Mathematics and statistics

The Department of Mathematics and Statistics offers a variety of subjects at first-, second- and third-year levels which 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, decision management 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 13. Statistics is required in the environmental science co-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 First Year Learning Centre)

The Department of Mathematics and Statistics offers a number of subjects at 100-level. The department has a First Year Learning Centre (FYLC) 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	sem	normal entry requirements
Statistics	620-160 Experimental Design & Data Analysis *(p.6)*	Sum, 1, 2	VCE Mathematical Methods 3/4
	620-131 Scientific Programming & Simulation *(p.5)*	1	Corequisites: one of 620-121, 620-141
For detailed prerequisites, see individual subject descriptions.			

Table 1: Mathematics and statistics 100-level subjects

	subject	sem	normal entry requirements
Mathematics	620-161 Introductory Mathematics *(p.6)*	1	VCE Mathematical Methods 3/4
	620-140 Intermediate Mathematics *(p.5)*	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
	620-163 Introductory Applied Mathematics *(p.6)*	1	Corequisite: 620-141
For detailed prerequisites, see individual subject descriptions.			

Table 1: Mathematics and statistics 100-level subjects			
	subject	sem	normal entry requirements
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.4)*	2	By invitation of the Head of Department
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 620-161 (mathematics) and/or 620-160 (statistics).

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 with exceptional grades in 620-161 in Semester 1 may be given permission to enrol in one or both of 620-142 and 620-143 in Semester 2. This enables entry into 200-level mathematics subjects in second year. Alternatively, 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, 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, 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 the subject 620-381 Computational Mathematics in a later year, which is a recommended subject for students interested in applied mathematics.

Standard and advanced subjects

620-121 Mathematics A (Advanced) requires a very strong level of achievement in VCE Specialist Mathematics 3/4 - as a guide, a study score of 38 in Specialist Mathematics 3/4. Students eligible for the advanced subjects 620-121, 620-122, 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, 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 (MUPHAS)

Students who have studied university-level mathematics at school via the Melbourne University Program for High-Achieving Students (620-120 MUPHAS Mathematics), 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 MUPHAS students who obtained a grade of H3 or better in MUPHAS mathematics is 620-211 in Semester 1, and 620-123 in Semester 2. All MUPHAS students should discuss their subject selection with the department's MUPHAS 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 [00]620-111, 620-121, 620-140, 620-141;
- more than one of [01]620-112, 620-122, 620-142, [99]620-200, 620-211;
- more than one of 620-113, 620-123, 620-143, [98]620-130, [98]620-132;
- more than one of 620-131, 620-152, 620-160.

For credit exclusions for subjects with 617-, 618-, 619- prefixes, see the Head of Department.

200-level subjects

Coordinator: Dr O Foda (200-level coordinator)

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)*
	620-211 Mathematics 2 (Advanced) *(p.7)*
	620-221 Real and Complex Analysis *(p.7)*
	620-231 Vector Analysis *(p.7)*
	620-233 Vector Analysis (Advanced) *(p.8)*
	620-261 Introduction to Operations Research *(p.8)*
	620-270 Applied Statistics *(p.8)*
Semester 2	620-202 Statistics *(p.7)*
	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 will be available in the Summer Semester, but only on a full-fee paying basis.

Probability and statistics: 620-201, 620-202, 620-270. The subject 620-270 is an applied statistics subject which can be taken by students majoring in other disciplines, as well as by students planning further studies in statistics via the decision management specialisation, and is required for students in environmental sciences: the emphasis is on applications and methods.

The pair of subjects 620-201 and 620-202 constitute the basic second-year course for students intending 300-level studies in probability and statistics, and are appropriate for students with a good mathematical background. 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, 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. Selected students will be invited to enrol in these subjects by the Head of Department.

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

300-level subjects

Coordinator: Associate Professor J Koliha (300-level coordinator)

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.10)*
	620-331 Applied Partial Differential Equations *(p.10)*
	620-341 Dynamical Systems & Chaos *(p.10)*
	620-351 Number Theory *(p.11)*
	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.10)*
	620-332 Integral Transforms & Asymptotics *(p.10)*
	620-342 Industrial & Applied Mathematics *(p.10)*
	620-352 Graph Theory *(p.11)*
	620-362 Applied Operations Research *(p.11)*
	620-372 Applied Statistical Analysis *(p.12)*
	620-382 Biostatistics *(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, 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, 620-382. 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, 620-341, 620-342, 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, 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, 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.

Additional subjects: 620-351 Number Theory and 620-352 Graph Theory. These subjects are supplementary to the subjects above and are designed to broaden the scope of studies in mathematics and statistics. Prospective secondary school mathematics teachers are encouraged to take at least one of 620-351, 620-352.

Generic skills: The following subjects 620-341, 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 both 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 (Honours) and Bachelor of Information Systems (Honours) (p.1)*). In particular, students wishing to take mathematics and statistics honours should ensure that all prerequisites for prospective 400-level subjects are satisfied. Honours entry is possible from an appropriate selection of four 300-level mathematics and statistics subjects. If only four subjects are taken, 620-351 or 620-352 would not normally be included in the selection. For a wider choice of honours options, additional mathematics and statistics subjects may be included.

Suggested course plans

Typical course plans for students wishing to take mathematics and statistics beyond 100-level are shown under the specialisations of the mathematics and statistics major on page 13. Note especially the slightly different 100-level requirements for each specialisation. All of the sample courses are suitable for prospective school mathematics teachers.

Students enrolled in the BCom/BSc combined degree program entering with VCE Specialist Mathematics 3/4 or equivalent preparation would benefit from the subjects 620-141 and 620-142, which allow access to the specialisation of operations research. If either 620-131 or 620-160 is also taken, the specialisations of statistics or decision management are available. Actuarial studies students should take 620-121, 620-123 and 620-131.

Students who plan to take only one semester-length subject in mathematics and statistics in their first year are usually advised to select 620-160, especially if their interests lie in the biological, environmental or social sciences.

Students in the Bachelor of Science often take a standard package in first year. Students selecting the life science package in first year could take one or both of the subjects 620-160 and 620-161. Having taken 620-161, students wishing to include only one Semester 2 subject may choose 620-160. Students with VCE Specialist Mathematics 3/4 would normally take 620-141 instead of 620-161.

Students selecting the environmental science package in first year must take 620-160. They may take additional mathematics subjects, depending on their school mathematics background. For example, taking the subjects 620-141 and 620-142 would enable them to start a statistics specialisation.

Students selecting the earth sciences package may take two or more mathematics and statistics subjects in first year. For example, they could take 620-141 and either 620-143 or 620-160, depending on their school background and interests. These subjects are also valuable for other disciplines including earth sciences and chemistry.

Students entering with VCE Specialist Mathematics 3/4 or equivalent preparation and taking the physical sciences package must take three mathematics subjects in first year: 620-141, 620-142 and 620-143 (or their advanced versions). This allows access to the specialisations of pure mathematics, applied mathematics and mathematical physics.

Some possible combinations of 100-level mathematics and statistics subjects are shown in Table 4.

Table 4: Sample selections at 100-level for various majors and courses

Course/major	Recommended subjects
Mathematics and statistics, physics, actuarial studies, BE(IT)/BSc, BE/BSc, environmental sciences, chemistry, earth sciences.	**Four-subject selections** 620-141, 620-142, 620-143 (or advanced versions), with one of 620-131 or 620-160 **Three-subject selections** 620-141 (or 620-121), with two of 620-142, 620-143 (or advanced versions), 620-131 or 620-160
Computer sciences, operations research, environmental sciences, chemistry, earth sciences.	**Two-subject selections** 620-141 (or 620-121), with one of 620-142, 620-143 (or advanced versions), 620-131 or 620-160 Note: Care has to be taken in the two-subject selection in choosing subjects to satisfy prerequisites for desired 200-level subjects.
Biological sciences, environmental sciences, chemistry, earth sciences.	**Two-subject selections** 620-160 with one of 620-121, 620-141, 620-161. **Single-subject selections** Either 620-160 or 620-161

Bachelor of Science (Honours)

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

Further information

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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.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr J Clark

Prerequisites: By invitation of the Head of Department.

Contact: Thirty-six 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 plus extensions material designed to provide deeper insight into interesting areas of mathematics.

Assessment: Up to 24 pages of written assignments, class tests totalling not more than 1.5 hours and a 3-hour end-of-semester written examination (as for 620-123), plus written submissions of up to 24 pages for the extensions material.

620-121 Mathematics A (Advanced)

Note: Students may only gain credit for one of [00]620-111, 620-121, 620-140, 620-141.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof B Hughes

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: Thirty-six lectures (three per week), 11 1-hour tutorials (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 solution of systems of linear equations by row operations, row echelon form and reduced row echelon form; matrices, rank of a matrix, inverses, applications to solving sytems 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, differentiability. Single and multivariable differential calculus topics include treatment of polynomial, rational, trigonometric, exponential, logarithmic, and hyperbolic functions and their inverses; implicit differentiation; applications to graph sketching; level curves, partial derivatives, chain rules for partial derivatives, 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; and fundamental theorem of calculus, Liebniz's theorem, improper integrals.

Assessment: Up to 24 pages of written assignments, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-122 Mathematics B (Advanced)

Note: Students may gain credit for only one of [01]620-112, 620-122, 620-142, [99]620-200, 620-211.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr S Gadde

Prerequisites: One of [00]620-111, 620-120 (MUPHAS Mathematics), 620-121 or a grade of H1 in either 620-140 or 620-141.

Contact: Thirty-six lectures (three per week), 11 1-hour tutorials (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 all 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.

Sequences and series topics include convergence and divergence of sequences and series; tests for convergence; and Taylor's theorem and series representation of elementary functions. Linear algebra topics include vector spaces in general, axioms, linear independence, basis sets, dimensionality, R_n and C_n; inner products; linear transformations, matrix of a linear transformation, change of basis, rank, inverse, solution of linear equations; and eigenvectors and eigenvalues, quadrics and conics, rotation matrices, diagonal, real-symmetric and orthogonal matrices.

Assessment: Up to 24 pages of written assignments, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-123 Applied Mathematics (Advanced)

Note: Students may only gain credit for one of 620-113, 620-123, 620-143.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr J Clark

Prerequisites: One of [00]620-111, 620-120 (MUPHAS Mathematics), 620-121 or a grade of H1 in either 620-140 or 620-141.

Contact: Thirty-six lectures (three per week), 11 1-hour tutorials (one per week) *(Semester 2).*

Description: This subject introduces the classification and principles governing the solution of the basic first and second order differential equations. Students completing the subject develop the ability to classify and solve with accuracy and confidence 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 systematic integration; approximate integration; applications of integration, areas, arc length, surface areas and volumes of solids of revolution in cartesian and polar coordinates. Differential equations topics include first order differential equations (linear via integrating factors, separable and homogeneous) and applications; second order differential equations (reducible to first order, linearly independent solutions), second order linear differential equations with constant coefficients, particular integrals, complementary functions and applications. Systems of differential equations include systems of linear differential equations with constant coefficients, applications of matrix methods, stability; equilibrium and stability of conservative systems, small oscillations; and first-order autonomous nonlinear systems and the phase plane.

Assessment: Up to 24 pages of written assignments, class tests totalling not more than 1.5 hours and a 3-hour end-of-semester written examination.

620-131 Scientific Programming & Simulation

Note: Students may only gain credit for one of 620-131, 620-152, 620-160.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr S Carnie

Pre or Corequisites: One of 620-120 (MUPHAS Mathematics), 620-121, 620-140, 620-141, 620-211.

Contact: Thirty-six lectures (three per week), 22 hours practical, 11 1-hour tutorials and 12 hours project work *(Semester 1).*

Description: This subject introduces the syntax of a programming language, the terminology of probability and the principles of probability modelling. Students completing the subject develop the ability to read, write and adapt computer programs, reformulate problems in a form suitable for computer solution, and use established numerical methods. They learn to carry out probability calculations using standard distributions, make an appropriate choice of model for standard situations, and to write programs to simulate simple probability models. The subject demonstrates the structure of a programming language, its potential and limitations, the application of probability modelling in describing the real world and the concept of randomness.

Introduction to programming topics include algorithms, simple data types, assignment, conditionals, iteration, functions and procedures, complex data types, array processing. Numerical methods: number representation, errors, numerical integration, solution of linear and nonlinear equations, sequences and series. Probability: basic probability theory, conditional probability and independence, law of total probability and Bayes' theorem. Elementary distribution theory: cumulative distribution function and quantiles; probability mass function and probability density function. Discrete and continuous distributions, using binomial and normal distributions as examples. Simulation: Uniform number generators. Simulation of observations on a given distribution. Simulation of probability models. Application of the computer to simulation. An introduction to the principles of estimation and hypothesis testing based on simple probability models.

Assessment: Up to 24 pages of written assignments or project work as required, and a 3-hour end-of-semester written examination.

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 [00]620-111, 620-121, 620-140, 620-141.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr F Barrington

Prerequisites: 620-161 or equivalent

Contact: Thirty-six lectures (three per week), 11 one-hour tutorials (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.

This subject develops problem-solving skills (especially through tutorial exercises) including facing unfamiliar problems, identifying relevant strategies and the ability to generalise mathematical arguments.

Topics covered: Matrices: matrix algebra, rank, inverses, applications to linear systems. Determinants: definitions, evaluation, applications. Vectors: dot and cross products, scalar triple product. Vector geometry: problems involving intersecting lines and planes, volumes and areas. Linear transformations: transformation matrices, orthogonal matrices, geometrical applications. Single variables: polynomial, rational, trigonometric, exponential, logarithmic and hyperbolic functions and their inverses; implicit differentiation. Multivariable calculus: partial derivatives, chain rules for functions of several variables, directional derivatives, tangent planes, extrema for functions of several variables. 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 24 pages of written assignments, class tests totalling not more than 1.5 hours and a 3-hour end-of-semester written examination.

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 [00]620-111, 620-121, 620-140, 620-141.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr F Barrington

Contact: Thirty-six lectures (three per week), 11 1-hour tutorials (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 basic work on complex numbers. Students should develop the ability to solve systems of linear equations, employ vector methods in geometrical problems, differentiate the basic functions of calculus 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, 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, applications to solving sytems 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. Single and multivariable differential calculus topics include treatment of polynomial, rational, trigonometric, exponential, logarithmic, and hyperbolic functions and their inverses; implicit differentiation; applications to graph sketching; level curves, partial derivatives, chain rules for partial derivatives, 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.

Assessment: Up to 24 pages of written assignments, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-142 Mathematics B

Note: Students may only gain credit for one of [01]620-112, 620-122, 620-142, [99]620-200, 620-211.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr P Forrester

Prerequisites: Normally one of 620-140 or 620-141. Or any one of [00]620-111, 620-120 (MUPHAS Mathematics), 620-121.

Contact: Thirty-six lectures (three per week), 11 1-hour tutorials (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 the basic properties of sequences and series, including Taylor series for functions. Students should develop the ability to understand the methods of linear algebra and convergence of series and sequences.

Linear algebra topics include vector spaces in general, axioms, linear independence, basis sets, dimensionality, R_n and C_n; inner products; linear transformations, matrix of a linear transformation, change of basis, rank, inverse, solution of linear equations; eigenvectors and eigenvalues, rotation matrices, diagonal, real-symmetric and orthogonal matrices. Sequences and series topics include convergence and divergence of sequences and series; tests for convergence; and Taylor's theorem and series representation of elementary functions.

Assessment: Up to 24 pages of written assignments, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-143 Applied Mathematics

Note: Students may only gain credit for one of 620-113, 620-123, 620-143.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr C Mangelsdorf

Prerequisites: Normally one of 620-140 or 620-141. Or any one of [00]620-111, 620-120 (MUPHAS Mathematics), 620-121.

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

Description: This subject introduces the terminology of ordinary differential equations; the principles of first and second order ordinary differential equations; and linear systems of first and second order ordinary differential equa-

tions and their applications. Students completing the subject develop the ability to solve analytically first order ordinary differential equations (ODEs), second order linear ODEs, and systems of two or three linear first order ODEs using eigenvalue/eigenvector techniques; and to apply the above techniques to simple problems. The subject demonstrates the role of differential equations in applied mathematics.

Integration topics include antiderivatives and the definite integral; systematic integration; applications of integration, areas, arc length, surface areas and volumes of solids of revolution in cartesian and polar coordinates. Differential equations topics include first order differential equations (separable, linear via integrating factor, homogeneous) and applications; second-order differential equations (reducible to first order, linearly independent solutions), second-order linear differential equations (particular integrals, complementary functions) and applications. Systems of differential equations topics include eigenvalues and eigenvectors; systems of first order differential equations and applications; and systems of second order linear differential equations and applications.

Assessment: Up to 24 pages of written assignments, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-160 Experimental Design & Data Analysis

Note:

- Students may only gain credit for one of [99]620-001, 620-131, 620-152, 620-160.
- Students who have completed 620-202, [01]620-204 or 620-270 may not enrol in this subject for credit.

Credit points: 12.5 **HECS-band:** 2

Coordinator: K Baker

Prerequisites: VCE Mathematical Methods 3/4

Contact: Thirty-six lectures (three per week), 11 hours practical classes (one hour per week) and 11 1-hour tutorials (one per week) *(Semester 1, repeat 2, Summer).*

Description: This subject lays the foundations for subsequent studies in probability and statistics, as well as being vital for students who need to use probability and statistics in other subjects in their course. Students completing this subject will develop skills in probability modelling and data analysis, and appreciate the significance of random variation in science, technology 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 distribution-free methods; introduction to bivariate data, including correlation and linear regression; scientific method and experimental design, including randomisation, blocking, factorial structure; inference for regression; and application of computer software to data analysis.

Assessment: Up to 36 pages of written assignments or project work and a 3-hour written examination.

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 [00]620-111, 620-121, 620-140 or 620-141 may not enrol in this subject for credit.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof M Sniedovich

Contact: Thirty-six lectures (three per week), 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; 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.

This subject develops problem-solving skills through tutorial exercises, including formulation analysis and solution of unfamiliar problems, identifying relevant strategies and the ability to generalise mathematical arguments and the use of on-line interactive software.

Assessment: Up to 24 pages of written project and assignment work, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-163 Introductory Applied Mathematics

Note:

- Students who have passed [00]620-111, 620-113, 620-120 (MUPHAS Mathematics), 620-121, 620-123 or 620-143 may not subsequently enrol in this subject for credit.
- Students may only gain credit for one of 620-151, 620-161, 620-163.

Credit points: 12.5

Coordinator: Dr D Coulson

Prerequisites: The assumed background for this subject is VCE Specialist Mathematics 3/4 or a very good result in VCE Mathematical Methods 3/4. It is recommended that students with a study score of less than 30 in VCE Specialist Mathematics 3/4 take 620-163 before proceeding to 620-143.

Corequisites: 620-141

Contact: Thirty-six lectures (three per week), 11 one-hour tutorials (1 per week) *(Semester 1).*

Description: This subject lays the foundations for subsequent studies in applied mathematics and differential equations. Students completing this subject will develop skills in discrete and continuous modelling and appreciate the possibilities for applications in physical sciences, statistics and other areas.

Topics covered: Differentiation: Review and extension of standard methods including implicit differentiation, derivatives of inverse functions and applications. Integration: Standard methods including integration by parts, applications to areas, volumes, lengths of curves, moments and centre of mass of laminas and continuous statistical distributions. Simple Differential Equations: single population models, springs and oscillatory processes, numerical solution of differential equations. Difference Equations: Standard methods for linear equations; discrete population models; stochastic modelling problems.

You will develop analytical skills including the ability to construct and express logical arguments and to work in abstract or general terms to increase the clarity and efficiency of analysis. You will also develop approaches to specific problem solving and the use of software tools where appropriate for problem solving.

Assessment: Up to 24 pages of written assignments, class tests totalling not more than 1.5 hours and a 3-hour end-of-semester written examination.

200-level subjects

620-201 Probability

Note: Students may only gain credit for one of [99]620-001, [99]620-005, 620-201, [01]620-203, 620-370, 431-325.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr A Xia

Prerequisites: One of [00]620-111, 620-120 (MUPHAS Mathematics), 620-121, 620-141 and one of 620-131, 620-160, [01]620-112, 620-122, 620-142, [99]620-200, 620-211, 620-113, 620-123, 620-143, [98]620-130, [98]620-132.

Contact: Thirty-six lectures (three per week) and 22 tutorial/practice class hours (two per week) *(Semester 1).*

Description: This subject introduces the fundamental concepts of probability, probability modelling and simulation. Students should develop the ability to use simple probability models and carry out standard probability calculations. They should learn to apply standard distributions to calculate probabilities and to use simulations to approximate probabilities. This subject demonstrates the breadth of application of probability, the principles of probability modelling and the application of computer software in probability calculations.

Simple probability models topics include Bernoulli trials, Poisson processes, sampling models, use of conditional probability. Random variables topics include descriptions of their probability distributions, probability mass function, probability density function, cumulative distribution function and quantiles, expectation. Standard distributions topics include hypergeometric, binomial, geometric, negative binomial, Poisson, normal, exponential and gamma distributions and their applications; mean, variance and other moments. Transformations topics include distribution of $g(X)$, approximations to the mean and variance of $g(X)$. Random variables topics include descriptions of their probability distributions; expectation of $g(X,Y)$; bivariate normal distribution; covariance and correlation; independence of random variables; distribution of $g(X,Y)$, where X and Y are independent, conditional dis-

tributions, conditional means and variances and their uses. Probability generating functions topics include applications; random sums; branching processes. Other topics: Markov chains; simulation of random variables and processes; moment generating functions; the law of large numbers and the central limit theorem.

This subject contributes to developing students' generic skills as well. These include the ability to adopt new ideas, from participation in the lecture program, to use simple probability models and carry out standard calculations, and to develop creative ways of solving unfamiliar problems, especially through practice classes.

Assessment: A 3-hour end-of-semester written examination; up to 50 pages of assignments may be assessed.

620-202 Statistics

Note:

- Students may gain credit for only one of 620-202 and [01]620-204.
- Passing 620-202 precludes subsequent credit for 620-152 or 620-160.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof R Watson

Prerequisites: 620-201 or [01]620-203.

Contact: Thirty-six lectures (three per week) and 22 tutorial/practice class hours (two hours per week) *(Semester 2).*

Description: This subject introduces the fundamental concepts of mathematical statistics, the theory underlying statistical inference and the basic principles of experimental design. Students should develop the ability to carry out a range of probability calculations and to carry out standard statistical analyses. This subject demonstrates the breadth of application of probability and statistics, the importance of the underlying mathematical theory of statistics and the application of computer software in probability calculations, simulation and statistical analysis.

Random sampling topics include properties of random samples; review of descriptive statistics; distributions of statistics, in particular sample mean and sample frequencies; distribution of sample mean and sample variance for sampling from a normal distribution. Estimation topics include estimation of parameters of probability distributions; point estimation and interval estimation; methods of estimation, method of moments, maximum likelihood estimation, confidence intervals and prediction intervals; likelihood intervals; introduction to Bayesian methods; hypothesis testing; likelihood ratio tests; and the theory and applications of the general linear model; regression problems; analysis of one-way and two-way classifications; analysis of standard statistical experiments; basic principles of experimental design.

Assessment: A 3-hour end-of-semester written examination; up to 50 pages of assignments may be assessed.

620-211 Mathematics 2 (Advanced)

Note: Students may gain credit for only one of [01]620-112, 620-122, 620-142, [99]620-200, 620-211.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Prof C Miller

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

Contact: Thirty-six lectures (three per week), 11 1-hour tutorials (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, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-221 Real and Complex Analysis

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr K Wysocki

Prerequisites: One of [01]620-112, 620-122, [99]620-200 or 620-211; a grade of H3 or better in the prerequisite is recommended. Students with a grade of H1 in 620-142 will be permitted to enrol on completion of additional summer reading.

Corequisites: One of 620-113, 620-123, 620-143.

Contact: Thirty-six 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; 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, absolute and conditional convergence; tests for convergence; power series of complex numbers, radius of convergence; basic topological concepts in the complex plane; continuous functions and their properties; homomorphic functions, 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, Weierstrass M-test; equivalence of complex differentiability to the local power series expansion; Laurent series, singularities, poles; and residue theorem, evaluation of integrals, summation of series.

Assessment: Up to 24 pages of written assignments and a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-222 Linear and Abstract Algebra

Credit points: 12.5 **HECS-band:** 2

Coordinator: Prof H Rubinstein

Prerequisites: One of [01]620-112, 620-122, [99]620-200 or 620-211; a grade of H3 or better in the prerequisite is recommended. Students with a grade of H1 in 620-142 will be permitted to enrol on completion of additional reading.

Contact: Thirty-six 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; 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; 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 and a 3-hour end-of-semester written examination.

620-231 Vector Analysis

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr C Mangelsdorf

Prerequisites: Either one of 620-113, 620-123, 620-143; or one of [98]620-122, [98]620-142 and one of [98]620-130, [98]620-132.

Contact: Thirty-six 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, 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, Stokes' theorem; curvilinear coordinates.

Assessment: Up to 24 pages of written assignments; a 3-hour end-of-semester written examination; and class tests totalling not more than 1.5 hours.

620-232 Mathematical Methods

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr A Tordesillas

Prerequisites: One of [01]620-112, 620-122, 620-142, [99]620-200, 620-211, and one of 620-113, 620-123, 620-143, [98]620-130, [98]620-132.

Note: [98]620-142 is not sufficient to enrol in this subject.

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

Description: This subject introduces the terminology of classifying and describing ordinary and partial differential equations; the concept of obtaining complete and general solutions. It develops general methods to solve linear ordinary differential equations and partial differential equations using Fourier series, Laplace transforms and special functions to provide solutions to such equations. Students should develop the ability to use standard methods such as Laplace transforms, series solutions, separation of variables for obtaining solutions. This subject demonstrates the complexity and the necessary ingredients required in obtaining solutions to ordinary and partial differential equations and indicates more advanced techniques available in further courses on mathematical methods.

Partial differential equations topics include Laplace's equation, wave equation and heat equation; separation of variables; Fourier series. Ordinary differential equations topics include introduction to Laplace transforms and applications; differential equations with variable coefficients, independent solutions, Wronskians; series solutions of ordinary differential equations; Bessel functions, Legendre polynomials and other special functions.

Assessment: Up to 24 pages of written assignments, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-233 Vector Analysis (Advanced)

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr C Mangelsdorf

Prerequisites: Entry to this subject will be by invitation of the Head of Department, usually requiring a very high level of achievement in the prerequisites for 620-231 Vector Analysis *(p.7)*

Contact: Thirty-six lectures (three per week) and 11 1-hour tutorials (one per week) plus up to 12 additional contact hours *(Semester 1)*.

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

Assessment: Up to 48 pages of written assignments; a 3-hour written examination at the end of semester; and class tests totalling not more than 1.5 hours.

620-234 Mathematical Methods (Advanced)

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr A Tordesillas

Prerequisites: Entry to this subject will be by invitation of the Head of Department, usually requiring a very high level of achievement in the prerequisites for 620-232 Mathematical Methods *(p.7)*.

Contact: Thirty-six lectures (three per week) and 11 1-hour tutorials (one per week) plus up to 12 additional contact hours *(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 the interesting areas of mathematical methods.

Assessment: Up to 48 pages of written assignments; a 3-hour written examination at the end of semester; and class tests totalling not more than 1.5 hours.

620-252 Analysis

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof P Pearce

Prerequisites: One of [01]620-112, 620-122, 620-142, [99]620-200, 620-211, and one of 620-113, 620-123, 620-143, [98]620-130, [98]620-132.

Note: [98]620-142 is not sufficient to enrol in this subject.

Contact: Thirty-six 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, 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, Cauchy's integral theorem; Laurent series; singularities, poles, Liouville's theorem; residue theorem, limiting contours, and evaluation of integrals using contour integration.

Assessment: Up to 24 pages of written assignments; a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-261 Introduction to Operations Research

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof M Sniedovich

Prerequisites: One of [01]620-112, 620-122, 620-142, [99]620-200, 620-211.

Note: [98]620-142 is not sufficient to enrol in this subject.

Contact: Thirty-six 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, shortest path and critical path problems, knapsack problem, applications of operations research techniques to real-world problems; and use of computer packages and internet resources will be covered.

Assessment: Up to 24 pages of written assignments and a 3-hour end-of-semester written examination.

620-262 Decision Making

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof M Sniedovich

Prerequisites: 620-261.

Contact: Thirty-six 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, and what kind of practical problems have these features. It develops a number of basic mathematical approaches to such situations and the techniques used to solve decision-making situations 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 evaluate rules for decision-making problems under strict uncertainty. This subject demonstrates the complexity of decision-making situations encountered in operations research investigations, the extent and limitations of a number of operations research techniques used to solve such problems, and the important role that linear algebra and calculus play in the development of these techniques.

A selection of topics in decision analysis will be covered, including single-stage and multi-stage decision models, in particular those using linear programs; zero-sum games; preference relations and optimisation; multi-criteria decision-making; and decision trees. Use of computer packages and internet resources will also be covered.

Assessment: Up to 24 pages of written assignments and a 3-hour end-of-semester written examination.

620-270 Applied Statistics

Note:

- Students may only gain credit for one of 620-270 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 **HECS-band:** 2

Coordinator: Dr M Ng

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

Contact: Thirty-six lectures (three per week), 22 tutorial/practice class hours (two 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, 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; introduction to confounding. Analysis of covariance topics include detailed treatment of the case with one factor and one covariate; 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 assignments and a 3-hour end-of semester written examination.

300-level subjects

620-301 Stochastic Modelling

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof K Borovkov

Prerequisites: One of 620-201 or [01]620-203; and at least one of [01]620-112, 620-113, 620-122, 620-123, [98]620-130, [98]620-132, 620-142, 620-143, [99]620-200, 620-211.

Contact: Thirty-six 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 Poisson process, Markov chains in discrete and continuous time (with some applications), renewal processes and time series. 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, type 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; elements of time series (stationarity, filtering, basic linear models, identification and estimation); and elements of simulation.

This subject contributes to developing students' generic skills as well. These include the ability to adopt new ideas, from participation in the lecture program, and to develop creative ways of solving unfamiliar problems, especially through practice classes.

Assessment: Up to 50 pages of written assignments (20%); and a 3-hour end-of-semester written examination (80%).

620-302 Chance and Options Pricing

Note: Credit cannot be gained for both 620-302 and 300-332.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof K Borovkov

Prerequisites: 620-301. Students with 620-201 or [01]620-203 and a strong mathematical background may be granted permission to enrol by the Head of Department.

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

Description: This subject focuses on modern probability methods and modelling with a view to applications in science, finance and insurance. Students learn probability modelling by using the concepts of stochastic processes. They learn basic models based on Brownian motion and apply these to continuous-time models of asset prices. Students are introduced to stochastic calculus and to diffusion models in finance and biology as well as Monte Carlo simulations for these models. 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, transforms, conditioning, random walk, martingales, Brownian motion, Ito's formula, Brownian motion calculus, stochastic differential equations and diffusions; Levy processes and their applications. Applications include models in finance (such as the Black-Scholes model, multidimensional asset model and the Vasicek model for interest rates), and in biology (such as diffusion models in genetics and population dynamics); and Monte Carlo simulations of price processes of stocks and options.

This subject contributes to developing students' generic skills as well. These include the ability to adopt new ideas, from participation in the lecture program, and to develop creative ways of solving unfamiliar problems, especially through practice classes.

Assessment: Up to 50 pages of written assignments (20%); and a 3-hour end-of-semester written examination (80%).

620-311 Metric Spaces

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof D Robbie

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: Thirty-six 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, 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, 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.

You will develop analytical skills including the ability to construct and express logical arguments and work in abstract or general terms to increase the clarity and efficiency of analysis. You will also develop approaches to specific problem solving and cooperative (team) work in assignments.

Assessment: Up to 24 pages of written assignments (20%); and a 3-hour end-of-semester written examination (80%).

620-312 Linear Analysis

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof J Koliha

Prerequisites: 620-311.

Contact: Thirty-six 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 24 pages of written assignments and a 3-hour end-of-semester written examination.

620-321 Algebra

Credit points: 12.5 **HECS-band:** 2

Coordinator: Prof H Rubinstein

Prerequisites: 620-222 (grade of H3 or better).

Contact: Thirty-six 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; examples including 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; integral domains and the field of quotients; Euclidean domains and principal ideal domains. Modules topics include submodules, homomorphisms of modules, quotient modules; free modules and bases; structure of a finitely generated module over a principal ideal domain; 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. 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 and a 3-hour end-of-semester written examination.

620-322 Topology

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr S Gadde

Prerequisites: 620-231 or 620-233; 620-311 and 620-321.

Contact: Thirty-six 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; introduction to homology theory.

Assessment: Up to 24 pages of written assignments and a 3-hour end-of-semester written examination.

620-331 Applied Partial Differential Equations

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof K A Landman

Prerequisites: One of 620-231 or 620-233; and one of 620-232 or 620-234.

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

Description: This subject introduces the various types of partial differential equations and their methods for solution, and how they arise in physical problems. It develops the idea of characteristics and propagation of information, the need for shocks and the concepts of diffusion and flux. Students should develop the ability to solve wave equations using the methods of characteristics and shocks; to solve diffusion equations and their steady state versions; and to solve second order linear partial differential equations using various methods, including eigenfunction methods, integral transforms, and Green's functions. This subject demonstrates the description of many physical processes (for example traffic flow, sedimentation, head transfer, fluid flow) as partial differential equations; and it shows the power of various mathematical techniques to solve real-world problems.

First order partial differential equations topics include continuity equation, wave equation, method of characteristics, shocks; applications from traffic flow, sedimentation. Second order wave equation topics include d'Alembert's solution, method of characteristics, nonlinear wave equations, dispersive waves. Diffusion and conduction topics include Fick's and Fourier's laws, similarity solutions, Stefan problems, Laplace and Poisson equations for steady-state problems. Second order linear partial differential equations topics include classification, eigenfunction methods, integral transforms, Green's functions.

Assessment: Up to 24 pages of written assignments, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-332 Integral Transforms & Asymptotics

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr O Foda

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

Contact: Thirty-six 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 topics include contour integration, branch cuts, and evaluation of integrals. Integral transforms topics include wave equation, Fourier series; Fourier transform, Fourier integral theorem, convolution, applications; Laplace transform, inversion, examples; application to ordinary differential equations; convolution and applications; and Mellin transform examples. Asymptotics topics include asymptotic expansions, application of Mellin transform; Laplace's method for integrals, method of steepest descent, applications; method of stationary phase, examples; and WKB method for ordinary differential equations, asymptotic matching.

Assessment: Up to 24 pages of written assignments, a 3-hour end-of-semester written examination and class tests totalling not more than 1.5 hours.

620-341 Dynamical Systems & Chaos

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr I Aitchison

Prerequisites: One of 620-113, 620-123, 620-143, [98]620-130, [98]620-132; and one of 620-221, 620-231, 620-232, 620-233, 620-234, 620-252.

Contact: Thirty-six lectures (three a 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 both oral and written presentations.

This subject introduces the basic concepts and recent developments in the fields of dynamical systems and chaos, including stability of equilibria and renormalisation theory of transitions to chaos. Students should develop the ability to analyse simple nonlinear discrete and continuous dynamical systems, and to chart parameter regions of stability, periodicity and chaos. This subject demonstrates the power as well as the limitations of dynamical systems theory and chaos applied to realistic complex systems.

Dynamical systems topics include phase space, Poincare sections, phase portraits, invariant measures. Chaos topics include integrable and chaotic systems, maps on an interval, period doubling and universality, iteration in the complex plane, Mandelbrot and Julia sets, renormalisation and scaling, reversible mappings, KAM theorems, strange attractors, fractals, limit cycles, Hopf bifurcation, Lorentz attractor, Lyapunov exponents, dimensions of strange attractors, hierarchies of chaos; and applications to ecology, chemical reactions, economics, management and meteorology.

Assessment: Up to 24 pages of written assignments and a 3-hour end-of-semester written examination.

620-342 Industrial & Applied Mathematics

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr S L Carnie

Prerequisites: 620-331.

Contact: Thirty-six 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 which 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, 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 24 pages of written assignments and a 3-hour end-of-semester written examination.

620-351 Number Theory

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr J R Groves

Prerequisites: One of [00]620-111, 620-120 (MUPHAS Mathematics), 620-121, 620-141.

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

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

Assessment: Up to 24 pages of written assignments and a 3-hour end-of-semester written examination.

620-352 Graph Theory

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr R Brak

Prerequisites: Twenty-five points from the following: 200-level science mathematics subjects, 200-level science statistics subjects, computer science 433-253.

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

Description: This subject introduces the basic concepts of graph theory including paths and cycles, trees and counting, automorphism groups, planar graphs, colouring properties, chromatic polynomials, matching theory. 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. This subject demonstrates the variety of applications of graph theory both within and outside mathematics.

Introduction to graph theory topics include basic concepts, paths and cycles, trees and counting, combinatorics, matching theory, and probabilistic method. Algorithms topics include minimum spanning trees, maximum matchings, flows, approximation algorithm.

Assessment: Up to 24 pages of written assignments and a 3-hour end-of-semester written examination.

620-361 Operations Research: Techniques

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr N Boland

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

Contact: Thirty-six 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 both oral and written presentations.

This subject introduces a number of basic techniques of operations research, selecting topics from nonlinear and parametric optimisation, 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 nonlinear techniques, decision tree models, parametric optimisation, simulation. Use of computer packages and internet resources is examined. Case studies and projects are undertaken.

Assessment: Up to 24 pages of written assignments, a group project and a 3-hour end-of-semester written examination.

620-362 Applied Operations Research

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr N Boland

Prerequisites: 620-361 or 620-262. Also recommended is 620-131 or computer science 433-141.

Contact: Thirty-six 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 both 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 100 pages of project reports and written assignments, and up to 2-hour mid-semester test.

620-371 Linear Models

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr K Sharpe

Prerequisites: One of 620-202, [01]620-204 or 620-270.

Contact: Thirty-six 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 both 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 and a 3-hour end-of-semester written examination.

620-372 Applied Statistical Analysis

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

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr K Sharpe

Prerequisites: 620-371 and one of 620-202 or [01]620-204.

Contact: Thirty-six lectures (three per week) and 11 practice classes (one per week) *(Semester 2).*

Description: This subject extends the theory of inference developed in 620-202 Statistics *(p.7)* and demonstrates how it is applied in practice. In addition, a number of recently developed techniques for analysing data, which involve extensive computer computations, are considered. 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. Generalised linear models. Application of the above methodologies - in particular, application to logistic regression and log-linear models. Introduction to Bayesian methods.

Re-sampling methods; jack-knife and the bootstrap; use of the bootstrap for exploring the sampling distribution of an estimator.

The subject develops the students' generic skills, including thinking critically and organising knowledge; analysing data, interpreting results and presenting conclusions in a clear and comprehensible manner; using computers for data analysis and presentation; and solving problems.

Assessment: Up to 50 pages of written assignments and a 3-hour end-of-semester written examination.

620-381 Computational Mathematics

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr J Clark

Prerequisites: Any one of [01]620-112, 620-122, 620-142, [99]620-200, 620-211, together with one of 620-113, 620-123, 620-143, [98]620-130, [98]620-132 and one of computer science 433-171 or 433-142 or 620-131 or other evidence of competence in C, C^{++}, Fortran, Pascal, or similar languages.

Note: [98]620-142 is not sufficient to enrol in this subject.

Contact: Twenty-four lectures (two per week), 12 practical classes (one per week) and 60 hours project work *(Semester 1).*

Description: This subject introduces the underlying basis for numerical techniques to solve a variety of problems; 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, stability; root-finding, iteration, bisection, Newton's method, secant method; linear systems, Gauss elimination, pivoting, LU factorisation, tridiagonal systems, condition number; interpolation, polynomial, spline; data fitting, least squares methods; quadrature, Newton-Cotes, Gaussian quadrature, adaptive quadrature, improper integrals; and differential equations, initial value problems: Euler, Runge-Kutta, predictor-corrector, stiff problems.

Assessment: A 2-hour end-of-semester written examination and project work as required.

620-382 Biostatistics

Credit points: 12.5 **HECS-band:** 2

Coordinator: Dr G Byrnes

Prerequisites: 620-371 and one of 620-202 or [01]620-204.

Contact: Thirty-six lectures (three per week) and 11 practice classes (one per week) *(Semester 2).*

Description: This subject introduces a range of methods and concepts used in the design of studies for the biological sciences, and the analysis of the resultant data. The emphasis of the course is on understanding how, why and when the various methods should be used rather than on a detailed theoretical development. Students will develop an understanding of a range of important statistical methodology relevant to the biological sciences and its practical implementation.

Topics are selected from issues in study design: designed experiments versus observational studies, randomisation, blocking, stratification, matching, confounding, sample size, practical issues in randomised controlled trials. Design of surveys and analysis of survey data. Statistical aspects of diagnostic tests, including sensitivity and specificity, positive and negative predictive values, receiver operating characteristic curve. Survival analysis: Kaplan-Meier estimates, parametric models, non-parametric models. Bioinformatics: an introduction.

The subject develops the students' generic skills, including thinking critically and organising knowledge; analysing data, interpreting results and presenting conclusions in a clear and comprehensible manner; using computers for data analysis and presentation; and solving problems.

Assessment: Up to 50 pages of written assignments and a 3-hour end-of semester written examination;

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 extended degree students only

620-081 Preliminary Mathematics A

Note: This subject is only available to students enrolled in the extended BE or extended BSc degree. This subject is not available for science credit points.

Credit points: 12.5 **HECS-band:** 2

Coordinator: K Baker

Prerequisites: Mathematics as a final year subject at school.

Contact: Thirty-six lectures, 11 1-hour tutorials *(Semester 1, repeat 2).*

Description: This subject forms the first part of a two-semester sequence of subjects suitable for students who have taken standard mathematics in the final year of an international secondary school. On successful completion of 620-081, students will have acquired mathematical skills at least equivalent to those gained by the completion of VCE Mathematical Methods 3/4.

Algebra topics include polynomials, linear factors, factor theorem, remainder theorem, quadratic and cubic equations, surds, binomial theorem, general transposition of formulae, partial fractions. Functions topics include trigonometric, exponential and logarithmic functions; graphs, domains, asymptotic behaviour, elementary coordinate geometry; composite functions, inverse functions; solution of equations involving transcendental functions. Calculus topics include derivatives, rules for differentiation including product, quotient and chain rules, use of derivatives in graph sketching; integration of simple functions, areas under curves. Probability and statistics topics include permutations and combinations, elementary probability; random variables: mean, variance; binomial, hypergeometric and normal distributions.

You will develop mathematical knowledge and skills, and the ability to apply mathematical knowledge to analyse, investigate, model and solve problems in a variety of situations, ranging from the well-defined and familiar situations to unfamiliar and open-ended situations.

Assessment: Up to 24 pages of written assignments (10%), a 3-hour end-of-semester written examination (75%) and class tests totalling not more than 1.5 hours (15%).

620-082 Preliminary Mathematics B

Note: This subject is available only to students enrolled in the extended BE or extended BSc degree. This subject is not available for science credit points.

Credit points: 12.5 **HECS-band:** 2

Coordinator: K Baker

Prerequisites: 620-081 Preliminary Mathematics A (or equivalent)

Contact: Thirty-six lectures, 11 1-hour tutorials *(Semester 2, repeat Summer).*

Description: This subject forms the second part of a two-semester sequence of subjects suitable for students who have taken standard mathematics in the final year of an international secondary school. On successful completion of 620-082, students will have acquired mathematical skills at least equivalent to those gained by the completion of VCE Mathematical Methods 3/4 and Specialist Mathematics 3/4.

Complex numbers topics include algebra of complex numbers, modulus, argument; Argand plane, polar form, de Moivre's theorem; solution of polynomial equations; regions in the complex plane. Vectors topics include geometrical vectors; components, scalar product, resolutes, position vectors, differentiation of position vectors and kinematical applications. Calculus topics include derivatives of inverse functions including inverse trigonometric functions, chain rule applications, integration techniques using trigonometric and other substitutions and using partial fractions; areas of regions in the

plane, volumes of solids of revolution; differential forms for velocity and acceleration, velocity-time graphs; simple differential equations. Coordinate geometry topics include sketching graphs of rational functions; asymptotic behaviour, stationary points; conic sections, including parametric forms.

You will develop mathematical knowledge and skills, and the ability to apply mathematical knowledge to analyse, investigate, model and solve problems in a variety of situations, ranging from the well-defined and familiar situations to unfamiliar and open-ended situations.

Assessment: Up to 24 pages of written assignments (10%), a 3-hour end-of-semester written examination (75%) and class tests totalling not more than 1.5 hours (15%).

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, [01]620-203, [01]620-204, 620-270, [99]620-001, [99]620-005.

Credit points: 12.5 **HECS-band:** 2

Coordinator: Assoc Prof R Watson

Prerequisites: One of [00]620-111, 620-121, 620-141, 620-211 and one of 620-113, 620-123, 620-143, [98]620-130, [98]620-132.

Contact: Thirty-six 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; 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 assignments and a 3-hour end-of-semester written examination.