid-semester test will be chosen so as to maximise the student's final mark.

620-122 Mathematics B (Advanced)

Note: Students may gain credit for only one of 620-122, 620-142, [05]620-192, [05]620-194 or 620-211.

Students in the combined degree BE/BSc should note that credit exclusions exist between this subject and Engineering mathematics subjects. Refer to entries for 431-201 Engineering Analysis A and 431-202 Engineering Analysis B for details.

Credit points: 12.5

Coordinator: Dr L Reeves

Prerequisites: One of 620-120 (UMEP Maths for High Achieving Students), 620-121, or a grade of H1 in either 620-140 or 620-141.

Contact: 36 lectures (three per week), 11 1-hour tutorials (one per week) and 11 1-hour practice classes (one per week) *(Semester 1, repeat 2).*

Description: This subject gives a solid grounding in key areas of mathematics needed in modern science and technology, and is the gateway to many recent mathematical developments. Little of the material here has been seen at school, and the level of understanding required represents a distinct advance on the minimum necessary in previous subjects.

Topics include general vector spaces, linear independence, bases, dimension, inner product spaces, linear transformations, matrix of a linear transformation, change of basis, rank, inverse, solution of linear equations, eigenvectors and eigenvalues, rotation matrices, diagonalization, real-symmetric and orthogonal matrices, modular arithmetic and Euclid's algorithm.

Applications include encryption, error correcting codes, graphs and networks, and the classification of quadratic forms.

Assessment: Up to 24 pages of written assignments due during the semester (15%); a 3-hour written examination in the examination period (85%).

620-123 Applied Mathematics (Advanced)

Note: Students may only gain credit for one of 620-113, 620-123, 620-143 or [05]620-193.

Credit points: 12.5

Coordinator: Dr O Warnaar

Prerequisites: One of 620-120 (UMEP Maths for High Achieving Students), 620-121 or a grade of H1 in either 620-140 or 620-141.

Contact: 36 lectures (three per week), 11 1-hour tutorials (one per week) and 11 1-hour practice classes (one per week) *(Semester 2).*

Description: This subject introduces the principles governing the solution of the basic first and second order ordinary differential equations (ODEs). This subject also introduces the basic properties of sequences and series, including Taylor series for functions. Students completing the subject develop the ability to classify and solve with accuracy the basic differential equations of first and second order and to translate that understanding into mathematical formulation of physical problems. This subject demonstrates the power of differential equation modelling in advancing an understanding of complex physical processes from a wide variety of real world phenomena.

Integration topics include techniques of integration; approximate integration; applications of integration to areas and arc length; improper integrals. Differential equations topics include first order ODEs (linear via integrating factors, separable and homogeneous) and applications; second order ODEs (reducible to first order, linearly independent solutions), and second order linear ODEs with constant coefficients, particular integrals, complementary functions and applications. Sequences and series topics include convergence and divergence of sequences and series; tests for convergence; Taylor's theorem and series representation of elementary functions; generation of series solutions of first order ODEs, including non-linear types not solvable by elementary methods. Difference equations.

Assessment: Up to 24 pages of written assignments due during the semester (10%); a 50-minute written test held mid semester (15%); a 3-hour written examination in the examination period (75%).

620-131 Scientific Programming & Simulation

Note: Passing 620-131 precludes subsequent credit for 620-152 or 620-160.

Credit points: 12.5

Coordinator: Dr O Jones

Pre or Corequisites: One of 620-120 (UMEP Maths for High Achieving Students), 620-121, 620-140, 620-141, 620-211.

Contact: 36 lectures (three per week), 11 two-hour computer laboratory classes (one per week) and 11 one-hour tutorials (one per week) *(Semester 1).*

Description: Many real world phenomena - financial markets, insurance risk, gambling, telecommunications networks - are best modelled as random processes involving uncertainty. They can be studied by performing a computer simulation of the process and treating the results as the outcome of an experiment.

In this subject, students develop high order problem-solving skills for tackling problems with an uncertain or random component. They learn how to select probability models to describe real world processes. They learn the basics of a general-purpose programming language, so they can implement computer simulations.

Students completing the subject develop the ability to read, write, debug and adapt simple computer programs, using techniques including conditional branching, loops, arrays and subroutines. They learn about convergence of sequences and series, and applications of convergence to solving equations. They learn to carry out probability calculations using standard distributions arising from Bernoulli trials and to write programs to simulate these processes. They compare traditional and Monte Carlo methods of numerical integration.

Assessment: Programming tasks during computer laboratory classes (16%); project work due during the semester (14%); a 3-hour written examination in the examination period (70%).

620-140 Intermediate Mathematics

Note: Students transferring from another tertiary institution should talk with the Director of First Year Studies in Mathematics and Statistics to ascertain which of the subjects 620-140 or 620-141 is more suitable for them. In 620-140 some basic knowledge of linear equations, row operations on matrices and elementary partial derivatives is assumed.

Students may only gain credit for one of 620-121, 620-140, 620-141.

Credit points: 12.5

Coordinator: K Baker

Prerequisites: 620-161 or equivalent.

Contact: 36 lectures (three per week), 11 1-hour tutorials (one per week) and 11 1-hour practice classes (one per week) *(Semester 2).*

Description: This subject introduces vectors, matrices and linear transformations, the concepts of vector geometry, the properties of basic functions of calculus, complex numbers and elementary complex functions. Students should develop the ability to employ vector methods in geometrical problems, apply linear transformation ideas in geometrical situations, differentiate the

basic functions of calculus and use calculus methods to solve optimisation problems including problems which involve functions of more than one variable. This subject develops the fundamental concepts in linear algebra, calculus and complex numbers necessary for further studies in mathematics.

The following topics are covered:

- matrices: matrix algebra, rank, inverses and applications to linear systems;
- determinants: definitions, evaluation and applications;
- vectors: dot and cross products and scalar triple product;
- vector geometry: problems involving intersecting lines and planes, volumes and areas;
- linear transformations: transformation matrices, orthogonal matrices and geometrical applications;
- single variables: polynomial, rational, trigonometric, exponential, logarithmic and hyperbolic functions and their inverses, and implicit differentiation;
- multivariable calculus: partial derivatives, chain rules for functions of several variables, directional derivatives, tangent planes, and extrema for functions of several variables; and
- complex numbers: Cartesian and polar form, De Moivre's theorem, roots of equations, complex exponential function and applications to derivatives and integrals.

Assessment: Up to 36 pages of written assignments during semester (10%); a 45-minute written test held mid semester (0% or 10%); a 3-hour written examination in the examination period (80% or 90%). The relative weighting of the examination and mid-semester test will be chosen so as to maximise the student's final mark.

620-141 Mathematics A

Note: Students enrolling in this subject are expected to have completed VCE Specialist Mathematics 3/4 or an equivalent subject. Students who have completed VCE Mathematical Methods 3/4 but not VCE Specialist Mathematics 3/4 should discuss their suitability for undertaking this subject with the Director of First Year Studies.

Students may only gain credit for one of 620-121, 620-140, 620-141.

Credit points: 12.5

Coordinator: Dr C Mangelsdorf

Contact: 36 lectures (three per week), 11 1-hour tutorials (one per week) and 11 1-hour practice classes (one per week) *(Semester 1, repeat 2).*

Description: This subject introduces the manipulation of vectors, matrices, and systems of linear equations, the concepts of vector geometry, the properties of basic functions of calculus and complex numbers. Students should develop the ability to solve systems of linear equations, employ vector methods in geometrical problems, sketch and manipulate hyperbolic functions and use differential calculus to solve extremal problems including problems involving functions of more than one variable. This subject develops the fundamental concepts in linear algebra, calculus and complex numbers necessary for further studies in mathematics.

Linear algebra, matrices and determinants, and vector geometry topics include solution of systems of linear equations by row operations, row echelon form and reduced row echelon form; matrices, rank of a matrix, inverses, and applications to solving systems of linear equations; determinants and applications; vectors in two and three dimensions; dot and cross products; problems involving lines and planes; and scalar triple product. Calculus topics include intuitive idea of limits, continuity and differentiability of functions of one variable; hyperbolic functions and their inverses; implicit differentiation; applications to graph sketching; level curves, partial derivatives, chain rules for partial derivatives, and directional derivative; tangent planes; and extrema for functions of several variables. Complex numbers topics include Cartesian and polar form, De Moivre's theorem, powers, roots of equations and complex exponential; conversions between powers and multiple angles; and derivatives of complex exponentials and applications.

Assessment: Up to 36 pages of written assignments during the semester (10%); a 45-minute written test held mid semester (0% or 10%); a 3-hour written examination in the examination period (80% or 90%). The relative weighting of the examination and mid-semester test will be chosen so as to maximise the student's final mark.

620-142 Mathematics B

Note: Students may only gain credit for one of 620-122, 620-142, [05]620-192, [05]620-194 or 620-211.

Students in the combined degree BE/BSc should note that credit exclusions exist between this subject and Engineering mathematics subjects. Refer to entries for 431-201 Engineering Analysis A and 431-202 Engineering Analysis B for details.

Credit points: 12.5

Coordinator: Dr D Coulson

Prerequisites: One of 620-120 (UMEP Maths for High Achieving Students), 620-121, 620-140 or 620-141.

Contact: 36 lectures (three per week), 11 one-hour tutorials (one per week) and 11 one-hour computer laboratory classes (one per week) *(Semester 1, repeat 2).*

Description: This subject develops the concepts of vectors, matrices and the methods of linear algebra as tools for modern mathematics and introduces modular arithmetic. Students should develop the ability to use the methods of linear algebra and gain an understanding of methods of mathematical proof. Students will also gain experience in using a mathematical software system.

Linear algebra topics include real n-space R^n, vector spaces in general, axioms, linear independence, bases, dimension, inner products; linear transformations, matrix representation of a linear transformation, change of basis, rank, inverse, solution of linear equations; eigenvectors and eigenvalues, rotation matrices, diagonal, real symmetric and orthogonal matrices. Modular arithmetic topics include computation modulo n, division with remainder, mathematical induction and Euclid's Algorithm. Applications will be chosen from error correcting codes, cryptography, graphs and networks, and the classification of conics and quadric surfaces.

Assessment: Up to 36 pages of written assignments or project work due during the semester (20%); a 3-hour written examination in the examination period (80%).

620-143 Applied Mathematics

Note: Students may only gain credit for one of 620-113, 620-123, 620-143 or [05]620-193.

Credit points: 12.5

Coordinator: Dr S Carnie

Prerequisites: One of 620-120 (UMEP Maths for High Achieving Students), 620-121, 620-140 or 620-141.

Contact: 36 lectures (three per week), 11 1-hour tutorials (one per week) and 11 1-hour practice classes (one per week) *(Semester 1, repeat 2, Summer).*

Description: This subject introduces the terminology of ordinary differential equations (ODEs), the principles of first and second order ODEs, and their applications. This subject also introduces the basic properties of sequences and series, including Taylor series for functions. Students completing the subject develop the ability to solve analytically first order ODEs, second order linear ODEs; and learn how to apply the above techniques to simple problems. Students should develop the ability to understand the convergence of series and sequences. The subject demonstrates the role of differential equations and sequences and series in applied mathematics.

Integration topics include techniques of integration; applications of integration to areas and arc length; improper integrals. Differential equations topics include first-order ODEs (separable, linear via integrating factor, homogeneous) and applications; second-order ODEs (reducible to first order, linearly independent solutions); second-order linear ODEs (particular solutions, complementary functions) and applications. Sequences and series topics include convergence and divergence of sequences and series; tests for convergence; Taylor's theorem and series representation of elementary functions; generation of series solutions of first order ODEs, including non-linear types not solvable by elementary methods.

Assessment: Up to 25 pages of written assignments due during semester (10%), a 45-minute written test held mid semester (15%); a 3-hour written examination in the examination period (75%).

620-160 Experimental Design & Data Analysis

Note: Students may not gain credit for 620-160 and one of 316-130 and 620-152.

Students who have completed 620-131, 620-202, 620-270 or 620-272 may not enrol in this subject for credit.

Credit points: 12.5

Coordinator: Dr A Robinson

Prerequisites: VCE Mathematical Methods 3/4.

Contact: 36 lectures (three per week), 11 one-hour computer laboratory classes (one per week) and 11 one-hour tutorials (one per week) *(Semester 1, repeat 2).*

Description: This subject lays the foundations for subsequent studies in statistics, as well as being vital for students who need to apply statistics in other subjects. Students completing this subject will develop skills in statistical modelling and data analysis, and appreciate the relevance of random variation to science, engineering and commerce.

Topics include data description and analysis; elementary distribution theory: binomial and normal distributions; random sampling; population parameters and sample statistics; estimation, confidence intervals and hypothesis testing based on the binomial and normal distributions; introduction to bivariate data, including correlation and linear regression; scientific method and experimental design, including randomisation and blocking; inference for regression;

one-way analysis of variance; contingency tables; and application of computer software to data analysis.

Assessment: Up to 36 pages of written assignments or project work during semester (20%); a 3-hour written examination in the examination period (80%).

620-161 Introductory Mathematics

Note: Students who have completed VCE Specialist Mathematics 3/4 or equivalent will not normally be permitted to enrol in this subject: such students should enrol in one of 620-121 or 620-141.

Students who have completed 620-121, 620-140 or 620-141 may not enrol in this subject for credit.

Students may only gain credit for one of 620-151, 620-161, [02]620-163.

Credit points: 12.5

Coordinator: A/Prof M Sniedovich

Prerequisites: VCE Mathematical Methods 3/4 or equivalent.

Contact: 36 lectures (three per week) and 11 1-hour tutorials (one per week) *(Semester 1).*

Description: This subject introduces elementary rules for manipulating matrices, some basic functions of one and two variables and demonstrates the usefulness of calculus for the optimisation of functions. Students should develop the ability to work with standard matrices and functions, to find derivatives of functions of one and two variables, and functions compounded from them; and to apply these skills to word problems in bioscience and finance. This subject demonstrates the sequential conceptual structure of the mathematics of functions and shows the value of mathematical techniques in life science and business.

Matrices topics include row operations, systems of linear equations, graphical and matrix methods for linear programming; and problems in bioscience and finance. Calculus topics include functions of one variable; product, quotient and chain rules for differentiation; applications; partial derivatives; maxima and minima; least-squares and other curve-fitting algorithms; simple differential equations; Taylor series; numerical solution of algebraic and differential equations; and applications in life science and business.

Assessment: Up to 40 pages of written assignments due during the semester (10%); a 45-minute written mid-semester test (0% or 15%); a 3-hour written examination in the examination period (75% or 90%). The relative weighting of the examination and mid-semester test will be chosen so as to maximise the student's final mark.

200-level subjects

620-201 Probability

Note: Students may only gain credit for one of 620-201, 620-205, 620-370, 431-325.

Students undertaking Actuarial Studies should take 620-201 instead of 620-205.

Credit points: 12.5

Coordinator: Dr R Maillardet

Prerequisites: One of 620-120 (UMEP Maths for High Achieving Students), 620-121, 620-140, 620-141 and one of 620-131, 620-113, 620-123, 620-143 (grade of H2B or above), [05]620-193 (grade of H2B or above).

Contact: 36 lectures (three per week), 11 one-hour tutorials (one per week) and 11 one-hour computer laboratory classes (one per week) *(Semester 1).*

Description: This subject offers a thorough grounding in the fundamental concepts and tools of mathematical probability, probability modelling and simulation. Basic concepts 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.

The probability distributions and models discussed in the course arise frequently in real world applications. These include a number of widely used one-dimensional distributions and fundamental probability models such as Poisson processes and Markov chains. Two dimensional (bivariate) distributions are also introduced (particularly the Bivariate Normal), leading naturally to an examination of notions of independence and dependence (covariance and correlation).

Methods for deriving the distribution of various transformations of random variables are also explored. Techniques to obtain the exact and approximate distributions of sums of random variables will be introduced. 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.

In computer labs students will learn to use software for both standard probability calculations and simulations of more complex probability models.

Assessment: Up to 50 pages of written assignments due during semester (20%); a 3-hour written examination in the examination period (80%).

620-202 Statistics

Note: Passing 620-202 precludes subsequent credit for 620-152 or 620-160.

Credit points: 12.5

Coordinator: Prof R Huggins

Prerequisites: 620-201 or 620-205.

Contact: 36 lectures (three per week), 11 one-hour tutorials (one per week) and 11 one-hour computer laboratory classes (one per week) *(Semester 2).*

Description: This subject introduces the theory necessary to understand modern statistical inference and statistical computation. It demonstrates how many commonly used statistical procedures arise as applications of a common theory. Students will develop the ability to fit probability models to data by both estimating and testing hypotheses about model parameters.

This subject demonstrates the importance of the underlying mathematical theory of statistics and the use of modern computer software. Topics include random samples and sample characteristics; desirable properties of estimators; methods for the estimation of parameters of probability distributions, including maximum likelihood estimation; confidence intervals and prediction intervals; theory and application of hypothesis tests; introduction to distribution free methods and goodness of fit tests, correlation and regression; the analysis of one-way and two-way classifications and introductions to experimental design and general linear models.

Assessment: Up to 30 pages of written assignments due during the semester (20%); a 45-minute computer laboratory test held mid-semester (10%); a 3-hour written examination in the examination period (70%).

620-205 Probability for Statistics

Note: Students may only gain credit for one of 620-201, 620-205, 620-370, 431-325.

Students taking this subject must achieve a mark of H2B or above in the subject to proceed to 620-301.

Students undertaking Actuarial Studies should take 620-201 instead of 620-205.

Credit points: 12.5

Coordinator: Prof R Huggins

Prerequisites: One of 620-120 (UMEP Maths for High Achieving Students), 620-121, 620-140, 620-141 and one of 620-131, 620-113, 620-123, 620-143, [05]620-193.

Contact: 36 lectures (three per week), 11 one-hour tutorials (one per week) and 11 one-hour computer laboratory classes (one 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: Up to 30 pages of written assignments due during the semester (20%); a 45-minute computer laboratory test held mid-semester (10%); a 3-hour written examination in the examination period (70%).

620-211 Mathematics 2 (Advanced)

Note: Students may gain credit for only one of 620-122, 620-142, [05]620-192, [05]620-194 or 620-211.

Students in the combined degree BE/BSc should note that credit exclusions exist between this subject and Engineering mathematics subjects. Refer to entries for 431-201 Engineering Analysis A and 431-202 Engineering Analysis B for details.

Credit points: 12.5

Coordinator: Dr I Aitchison

Prerequisites: By invitation of the Head of Department. The minimum prerequisite for consideration is an H3 or better in 620-120 (UMEP Maths for High Achieving Students), 620-121 or equivalent. Performance in a diagnostic test may be taken into consideration before an invitation is made.

Contact: 36 lectures (three per week), 11 1-hour tutorials (one per week) and 11 1-hour practice classes (one per week) *(Semester 1).*

Description: This subject consists of the material presented in 620-122 Mathematics B (Advanced) *(p.4).* Students will be expected to make an in-depth exploration of some aspects of the material designed to provide deeper insight into interesting areas of mathematics.

Assessment: Up to 36 pages of written assignments due during the semester (15%); a 3-hour written examination in the examination period (85%).

620-221 Real and Complex Analysis

Note: Students may only gain credit for one of 620-221 and 620-252.

Credit points: 12.5

Coordinator: Dr J Groves

Prerequisites: One of 620-122, [05]620-194, 620-211 together with one of 620-113 or 620-123; a grade of H3 or better in each of the prerequisites is recommended. Students with a grade of H1 in 620-142 or [05]620-192 together with a grade of H1 in 620-143 or [05]620-193 will be permitted to enrol on completion of additional summer reading as prescribed by the coordinator.

Contact: 36 lectures (three per week) and 11 tutorial/practice class hours (one per week) *(Semester 1)*.

Description: This subject introduces the structure and methods of proof; the concept of convergence of sequences and series; basic topological concepts in the real line and complex plane; and the basic concepts of functions of a complex variable. Students completing this subject develop an ability to construct rigorous and accurate arguments; determine convergence or otherwise of sequences and series; differentiate functions of a complex variable; calculate contour integrals; and to work with analytic functions in the cut plane and apply Cauchy's integral formula and the residue theorem. The subject demonstrates the importance of rigorous arguments via proofs; the fundamental concepts of topology of the complex plane; and the differences between functions of a real and a complex variable.

Topics include sequences of real and complex numbers and their properties; rigorous definition of the limit, Cauchy sequences; series of real or complex numbers, and absolute and conditional convergence; tests for convergence; power series of complex numbers and radius of convergence; basic topological concepts in the complex plane; continuous functions and their properties; homomorphic function and Cauchy-Riemann conditions; exponential and logarithm of the complex variable; other elementary functions; contour integration, Cauchy's theorem and Cauchy's integral formula; uniform convergence and Weierstrass M-test; equivalence of complex differentiability to the local power series expansion; Laurent series, singularities and poles; and residue theorem, evaluation of integrals and summation of series.

Assessment: Up to 24 pages of written assignments during the semester and a 50-minute written test held mid semester (equally weighted, with a total of either 0% or 20%); a 3-hour written examination in the examination period (80% or 100%). The relative weighting of the examination and the total assignment plus test mark will be chosen so as to maximise the student's final mark.

620-222 Linear and Abstract Algebra

Credit points: 12.5

Coordinator: Prof H Rubinstein

Prerequisites: One of 620-122, [05]620-194 or 620-211; a grade of H3 or better in the prerequisite is recommended. Students with a grade of H1 in 620-142 or [05]620-192 will be permitted to enrol on completion of additional reading.

Contact: 36 lectures (three per week) and 11 tutorial/practice class hours (one per week) *(Semester 2)*.

Description: This subject 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 which have important applications in science and technology. It also introduces the theory of groups, which is at the core of modern algebra, and which has applications in many parts of mathematics and in theoretical physics.

Linear algebra topics include revision and extension of basic concepts; vector spaces including complex spaces, inner products, linear transformations, eigenvalues and eigenvectors, dual spaces and the connection with inner products; the spectral theorem for normal matrices; and Jordan normal form, without proof but with applications. Groups topics include abstract groups, examples including matrix groups and permutation groups; homomorphisms, normal subgroups, quotients and the first homomorphism theorem; group actions and permutation groups; and conjugacy classes and their interpretation in symmetry groups, permutation groups and matrix groups. Applications topics may include wallpaper groups, symmetry groups of regular polyhedra, and permutation groups.

Assessment: Up to 24 pages of written assignments during the semester and a 45-minute written test held mid-semester (equally weighted, with a total of 0% or 20%); a 3-hour written examination in the examination period (80% or 100%). The relative weighting of the examination and the total assignment plus test mark will be chosen so as to maximise the student's final mark.

620-231 Vector Analysis

Note: Students may gain credit for only one of 620-231 and 620-233.

Students in the combined degree BE/BSc should note that credit exclusions exist between this subject and Engineering mathematics subjects. Refer to entries for 431-201 Engineering Analysis A and 431-202 Engineering Analysis B for details.

Credit points: 12.5

Coordinator: Dr R Brak

Prerequisites: One of 620-113, 620-123, 620-143, [05]620-193.

Contact: 36 lectures (three per week) and 11 1-hour tutorials (one per week) *(Semester 1, repeat 2)*.

Description: This subject develops the manipulation of partial derivatives and vector differential operators. Students should develop the ability to obtain extrema of functions of several variables, calculate line, surface and volume integrals, and to work in curvilinear coordinates. This subject demonstrates the fundamental concepts of vector calculus and the relations between line, surface and volume integrals.

Functions of several variables topics include limits, continuity, differentiability, matrix version of 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 and Stokes' theorem; and curvilinear coordinates.

Assessment: Up to 25 pages of written assignments due during the semester (10%); a 45-minute written test held mid-semester (15%); a 3-hour written examination in the examination period (75%).

620-232 Mathematical Methods

Note: Students may gain credit for only one of 620-232 and 620-234.

Students in the combined degree BE/BSc should note that credit exclusions exist between this subject and Engineering mathematics subjects. Refer to entries for 431-201 Engineering Analysis A and 431-202 Engineering Analysis B for details.

Credit points: 12.5

Coordinator: Dr A Tordesillas

Prerequisites: One of 620-122, 620-142, [05]620-192, [05]620-194, 620-211; and one of 620-113, 620-123, 620-143, [05]620-193.

Contact: 36 lectures (three per week) and 11 1-hour tutorials (one per week) *(Semester 2)*.

Description: Many phenomena in the biological and physical sciences as well as engineering and modern finance are described by differential equations. Examples include tissue engineering, contaminant transport, epidemic models, electrical circuits, dynamical systems and quantum mechanics. This subject describes analytical methods to solve linear ordinary and partial differential equations, as well as qualitative methods for linear and nonlinear systems of differential equations.

Transform methods for ordinary differential equations are introduced via the Laplace transform. The most common partial differential equations - Laplace's equation, the wave equation and the heat equation - are introduced and solved in simple geometries by separation of variables. This requires the development of Fourier series to represent functions and leads to an introduction to Fourier transforms. Linear systems of ordinary differential equations are solved by matrix methods and the phase plane is defined. Qualitative ideas such as stability and phase portraits are extended to nonlinear systems of differential equations. Applications include topics such as population models and normal modes.

Assessment: Two 45-minute written class tests held during semester (20%); a 3-hour written examination in the examination period (80%).

620-233 Vector Analysis (Advanced)

Note: Students may gain credit for only one of 620-231 and 620-233.

Students in the combined degree BE/BSc should note that credit exclusions exist between this subject and Engineering mathematics subjects. Refer to entries for 431-201 Engineering Analysis A and 431-202 Engineering Analysis B for details.

Credit points: 12.5

Coordinator: Dr J de Gier, Dr O Warnaar

Prerequisites: An H3 or better in 620-120 (UMEP Maths for High Achieving Students) or 620-121 together with an H3 or better in 620-123 or 620-113; or by invitation from the Head of Department.

Contact: 36 lectures (three per week) and 11 1-hour tutorials (one per week) *(Semester 1)*.

Description: This subject covers the material presented in 620-231 Vector Analysis *(p.7)* plus additional material designed to provide deeper insight into interesting areas of vector analysis.

The subject develops the manipulation of partial derivatives and vector differential operators. Students should develop the ability to obtain extrema of

functions of several variables; calculate line, surface and volume integrals; and to work in curvilinear coordinates. This subject demonstrates the fundamental concepts of vector calculus and the relations between line, surface and volume integrals.

Functions of several variables topics include limits, continuity, differentiability, matrix version of 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 averages, moments of inertia, centre of mass, Green's theorem, Divergence theorem and Stokes' theorem; and curvilinear coordinates. Possible additional topics include differential geometry of surfaces.

Assessment: Up to 36 pages of written assignments due during the semester (20%); a 3-hour written examination in the examination period (80%).

620-234 Mathematical Methods (Advanced)

Note: Students may gain credit for only one of 620-232 and 620-234.

Students in the combined degree BE/BSc should note that credit exclusions exist between this subject and Engineering mathematics subjects. Refer to entries for 431-201 Engineering Analysis A and 431-202 Engineering Analysis B for details.

Credit points: 12.5

Coordinator: A/Prof B Hughes

Prerequisites: An H3 or better in 620-120 (UMEP Maths for High Achieving Students) or 620-121 together with an H3 or better in 620-122, [05]620-194 or 620-211 together with an H3 or better in 620-123 or 620-113; or with special permission from the Head of Department.

Contact: 36 lectures (three per week) and 11 1-hour tutorials (one per week) *(Semester 2)*.

Description: This subject consists of the material presented in 620-232 Mathematical Methods *(p.7)* plus extensions material designed to provide deeper insight into interesting areas of mathematical methods.

Assessment: Up to 36 pages of written assignments due during the semester (20%); a 3-hour written examination in the examination period (80%).

620-252 Analysis

Note: Students may only gain credit for one of 620-221 and 620-252.

Credit points: 12.5

Coordinator: Dr D Coulson

Prerequisites: One of 620-122, 620-142, [05]620-192, [05]620-194, 620-211; and one of 620-113, 620-123, 620-143, [05]620-193.

Contact: 36 lectures (three per week) and 11 tutorial/practice class hours (one per week) *(Semester 2)*.

Description: This subject deals with convergence of sequences and series; elementary topology of the real line; the fundamentals of continuity, and differentiability of functions of several real variables; analytic functions of a complex variable; complex derivative; power and Laurent series in complex variables; basic topological concepts in the complex plane; and Cauchy's theorem and its applications. Students completing this subject develop the ability to determine the convergence or otherwise of sequences and series; differentiate functions of a complex variable; calculate contour integrals; work with analytic functions in the cut plane; and apply Cauchy's integral formula and the residue theorem. The subject demonstrates the differences between functions of a real and a complex variable; and the role of complex analytic methods in solving important problems in science and engineering.

Sequences and series topics include standard sequences and series, Cauchy convergence, ratio and n^{th} root tests, absolute and conditional convergence, re-arrangements and power series. Continuity topics include continuity and differentiability of functions of several real variables. Functions of a complex variable topics include elementary functions of a complex variable, branches, differentiation, analytic functions and Cauchy-Riemann equations. Integration topics include line and contour integrals, and Cauchy's integral theorem; Laurent series; singularities, poles and Liouville's theorem; and residue theorem, limiting contours, and evaluation of integrals using contour integration.

Assessment: Up to 36 pages of written assignments due during the semester (0% or 15%); a 3-hour written examination in the examination period (85% or 100%). The relative weighting of the examination and the total assignment mark will be chosen so as to maximise the student's final mark.

620-261 Introduction to Operations Research

Credit points: 12.5

Coordinator: Prof P Taylor

Prerequisites: One of 620-122, 620-142, [05]620-192, [05]620-194, 620-211.

Contact: 36 lectures (three per week) and 11 tutorial/practice class hours (one per week) *(Semester 1)*.

Description: This subject introduces the essential features of operations research methods and the type of problems they can solve; it develops a number of basic mathematical techniques used to solve typical generic problems and the theoretical foundations of these techniques. Students should develop the ability to construct formal mathematical models for practical optimisation problems, to solve linear programming problems and to assess the results, to use dynamic programming techniques in the modelling analysis and solution of operations research problems, and to conduct sensitivity analysis in the context of a number of operations research problems. This subject demonstrates the extent and limitations of operations research techniques such as linear programming, dynamic programming and sensitivity analysis in the context of real-world problems. It also shows the essential role that standard mathematical tools and computers play in the analysis and solutions of operations research problems.

Selected topics from mathematical modelling, linear programming, simplex and revised simplex methods, duality theory, sensitivity analysis, dynamic programming, the transportation problem, shortest path and critical path problems, and knapsack problems will be studied. Students will also look at the applications of operations research techniques to real-world problems and the use of computer packages and internet resources will be covered.

Assessment: Up to 36 pages of written assignments due during the semester (10%); a 3-hour written examination in the examination period (90%).

620-262 Decision Making

Credit points: 12.5

Coordinator: Dr S Zhou

Prerequisites: 620-261.

Contact: 36 lectures (three per week) and 11 tutorial/practice class hours (one per week) *(Semester 2)*.

Description: This subject introduces the essential features of decision-making situations encountered in operations research investigations. It develops a number of basic mathematical approaches to such situations and the techniques used to solve decision-making problems represented by these approaches. The theoretical foundations of these techniques are also considered. Students should develop the ability to construct formal mathematical models for practical decision-making situations; to solve a number of two-person games, including zero-sum and non-zero-sum games, cooperative and non-cooperative games; to use linear programming and dynamic programming techniques in the solution of a number of multi-objective optimisation problems; and to solve stochastic decision problems using techniques from probabilistic dynamic programming and Markov decision processes. This subject demonstrates the complexity of decision-making situations that may arise from business, economics, management, industry, etc., the extent and limitations of a number of operations research techniques used to solve such problems, and the important role that linear algebra, calculus and probability theory play in the development of these techniques.

Selected topics from game theory, multi-criteria decision-making, Bayesian decision analysis, decision trees and multi-stage decision making, probabilistic dynamic programming and Markov decision processes will be covered.

Assessment: Up to 24 pages of written assignments due during the semester (10%); a 3-hour written examination in the examination period (90%).

620-270 Applied Statistics

Note: Students may only gain credit for one of 620-270, 620-272 or 620-370.

Passing 620-270 precludes subsequent credit for 620-152 or 620-160.

Students who have completed 620-371 or 620-372 may not enrol in this subject for credit.

Credit points: 12.5

Coordinator: K Baker

Prerequisites: One of 620-131, 620-152 or 620-160.

Contact: 36 lectures (three per week), 11 one-hour tutorials (one per week) and 11 one-hour computer laboratory classes (one per week) *(Semester 2)*.

Description: This subject demonstrates the importance of statistical methods for interpreting data, the role of exploratory and formal data analysis and the importance of experimental design. Students should learn to examine data to determine underlying structures, formulate statistical models for a range of practical situations and check the assumptions of the model in specific situations. They should also learn to use the computer to carry out standard statistical analyses and to express conclusions in scientifically useful terms.

Introduction to statistical inference topics include estimation; confidence intervals; hypothesis testing including the power of tests; and determination of sample size using the width of confidence intervals and power. Correlation and regression topics include assumptions; method of least squares; interpretation; hypothesis testing; confidence and prediction intervals; residuals; regression diagnostics; transformations; collinearity; model selection; and polynomial regression. Analysis of variance models (one-way and two-way with equal numbers of observations per cell) topics include model; assumptions; estimation and hypothesis testing; interaction and its interpretation;

transformations; residuals; and diagnostics. Design of experiments topics include randomisation; replication; blocking; standard designs including completely randomised, randomised block and Latin square designs; factorial experiments: analysis; interpretation; and introduction to confounding. Analysis of covariance topics include detailed treatment of the case with one factor and one covariate; and extension to more complex situations. Contingency tables topics include tests for association; odds ratios, including confidence intervals; and introduction to loglinear models.

Assessment: Up to 50 pages of written assignments due during the semester (25%); a 3-hour written examination in the examination period (75%).

300-level subjects

620-301 Stochastic Modelling

Note: Credit cannot be gained for both 620-301 and [04]300-331.

Credit points: 12.5

Coordinator: A/Prof A Xia

Prerequisites: 620-201 or a grade of H2B or above in 620-205. Plus at least one of 620-113, 620-122, 620-123, 620-142, 620-143, [05]620-192, [05]620-193, [05]620-194 or 620-211.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 1)*.

Description: This subject introduces the concept of a stochastic process and deals with the important standard stochastic processes, including the Poisson process, Markov chains in discrete and continuous time (with some applications), and renewal processes. Students learn to understand, derive the behaviour and properties, and simulate simple stochastic process models derived from real-life situations. This subject demonstrates the importance of such models and in particular shows their applications to industry and the sciences.

Topics covered include review of the main concepts from probability theory, elements of utility theory, basic limit theorems and types of stochastic processes; analysis of Markov chains and their applications (including elements of Markov decision processes); random walks; the Poisson and general jump Markov processes and their applications (with elements of queueing models); renewal theory; and elements of simulation.

Assessment: Up to 50 pages of written assignments due during the semester (20%); a 3-hour written examination in the examination period (80%).

620-302 Chance and Options Pricing

Note: Students may only gain credit for one of 620-302, 300-316, [04]300-332.

Credit points: 12.5

Coordinator: A/Prof K Borovkov

Prerequisites: 620-301. Students with 620-201 and a strong mathematical background may be granted permission to enrol by the Head of Department.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: This subject focuses on modern probability theory methods and modelling with a view to applications in science, finance and insurance. Students learn probability modelling by using the concepts of the theory of stochastic processes. They are introduced to the basic machinery of the theory, to the ideas of no-arbitrage pricing through simple binomial models, and then to stochastic calculus and to diffusion models in finance and biology. This subject demonstrates the importance of probability methods in the sciences and finance.

Topics covered include basic methods in probability and distribution theory in discrete and continuous time, the concepts of no-arbitrage asset pricing and hedging, conditional expectations, integral transforms, random walks, martingales, Brownian motion process, stochastic calculus, diffusion processes and their applications. Applications include models in finance (such as the Black-Scholes model for asset pricing and diffusion models for interest rates) and biology (such as diffusion models in genetics and population dynamics).

Assessment: Up to 50 pages of written assignments due during the semester (20%); a 3-hour written examination in the examination period (80%).

620-311 Metric Spaces

Credit points: 12.5

Coordinator: Dr C Hodgson

Prerequisites: 620-221. Students who have achieved a grade of H1 in 620-252 will be permitted to enrol in this subject on completion of specified reading over summer.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 1)*.

Description: This subject introduces the generalised distance between elements of an abstract set, including sets of functions. It also introduces the notion of a general topological space, and the generation of such space from a metric space and from other structures. It emphasises the significance of completeness of a metric space and of the concepts of compactness and connectedness. Students should develop the ability to apply abstract methods of topology to obtain deeper results about real and complex numbers and Euclidean spaces, and to apply metric space methods to the approximate solution of linear equations, and differential equations by Picard's method. They learn to distinguish between pointwise and uniform convergence from the viewpoint of topology, and to understand the difference between topological and metric properties of topological spaces. This subject demonstrates the power of abstract topological concepts as applied to Euclidean spaces, to concrete spaces of functions, and to the approximate solution of equations. It also develops an appreciation of the rigorously presented concepts of convergence and continuity, the use of topology in the modern treatment of numerical mathematics, differential and integral equations, optimisation, logic and computing.

Topics include the concept of a metric and of the induced topology; open and closed sets; convergence and completeness; the contraction mapping theorem; continuity, uniform continuity and homeomorphism; compactness; connectedness; and applications.

Assessment: Up to 24 pages of written assignments due during the semester (20%); a 3-hour written examination in the examination period (80%).

620-312 Linear Analysis

Credit points: 12.5

Coordinator: A/Prof J Koliha

Prerequisites: 620-311.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: The most important topic of this subject is integration. Students meet this concept in a calculus course where an integral is defined as a Riemann integral. Although a Riemann integral is useful in many areas of mathematics, it is not adequate for many problems of modern analysis. The aim of the subject is to introduce students to the Lesbesgue theory of integration and measure theory. Included in this subject is an introduction to the fundamental concepts of functional analysis. Functional analysis is the common name for the study of infinite dimensional vector spaces and the linear maps between them. What distinguishes this subject from linear algebra is the role of topological considerations. These topics are not only beautiful and interesting but are also useful in other branches of mathematics such as probability theory, partial differential equations and quantum mechanics.

Topics include construction of measures, measurable functions, Lesbesgue integrals, convergence theorems, L^p-spaces, Fubini's theorem, normed spaces and Banach spaces, inner product and Hilbert spaces, linear functionals and linear operators.

Assessment: Up to 36 pages of written assignments due during the semester (either 0% or 20%); a 3-hour written examination in the examination period (80% or 100%). The relative weighting of the examination and the assignments will be chosen so as to maximise the student's final mark.

620-321 Algebra

Credit points: 12.5

Coordinator: Dr L Reeves

Prerequisites: 620-222 with a grade of H3 or better.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 1)*.

Description: This subject provides further experience with abstract algebraic concepts and methods. General structural results are proved and algorithms developed to determine the invariants they describe. The material covered is widely used in algebraic topology and in number theory.

Rings topics include: abstract rings and isomorphisms; matrix rings and polynomial rings; homomorphisms, ideals and quotient rings; integral domains and the field of quotients; units, irreducibles and primes; prime and maximal ideals; Euclidean domains; principal ideal domains; and unique factorisation domains. Modules topics include: submodules; homomorphisms of modules and quotient modules; free modules and bases; the structure of a finitely generated module over a principal ideal domain; and applications to abelian groups and to Jordan normal form of matrices. Field theory topics include: field extensions and their construction; the degree of a field extension; Galois extensions, splitting fields and the Galois correspondence. Applications topics may include tensor and exterior algebras, applications to number theory, the classical impossibility theorems, and structure theory for simple rings.

Assessment: Up to 24 pages of written assignments due during semester (20%); a 3-hour written examination in the examination period (80%).

620-322 Topology

Credit points: 12.5

Coordinator: Dr I Aitchison

Prerequisites: 620-311, 620-321 and one of 620-231 or 620-233.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: This subject introduces the basic concepts and examples of topological spaces, the definition of manifolds and the classification of surfaces, the idea of homotopy of mappings, the concept of covering spaces and their relationship with fundamental groups, and the basic ideas of homology theory. Students should develop the ability to work with the fundamental group and homology groups, to calculate and use the fundamental group, to convert problems involving topological spaces and continuous maps into problems in algebra, to distinguish between different topological spaces, and to construct homeomorphisms and homotopy equivalences between spaces. This subject investigates the basic questions in topology. It demonstrates the power of topological methods in dealing with problems involving shape and position of objects and continuous mappings, and shows how topology can be applied to many areas, including geometry, analysis, group theory and physics.

Topics include topological spaces and continuous maps; quotient spaces; homotopy and fundamental groups; surfaces; covering spaces; and an introduction to homology theory.

Assessment: Up to 36 pages of written assignments due during the semester (25%); a 3-hour written examination in the examination period (75%).

620-331 Applied Partial Differential Equations

Credit points: 12.5

Coordinator: Dr O Foda

Prerequisites: Either 620-231 or 620-233; and either 620-232 or 620-234.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 1)*.

Description: This subject illustrates how partial differential equations (PDE's) of first and second order arise in mathematical modelling of the real world. It introduces basic techniques for solving these PDE's such as eigenfunction expansions, Green's functions, similarity solutions, method of images, and addresses general features of the solutions. The subject also covers certain topics in ordinary differential equations (ODE's). Topics covered include:

- First-order non-linear PDE's: characteristics, fans, shocks and applications.
- Classification of linear second order PDE's in two variables, canonical forms, initial and boundary conditions.
- The wave equation, d'Alembert's solution.
- Laplace's equation, Poisson's equation, harmonic functions, maximum and minimum principles.
- The heat equation, convective diffusion equation, Burgers' equation and the Hopf-Cole transformation.
- Sturm-Liouville equation, properties of eigenfunctions and eigenvalues.
- Series solutions of ODE's, ordinary points, regular singular points, Bessel and Legendre functions.

Assessment: A 45-minute written test held mid-semester (either 0% or 20%); a 3-hour written examination in the examination period (80% or 100%). The relative weighting of the examination and the mid-semester test will be chosen so as to maximise the student's final mark.

620-332 Integral Transforms & Asymptotics

Credit points: 12.5

Coordinator: A/Prof P Pearce

Prerequisites: One of 620-232 or 620-234; and one of 620-221 or 620-252.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: This subject introduces methods of evaluating real integrals using complex analysis; and develops methods for evaluating and inverting Fourier, Laplace and Mellin transforms, with selected applications including summing series and computing asymptotic series. Students should learn what an asymptotic expansion is and how it provides approximations; how to use Watson's lemma and the methods of Laplace, stationary phase and steepest descents to evaluate asymptotic expressions; and how to find asymptotic solutions to ordinary differential equations. This subject demonstrates a range of important and useful techniques and their power in solving problems in applied mathematics.

Complex analysis covers advanced applications of contour integration. Integral transforms covers Fourier, Laplace and Mellin transforms; inversion by contour integration; convolution; and applications. Asymptotic expansions covers convergence and divergence; integrals with a large parameter, Watson's Lemma, Laplace's method, steepest descent, stationary phase; and WKB method for ordinary differential equations.

Assessment: A 45-minute written test held mid-semester (either 0% or 20%); a 3-hour written examination in the examination period (80% or 100%). The relative weighting of the examination and the mid-semester test will be chosen so as to maximise the student's final mark.

620-342 Industrial & Applied Mathematics

Credit points: 12.5

Coordinator: A/Prof J Sader

Prerequisites: 620-331.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: This subject introduces the basic principles governing flow and transport processes within continuous media. It develops vector and tensor methods needed to formulate these principles mathematically; and also introduces the concept of a constitutive equation. Students should develop the ability to select a constitutive equation and correctly pose relevant boundary-value problems; to solve transport and flow problems in simple geometries; to identify valid approximate analyses; and to interpret solutions in physical terms. This subject demonstrates the potential for mathematical modelling of flow and transport processes that arise in manufacturing, mineral exploitation and other areas of science and technology. It also shows the intimate connection between continuum mechanical problems and fundamental mathematical problems.

Introduction to continuum mechanics topics include the continuum approximation, Eulerian and Lagrangian viewpoints, streamlines, conservation of mass, Cauchy equation of motion, constitutive equation for stress tensor, Cartesian tensors and dyadic notation, and hydrostatics. Incompressible ideal fluids topics include Euler equations, Bernoulli's theorem, potential flow, persistence of irrotationality and d'Alembert's paradox. Incompressible viscous fluids topics include Navier-Stokes equations, dynamical similarity and exact solutions. Special flows topics include creeping flow, Stokes drag, thin film flows, Hele-Shaw flow, lubrication, laminar boundary layer flow, flow past a plate and boundary layer separation.

Assessment: Up to 48 pages of written assignments due during the semester (30%); a 3-hour written examination in the examination period (70%).

620-351 Number Theory

Credit points: 12.5

Coordinator: Dr J Groves

Prerequisites: One of 620-120 (UMEP Maths for High Achieving Students), 620-121, 620-140, 620-141.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: This subject introduces the elementary concepts of divisibility; the basic theory and use of congruences; the properties of powers of elements in congruences, particularly Euler's theorem; the law of quadratic reciprocity; and basic properties of continued fractions and some applications. It develops applications of all of the above to primality testing, factorisation algorithms and cryptanalysis. Students should develop the ability to perform the algorithms inherent in the subject material; and to understand and present proofs related to the subject material. This subject demonstrates the extent and uses of elementary number theory, its applicability in other parts of mathematics, and its potential for application outside of mathematics.

Topics include factorisation, primes and greatest common divisors; congruences; primitive roots; quadratic reciprocity; continued fractions and Pell's equation; compositeness testing and factorisation; and applications to cryptanalysis.

Assessment: Up to 24 pages of written assignments due during the semester and a 50-minute written test held mid-semester (equally weighted, with a total of either 0% or 20%); a 3-hour written examination in the examination period (80% or 100%). The relative weighting of the examination and total assignment plus test mark will be chosen so as to maximise the student's final mark.

620-352 Graph Theory

Credit points: 12.5

Coordinator: A/Prof A Owczarek

Prerequisites: Any two 200-level subjects from the Department of Mathematics and Statistics. Computer Science 433-253 may be substituted for one of these subjects.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 1)*.

Description: This subject introduces the basic concepts of graph theory including isomorphic graphs, subgraphs, connectedness, bipartite graphs, paths and cycles, trees, weighted graphs and distance in graphs, Steiner trees, matchings, flows and eulerian circuits. Students should develop the ability to implement algorithms on graphs for finding objects such as minimum spanning trees, maximum matchings and flows; and to implement approximation algorithms. Students should also develop the ability to prove simple results in

graph theory. This subject demonstrates the variety of applications of graph theory within and outside mathematics.

Introduction to graph theory topics include the concepts listed above, but may also include colouring properties, combinatorics, and the probabilistic method.

Assessment: Up to 24 pages of written assignments due during semester (0% or 10%); a 3-hour written examination in the examination period (90% or 100%). The relative weighting of the examination and the total assignment mark will be chosen so as to maximise the student's final mark.

620-353 Discrete Mathematics

Credit points: 12.5

Coordinator: Prof P Forrester

Prerequisites: Any two 200-level subjects from the Department of Mathematics and Statistics. Computer Science 433-253 may be substituted for one of these subjects.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: Discrete mathematics is concerned with the study of objects which are finite in number and typically computable. At a computational level one seeks efficient algorithms and formulas for the listing and counting of the objects. Theory provides a way to these algorithms and formulas, and further provides links between seemingly disparate areas of discrete mathematics.

The main topics to be covered are enumeration and listings; permutations; designs, codes and finite geometry; patterns and Ramsey theory; and physical combinatorics. Designs are relevant to statistics, codes to communication engineering, patterns and Ramsey theory to computer science, and physical combinatorics to mathematical physics.

A common theme throughout the course will be the constructive aspect of the subject, whereby algorithms and formulas are formulated for the enumeration and listing of discrete objects. Through studying this course students will gain an appreciation of the practical use of theoretical analysis, and will also gain experience in the implementation of algorithms.

Assessment: Up to 48 pages of written assignments due during semester (20%); a 3-hour written examination in the examination period (80%).

620-361 Operations Research: Techniques

Credit points: 12.5

Coordinator: A/Prof F Vazquez-Abad

Prerequisites: 620-261. Also recommended is one of 620-231, 620-233, 620-262.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 1)*.

Description: This subject develops problem-solving skills and sharpens analytical skills. Students will work in groups, tackling unfamiliar problems. Each team will plan their project work and deliver oral and written presentations.

This subject introduces a number of basic techniques of operations research, selecting topics from nonlinear and parametric optimisation, and decision-tree, network and inventory models. It develops the formulation of operations research models and algorithms with application in production planning, scheduling, inventory management and capital budgeting. Students should develop skills in setting up and analysing operations research models for a number of planning problems; and competence in the use of computer packages for the solution of operations research problems. This subject demonstrates the factors and restrictions involved in building and using models for planning and management problems.

Topics are selected from operations research models; formulation of planning and management problems, including linear programming models, scheduling models, inventory management and capital budgeting; and linear and non-linear techniques, decision tree models, parametric optimisation and simulation. Use of computer packages and internet resources is examined. Case studies and projects are undertaken.

Assessment: Up to 24 pages of written assignments due during the semester (10%); a group project involving a written report of up to 15 pages due during the semester (15%) and a 20-minute oral presentation during the semester (10%); a 3-hour written examination in the examination period (65%).

620-362 Applied Operations Research

Credit points: 12.5

Coordinator: A/Prof M Sniedovich

Prerequisites: 620-361 or 620-262. Also recommended is 620-131 or one of computer science 433-152 or 433-172.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: This subject develops problem-solving skills and sharpens analytical skills. Students will work in groups, tackling unfamiliar problems. Each team will plan their project work and deliver oral and written presentations.

This subject introduces the technical issues involved in applying operations research principles, methods and algorithms in the solution of real-world problems, and the practical aspects of group projects in operations research. Students should develop the ability to apply various operations research methods, algorithms and software in the solution of practical problems; and to participate successfully in group projects in operations research, including preparing reports and giving presentations. This subject demonstrates the scope and limitation of operations research methods, algorithms and software as far as solving practical problems is concerned. It also exhibits the practical issues and difficulties involved in group projects in operations research.

Practical and technical aspects of various operations research methods for linear programming, integer programming and combinatorial optimisation are covered, including topics selected from complexity, interior point methods, cutting planes, branch-and-bound, meta-heuristics, special heuristics and constraint logic programming. Students examine applications in vehicle routing, facility location, cutting stock, manpower planning, and machine scheduling and other logistics problems; and become familiar with operations research software.

Assessment: Up to 50 pages of written assignments due during the semester (35%); a group project during the semester with a 15-minute oral presentation and a written report of up to 50 pages (40%); a 90-minute written test held mid semester (25%).

620-371 Linear Models

Note: Passing 620-371 precludes subsequent credit for 620-270 or 620-272.

Credit points: 12.5

Coordinator: Dr K Sharpe

Prerequisites: One of 620-202, 620-270 or 620-272.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 1)*.

Description: This subject develops problem-solving skills and sharpens analytical skills. Students will work in groups, tackling unfamiliar problems. Each team will plan their project work and deliver oral and written presentations.

This subject introduces the basic theory of the general linear model and explains how linear models are used to analyse data. Students should develop the ability to examine data for common structures and patterns and to formulate linear models in specific practical situations, including univariate normal responses with a combination of explanatory factors. They learn to carry out the necessary computations on the computer, check the assumptions of the model in specific situations, and express the results of modelling in scientifically useful terms. This subject demonstrates the importance of the general linear model in analysing a variety of data and giving useful information about scientific subject matter.

Topics covered include general least squares theory of estimation and hypothesis testing; application to one and two-way classifications; factorial experiments; analysis of covariance; multiple regression; polynomial regression; use of statistical computer packages; nested and crossed factors; fixed and random effects; and multiple and orthogonal contrasts.

Assessment: Up to 50 pages of written assignments due during the semester (20%); a group project during semester with a 30-minute oral presentation and a written report of up to 30 pages (15%); a 3-hour written examination in the examination period (65%).

620-372 Applied Statistical Inference

Note: Passing 620-372 precludes subsequent credit for 620-270 or 620-272.

Credit points: 12.5

Coordinator: Dr A Robinson

Prerequisites: 620-371 and 620-202.

Contact: 36 lectures (three per week) and up to 12 practice classes (one per week) *(Semester 2)*.

Description: This subject extends the theory of inference developed in 620-202 Statistics *(p.6)* and demonstrates how it is applied in practice. Students will develop an understanding of the principles of statistical inference and will learn to use a number of important specific techniques in applied statistics.

Topics covered include principles and fundamental results in estimation and hypothesis testing, including consistency, sufficiency, minimum variance unbiased estimation, likelihood methods and associated asymptotic theory, optimal tests and likelihood ratio tests; and generalised linear models. Application of the above methodologies to logistic regression (analysis of grouped and ungrouped binary data), log-linear models (analysis of two- and higher-dimensional contingency tables) and survival analysis (Kaplan-Meier estimates, parametric models, non-parametric models) is also studied.

Assessment: Up to 50 pages of written assignments due during semester (20%); a 3-hour written examination in the examination period (80%).

620-374 Sampling and Forecasting

Credit points: 12.5

Coordinator: Dr O Jones

Prerequisites: 620-202

Contact: 36 lectures (three per week) and up to 12 practice classes (1 per week) *(Semester 2)*.

Description: This subject covers a range of important and generally applicable statistical methods.

Students should develop the ability to employ these methods to implement a range of practically useful statistical analyses. The following three topics will be covered:

- sample surveys: simple random sampling; stratified sampling - optimal allocation, post-stratification; cluster sampling; ratio estimation;
- time series and forecasting: patterns in time series; simple methods for exploratory data analysis; smoothing techniques; decomposition, trends and seasonal variation; simple forecasting methods; models for time series: stationarity, autocorrelation, ARMA processes; estimation and model fitting; and
- re-sampling methods: jack-knife and the bootstrap; and use of the bootstrap for exploring the sampling distribution of an estimator.

Assessment: Up to 50 pages of written assignments during the semester (20%); a 3-hour written examination in the examination period (80%).

620-381 Computational Mathematics

Credit points: 12.5

Coordinator: Dr S Carnie

Prerequisites: Any one of 620-122, 620-142, [05]620-192, [05]620-194, 620-211; together with one of 620-113, 620-123, 620-143, [05]620-193; and one of computer science 433-171 or 433-151 or 620-131 or other evidence of competence in C, C^{++}, Fortran, Pascal, or similar languages.

Contact: 24 lectures (two per week), 12 computer laboratory classes (one per week) and 60 hours of project work *(Semester 1)*.

Description: This subject introduces the underlying basis for numerical techniques to solve a variety of problems; and the role of various kinds of numerical error and how algorithms are designed to minimise this error; and develops basic algorithms in the areas of root-finding, linear systems, interpolation, quadrature and solution of differential equations. Students should acquire skills in implementing the above algorithms in well-constructed computer programs and interpreting the results obtained from the programs. This subject demonstrates the difficulties and possible pitfalls in numerical computation. It also shows where to find sources of reliable numerical software.

Topics include errors, roundoff, truncation error and stability; root-finding, iteration, bisection, Newton's method and secant method; linear systems, Gauss elimination, pivoting, LU factorisation, tridiagonal systems, condition number; interpolation, polynomial and spline; data fitting and least squares methods; quadrature, Newton-Cotes, Gaussian quadrature, adaptive quadrature and improper integrals; and differential equations and initial value problems: Euler, Runge-Kutta, predictor-corrector and stiff problems.

Assessment: Computational assignments of up to 75 pages in total due during the semester (50%); a 2-hour written examination in the examination period (50%).

600-311 Research Project A

See full subject details on page 1.

600-312 Research Project B

See full subject details on page 1.

Mathematics and statistics subjects available to Bachelor of Optometry students only

620-272 Applied Statistics for Optometrists

Note: This subject is available only to BOptom students.

Students may gain credit for only one of 620-270, 620-272 and 620-370.

Students who have completed 620-371 or 620-372 may not enrol in this subject for credit.

Credit points: 12.5

Coordinator: Dr K Sharpe

Prerequisites: VCE Mathematical Methods 3/4.

Contact: 36 lectures (three per week), 11 one-hour computer laboratory classes (one per week) and 11 one-hour tutorials (one per week) *(Semester 2)*.

Description: This subject lays the foundations for an understanding of the fundamental concepts of probability and statistics, as they relate to optometry. Students will learn about the importance of good study design in scientific research, how to examine data to determine underlying structures, formulate statistical models for a range of practical situations and check the assumptions of the model in specific situations. They will also learn to use the computer to carry out standard statistical analyses and to express conclusions in scientifically useful terms.

Topics include: probability, including the concepts of incidence, prevalence, specificity, sensitivity and predictive probability; Bayes' theorem. Random variables and their properties: distribution, mean, variance; binomial and normal distributions; random sampling. Statistical inference: estimation; confidence intervals; hypothesis testing; determination of sample size. Correlation and regression: assumptions; method of least squares; hypothesis testing; confidence and prediction intervals; residuals; transformations; polynomial regression. Analysis of variance models (one-way and two-way models): model specification; assumptions; estimation and hypothesis testing; interaction; transformations; residuals; diagnostics. Design of experiments: randomisation; replication; blocking; standard designs including completely randomised and randomised block designs. Guidelines for supporting an argument for cause and effect based on observational data. Contingency tables: tests for association; odds ratios. Use of the statistical package Minitab.

Assessment: Up to 50 pages of written assignments due during the semester (25%); a 3-hour written examination in the examination period (75%).

Mathematics and statistics subjects available to engineering students only

620-370 Statistics for Mechanical Engineers

Note: This subject is only available to engineering students. Combined science/engineering students should speak to an engineering course adviser before enrolling in this subject as it may be recommended that they complete mathematics and statistics subjects which earn science credit instead.

This subject is not available for science credit points.

Students in the combined degrees BE/BSc or BE/BCom, and students wishing to have access to all 300-level statistics subjects, are advised to enrol in both 620-201 and 620-202 instead of 620-370.

Students may not gain credit for any of 620-152 or 620-160 after having completed 620-370.

It is not possible to gain credit for both 620-370 and any of the following subjects: 620-201, 620-202, 620-205, 620-270, 620-272.

Credit points: 12.5

Coordinator: A/Prof R Watson

Prerequisites: One of 620-113, 620-123, 620-143 or [05]620-193.

Contact: 36 hours of lectures (three per week) and 11 hours of tutorials (one per week) *(Semester 2)*.

Description: This subject introduces the fundamental concepts of probability and statistical inference. Students should develop the ability to use simple probability models in applications to standard situations and to carry out standard statistical analyses. This subject shows the breadth of application of statistics and the important role statistics has in quality improvement, and covers the following topics: basic probability theory; simple probability models (including Bernoulli trials, Poisson processes, sampling models); random variables and descriptions of their probability distributions; simple distribution theory, including binomial, Poisson and normal distributions; mean and variance: the importance of variance in quality management, engineering practice and decision-making under uncertainty; quality checking: acceptance sampling; exploratory data analysis; random sampling and properties of random samples; introduction to statistical inference: estimation, confidence intervals and hypothesis testing in standard situations based in the binomial, Poisson and normal distributions; quality management: control charts; analysis of variance; linear regression and prediction; multiple regression and polynomial regression; and quality improvement: the principles of experimental design and the analysis of some simple designed experiments, including factorial designs and Taguchi methods.

Assessment: Up to 50 pages of written weekly homework during the semester (20%); a 3-hour written examination in the examination period (80%).