SCHOOL OF MATHEMATICAL SCIENCES

BACHELOR OF APPLIED SCIENCE (MATHEMATICS)

COURSE HANDBOOK

1991

School of Mathematical Sciences

HANDBOOK

Bachelor of Applied Science

and

Bachelor of Applied Science (Honours)

Broadway Campus
Building 1, Level 15

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Cover Illustration

A Julia fractal curve. This is a set that remains invariant under the transformation $x := f(x) = x^2 - \mu$, where μ is a complex number. Mandelbrot, who examined such sets in his work on fractals, named this a *self-squared dragon*.

Contents

1. The School of Mathematical Sciences

The School of Mathematical Sciences is one of two Schools in the Faculty of Mathematical and Computing Sciences and is located on Level 15 of the Tower Building on the University's Broadway Campus. The School offers two undergraduate courses leading to Bachelor's degrees, two postgraduate courses leading to qualifications at the Graduate Diploma and Master's levels and two research degrees leading to Master's and Doctoral level qualifications.

The courses are:

* the *Bachelor of Applied Science (Mathematics)*, which is offered as a three year pass degree and a four year Honours degree;

* the *Bachelor of Mathematics and Finance*, offered in conjunction with the School of Finance and Economics, as a three year pass degree and a four year Honours degree;

* the *Graduate Diploma in Operations Research;*

* the *Master of Applied Science in Operations Research by Coursework;*

* the *Master of Applied Science*, which is awarded on the basis of approved research work and presentation of a thesis;

* the *Doctor of Philosophy*, which is awarded on the basis of research and presentation of a thesis.

This handbook describes the *Bachelor of Applied Science* programs. A separate handbook is provided for the *Bachelor of Mathematics and Finance* degree, while the postgraduate programs are described in the Faculty handbook and the Faculty's Graduate Studies booklet.

2. Principal Dates for 1991

The academic year is divided into two semesters, each containing fourteen teaching weeks. Within each semester is scheduled a non-teaching week during which students are advised to pursue their studies independently. The semesters are separated by a three week recess period.

Principal dates throughout the year are as follows:

8 February	Enrolment of new students.
11 - 12 February	Enrolment of continuing students.
4 March	Autumn Semester classes commence for all students.
29 March	Easter Friday.
1 April	Easter Monday.
1-5 April	Non-teaching Week.
17 June - 5 July	Formal Examination Period.
8-26 July	**Inter-semester Recess (3 weeks).**
29 July	Spring Semester classes commence for all students.
30 September - 4 October	Non-teaching Week.
11 November - 29 November	Formal Examination period

3. General Information

Students requiring information regarding admission, enrolments or attendance at the University should check the University Calendar or Faculty handbook on sale at the Co-operative Bookshop, 11 Broadway, or contact the UTS Information Service located in the foyer of the Tower Building on the Broadway Campus.

3.1. UTS Information Service

This is located in the foyer of the Tower Building at Broadway. It provides information and assistance to the public with all aspects of application for UTS courses. As the student centre, it is the principal point of contact between students and the central administration. Through this centre, students can obtain assistance with a broad range of enquiries.

3.2. Student Health and Counselling Service

3.2.1. Student Counselling

The aim of this service is to assist students to perform to the best of their ability. Problems of a personal nature, study difficulties, selection of courses or anything else that is likely to affect a student's progress may be discussed in confidence with the student counsellors.

3.2.2. Health Service

A free health service is provided for students of the University. A medical practitioner and a nursing sister staff the service and all consultations are considered strictly confidential.

3.2.3. Student Welfare Service

A Welfare Officer coordinates several areas of student welfare including accommodation, student loans, Austudy applications and, if needed, advocacy when academic and administrative problems arise. All interviews are confidential and suggestions for services required by students are welcome.

3.2.4. Students with Physical Disabilities

The Special Needs Coordinator is able to assist students with an increasing range of services. These include: parking arrangement; amanuenses (note takers); hearing enhancement equipment; tape recorders; examination concessions (time and print size of paper). A seminar is held early in each semester to inform students with special needs of UTS policy.

3.3. English Classes

The University offers a variety of English classes which have been designed especially for students for whom English is not their native language. Interested students should contact the Student Services Unit in the first instance for further details.

3.4. Child Care

The Magic Pudding Child Care Centre, on the Broadway Campus, provides full-time and part-time care for children of both students and staff. Care is available for children aged up to five

years. Opening hours are Monday to Friday (8.00 a.m. - 10.00 p.m.). Fees are calculated on a sliding scale based on family income. For further information please call 218 9507 or drop into the Centre at the City Campus.

3.5. Financial Assistance

This is available to Australian residents under the AUSTUDY Assistance Scheme. The Australian Government provides means-tested living and other allowances to full-time and sandwich students undertaking approved tertiary courses. Further information is available from The Director, Department of Employment, Education and Training, Plaza Building, 59 Goulburn Street, Sydney, NSW 2000. Telephone (02) 218 8800. Information booklets and application forms are also available from the Student Welfare Officer in the Student Services Unit at the University.

3.6. Fees and the Higher Education Contribution Scheme

Compulsory fees are payable to the University Union and Students' Association. In 1991, the fees are $37 for the Students' Association and $130 for the Union.

The Higher Education Contribution Scheme (HECS), introduced by the Commonwealth Government, collects a contribution from higher education students towards the cost of their education. Almost all students are required to make a contribution of approximately 20 per cent of their course costs. In 1991 this is about $1993 for a full-time course load. The contributions will only be required if and when the person has the capacity to pay.

Under HECS, an annual course charge of $1993 will apply for each year of equivalent full-time study undertaken. Relative charges will apply according to the actual proportion of equivalent full-time load being undertaken. If a student undertakes 75 per cent of a full-time load, then she or he will be charged approximately $ 1495 (75 per cent of $1993). The charge increases annually in line with tertiary education costs.

Student compulsory fees and HECS "upfront" charges are due and payable by a date determined by the Registrar and Secretary.

3.7. Students' Association

The Students' Association (SA) represents all students at the University. The Students' Council is the governing body of the SA. Elected by students, it is accountable to the student body. Each Faculty is represented on the Council along with a number of general members elected by all students.

The full-time paid President of the SA is elected directly by students. An Executive Committee assists the President in carrying out the directions of the Students' Council and the day to day management of the Association. The Vice-President is employed full-time to represent student education interests.

In general, the SA plays a representative and advocacy role on behalf of students. It liaises closely with the University Union and the Student Services Unit. Additionally, it negotiates

with and/or lobbies government and non-government organisations on education and welfare issues in the interests of the students. The Students' Association maintains close links with student bodies in other tertiary institutions and has a political role to play in maintaining educational standards and conditions for students within both the University and the tertiary education sector as a whole.

The main office of the SA is located at the Broadway Campus on Level 3A of the Tower Building (telephone 218 9064). Hours of opening are 9 a.m. to 6 p.m.

3.8. Equal Opportunity Coordinator

The Equal Opportunity Coordinator is available to assist any students who feel they have been discriminated against in their study. Whether the problem is sexual harassment or other unfair treatment because of gender, marital status, physical disability, racial vilification or homosexuality - you will be assured of a confidential hearing. You can contact the Equal Opportunity Coordinator on 20930.

3.9. Ombudsman

The University Ombudsman is available to investigate students' complaints against the University and its academic and support staff. Students who feel that they may have a grievance that has not been adequately resolved may write to the Ombudsman giving details of the matter. The Ombudsman will then decide whether the complaint falls within his/her prescribed role and function and will take action accordingly. Students who believe that they may be in need of such services are advised to contact Student Services or the Students' Association. The office of the Ombudsman can be contacted by phone on 20930.

3.10. University Union

The University Union acts as the University's community centre and provides a focus for the social, cultural and recreational activities of the whole of the University community. All students are members of, and pay fees to, the Union; all University staff, whose fees are paid by way of an annual lump sum grant from the University to the Union, are also members; all graduates are eligible for life membership of the Union.

The Union fulfils its objectives by providing food services, licensed bars, lounge, meeting and function rooms, stationery shops, a newsagency, sporting facilities (including squash courts, gymnasium, weights rooms and a basketball/volleyball court), sports programs and activities programs which include dances, concerts, lunchtime speakers and entertainment, films and creative leisure courses. The Union also provides considerable financial and other assistance to affiliated clubs and societies. Miscellaneous services include free accident insurance, free legal advice, free diaries and other publications, lockers, telephones and TVs.

The Union has also established the University's Careers and Appointments Service which provides a graduate placement service, casual employment and careers counselling.

The Union is controlled by a board of 15 persons, including eight students. Elections are usually held in September of each year and all interested students are encouraged to stand for a position on the Board.

For further information, contact the Union Office on Level 6 of the Tower Building, phone 218 9403.

3.11. Library

The University Library offers information from libraries on the City Campus (in the Haymarkets), the North Shore Campus, the Kuring-gai Campus and the Balmain Campus. A wide variety of materials is available. Tours, as well as comprehensive sessions on the literature of various subjects, are given by library staff at the beginning of each semester.

The Haymarket library is located in Block A of the Markets Campus and opening times during the semester are: Monday to Thursday 8.30 am - 10.00 pm, Friday 8.30 am - 8.30 pm, Saturday 9.00 am - 5.00 pm, Sunday 11.00 am - 4.00 pm. During the inter-semester recess, the opening hours are Monday to Friday 9.00 am - 6.00 pm.

3.12. Computing Services

The Computing and Communications Services Division (CCSD) provides a variety of facilities and services for undergraduate and postgraduate students. The main installation is on Level 9 of the Tower Building at Broadway with additional locations at Broadway and at the other campuses. The CCSD also operates the Microcomputer Shop which is located on Level 27 of the Tower Building. It sells and services personal computers (both Apple Macintosh and IBM comptatible) and a wide range of software and accessories.

3.13. Scholarships

From time to time a number of companies, institutions and government authorities offer scholarships, cadetships, or employment to students about to commence courses at the University. Details are usually advertised in the press in the latter part of the year or early January. The UTS Information Service maintains a noticeboard devoted to such press clippings in the foyer of the Tower Building.

3.14. Prizes

Prizes are awarded annually to students at UTS for excellence in study. These are made available through the generosity of private individuals and public organisations.

4. Course Information

4.1. Course Enquiries

Enquiries should normally be directed to the School Clerk located on Level 15 of the Tower Building in Room 1523. The School Clerk is available to assist students with any problems and provide advice regarding the course and may be contacted by phoning 20930 ext. 9959 or 218 9959.

Timetables, enrolment information and examination information can be sighted on the Notice Board at the School Office.

4.2. Exemptions

Students who have undertaken previous studies in this or other universities may be eligible for entry to the course with advanced standing. Enquiries about such standing and exemptions from subjects of the BAppSc degree program should be made on or before the date of enrolment by consulting the School Clerk, Leah Kilkelly (Room 1523), and arranging for an appointment with the Exemption Coordinator, Associate Professor Graeme Cohen (Room 1538).

4.3. Academic Advisors

Each undergraduate student enrolled in the School is assigned an Academic Advisor. These people can provide advice in connection with the course and counselling. Students should feel free to consult their advisors at any time in connection with these matters.

4.4. Mathematics Study Centre

The Mathematics Study Centre, under the direction of Ms Leigh Wood (Room 1543), aims to provide assistance to students in mathematics and mathematics-based courses at the University. The majority of teaching in the Centre is performed on an individual level, with students dropping into the Centre at any time. Normally the centre operates for at least 30 hours per week and certain times are devoted to particular areas of mathematics.

Students can obtain help with individual problems, specific to a particular course. Alternatively, students with more systematic problems may study in the centre on a regular basis, obtaining assistance from a tutor as necessary.

The Centre is located on the southern side of Level 10 of the Tower Building on the City Campus. Consult the School notice boards or the Centre on 218 9196 for further details of its 1991 program.

4.5. UTS Mathematics Society

This is run by a group of students whose aims are to graduate with a degree in Mathematics from the University and, through this society, to:

- improve the course;
- provide information for students about the course; and
- organise social functions where students can meet and enjoy some time away from study.

For any of these things to be done successfully we need your participation (with a little help from staff as well). The Mathematics Society provides ideal opportunities to meet other students and keep in touch with what is happening at the University.

Become a member of the Mathematics Society for your own enjoyment and benefit.

4.6. Computing Facilities

The School of Mathematical Sciences makes extensive use of the University's central facilities which consist of an Amdahl 470V/8 mainframe with 16 Mbytes of central memory and 2.5 Gbytes of disc storage. This machine runs under Amdahl UTS/V - a derivative of AT & T System V Unix and is accessed from several laboratories of PCs via an ethernet network.

The School also owns and operates five powerful minicomputer systems. A MIPS M/800 system, with 8 Mbytes of main memory and 1 Gbyte of disc storage, acts as a gateway between the Internet and the School's local area network. This machine also provides computational resources for over 32 simultaneous users. A HP-9000/550 triple processor system with 8 Mbytes of memory and 404 Mbytes of disc storage provides database and statistical services as well as handling printing for the other machines. A pair of Silicon Graphics 4D/20 and 4D/25 machines and a Sun SPARCStation 1 provide additional graphics, language and computational services. All of these systems run the Unix operating system with all but the Sun being derivatives of AT&T System V. The SPARCStation runs SunOS which is derived from Berkeley Unix.

Access to these systems is provided from three laboratories, owned and operated by the School, as well as from the public access laboratories operated by the Computer Services Division. Two of the School's laboratories each provide 20 serial connections, either to the MIPS computer or to the University-wide network. The third laboratory contains 24 IBM-PC compatible machines which are linked by a Novell network. These machines can be used as stand-alone systems, can access software on the Novell file server or can act as terminals on the School's local area network and the broader University network.

The School possesses a wide range of instruments for computer graphics, including:

* Silicon Graphics Personal Iris-4D;
* HP 2397 colour graphics terminal;
* Tektronix 4014 monochrome terminal;
* IBM-PCs emulating Tektronix 4014 monochrome terminals and HP 2397 colour graphics terminals;
* HP 7280A A1 drafting plotter;
* PC-based Image Processing hardware; and
* 2 Apple Laserwriter laser printers.

At present, the most commonly used graphics software consists of an extensive library of FORTRAN subroutines, providing both 2D and 3D facilities, that has been written in-house.

The School has also acquired a significant quantity of software running on the HP, MIPS and Sun systems and on IBM microcomputers to support teaching and research in statistics, operations research, applied mathematics and computing. This is supplemented by other software resources that are supplied centrally by the Computer Services Division.

5. Staff of the School of Mathematical Sciences

5.1. Academic Staff

Associate Professor and Head of School
L. C. Botten, BSc(Hons), PhD(Tas), MAIP, MACS, MOSA

Professor of Applied Mathematics and Deputy Head of School
A. G. Shannon, AM, BSc, DipEd (Syd), MA, PhD, MLitt (UNE), FCP, FIMA, FACE

Professor of Applied Mathematics and Computing
B. S. Thornton, PhD (NSW), DSc (Syd), FInstP, FBCS, FACS, CPhys., CEng., FRAeS

Director of Undergraduate Studies
G. J. McLelland, BSc, PhD (Syd)

Department of Mathematics

Professor of Applied Mathematics and Head of Department
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Associate Professor
G. L. Cohen, MSc (Syd), PhD (NSW), FIMA

Director of Undergraduate Studies
G. J. McLelland, BSc, PhD (Syd)

University Reader
B. J. Moore, MSc (Syd), PhD (Cantab)

Senior Lecturers
J. G. Sekhon, BSc (WA), MSc (Lough), DipEd, PhD (UNE), FCollP, FIMA, MACE
G. H. Smith, MSc (Rand), PhD (NSW), DipGeoscience (Macq)

Lecturers
M. Coupland, BSc, DipEd (Syd)
B. W. Stephenson, BAppSc (NSWIT), DipEd (STC), MA (NSW)
Y. K. Yap, BSc (Malaya), MSc (IIT), PhD (W'gong), AFIMA

Department of Computational Mathematics

Professor of Applied Mathematics and Computing and Head of Department
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Associate Professor
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Senior Lecturers
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T. M. Park, BSc (Manch), MSc (NSW), MIEEE, MBCS, FACS

Lecturers
T. N. Langtry, BA (NSW), BAppSc, MAppSc(NSWIT), MACS
B. R. E. Lederer, BSc (Hons), MEngSc (NSW), PhD (Syd), MACS
D. R. Porteus, BSc, DipEd (Tas), MACE
R. M. Sorli, BSc (Syd), MAppSc (NSWIT), MACS

Department of Operations Research

Professor of Applied Mathematics and Computing and Head of Department
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Senior Lecturer and Director of Graduate Studies in Operations Research
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Lecturers
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J. M. Hogg, BSc (Syd), MSc(NSW), MASOR
R. I. Rozsasi, BSc (Syd), AFIMA

Department of Statistics

Head of Department
Vacant

Senior Lecturers
S. H. Huxham, BSc, PhD (NSW), FSS
P. Petocz, BSc (Hons), PhD (NSW), DipEd (Tech) (SCAE)

Lecturers
E. Lidums, BSc (Hons), MSc (Syd)
L. Wood, BSc (Hons) (NSW), DipEd (Tech) (SCAE), MA (Macq)

5.2. Support Staff

Administrative Officer
J. C. Smith

School Clerk
L. M. Kilkelly

Word Processor Operator
M. Murray

Senior Systems Programmer
M. J. Caden, BAppSc (NSWIT)

Computer Systems Support Officer
E. B. Lindsay

6. Bachelor of Applied Science

6.1. Overview

This degree aims to prepare professional people for employment in industry, commerce and government and to provide the foundation for higher studies in Mathematics. It provides great flexibility by allowing students to follow a course of study which best suits their interests and aspirations. It aims to help the student acquire sufficient experience and understanding in a broad range of mathematical disciplines to enable him or her to apply mathematical and computing techniques to industrial and commercial problems.

The course operates as either a three year pass degree or a four year honours degree. The basic structure of the pass degree is:

* *The core* - providing a thorough grounding in the elements of mathematics, statistics, operations research, computing, and their applications. This component, occupying half of the pass degree program, is taught during the first two years of the full-time program;

* *A mathematics major* - which occupies half of the third year of the full-time course and may be taken in one of the areas of applied mathematics, statistics or operations research. This framework provides for specialised study in a particular area of application. A major in Operations Research involves topics such as linear programming, simulation and optimisation. The Statistics major aims to expose students to realistic statistical problems, preparing them to cope with data and its associated uncertainty and variability. Applied mathematics, particularly since the advent of computers, has developed a large collection of tools for the solution of practical problems. In many cases, these can be unified by a few basic geometric, analytic and algebraic ideas. The Applied Mathematics majors aim to develop these ideas and apply them in a variety of complex and practical situations;

* *Electives* - which occupy one third of the course and are subjects from any School of the University chosen by students to strengthen their understanding in an area of their choice. Common choices are the major in Computing offered by the School of Mathematical Sciences, an additional major in Mathematics, a sub-major in Finance and Economics and various sub-majors in the sciences.

  The Computing major provides students with both practical and theoretical training in computer science (and its mathematical foundations), information systems and commercial computing, and a wide variety of applications. Because the Computing major occupies the entire elective sequence, students who wish to pursue it are advised to commence it in their first year of study. However, because it is an elective major, students are not obliged to follow it to completion. Those who do, however, are eligible to apply for Associate Membership of the Australian Computer Society.

The course may be attempted on either a full-time or a part-time basis. A total of 108 semester hours of attendance at lectures and tutorials is required for the course. The 108 semester hours may be taken in any of the following four attendance patterns:

* three years on a full-time basis;

* two years on a full-time basis followed by two years on a part-time basis;

* one year on a full-time basis followed by four years on a part-time basis;

* six years on a part-time basis.

1991 will be the final year in which special evening classes will be scheduled for part-time students enrolled in Stages 1 and 2 (the equivalent of the first year of full-time study). From the beginning of 1992 subjects in the first year of the full-time program will be taught only during the mornings and afternoons. For the subjects in year 2 (of the full-time program) and later, part-time students will be accommodated by the provision of special evening classes and it is expected that all part-time students will be able to attend classes for one afternoon and two evenings per week.

Listed in Section 6.2, under the heading **New Course**, is the course program for students enrolling in 1991 (or later). Students who enrolled in 1990 or earlier are advised to consult Section 6.3, headed by **Old Course**.

6.2. New Course

Listed below is the full-time curriculum. The entries in the columns labelled Autumn and Spring refer to the duration, in hours per week, of the subject.

6.2.1. Full-Time Program

Year 1		Autumn	Spring
34700	Discrete Mathematics	3	
34701	Algebra 1	3	
34710	Calculus	6	
34770	Computing 1A	3	
	Electives (+)	3	
34711	Analysis 1		3
34740	Introduction to OR Models		3
34751	Statistics 1		3
34790	Numerical Computing		3
	Electives (+)		6

Year 2		Autumn	Spring
34802	Algebra 2	3	
34815	Ordinary Differential Equations	3	
34817	Vector Calculus	3	
34891	Numerical Methods A	3	
	Electives (+)	6	
34803	Algebra 3		3
34812	Analysis 2		3
34818	Complex Variables		3
34821	Partial Differential Equations 1		3
34852	Statistics 2		3
	Electives (+)		3

Year 3	Autumn	Spring
Mathematics Major (++)	9	
Electives (+)	9	
Mathematics Major (++)		9
Electives (+)		9

(+) These electives may be chosen from subjects listed within the University Calendar and acceptable to the School of Mathematical Sciences. The most common choice of elective pattern is the Computing major. Electives are discussed in a Section 6.2.4.

(++) The mathematics majors in the third year consist of prescribed sequences of six 3 semester hour subjects taken from one of the four strands in Statistics, Operations Research and Physical and Modern Applied Mathematics.

6.2.2. Part-Time Program

Year 1		Autumn	Spring
34700	Discrete Mathematics	3	
34710	Calculus	6	
34701	Algebra 1		3
34770	Computing 1A		3
	Electives (+)		3

Year 2		Autumn	Spring
34711	Analysis 1	3	
34751	Statistics 1	3	
	Electives (+)	3	
34740	Introduction to OR Models		3
34790	Numerical Computing		3
	Electives (+)		3

Year 3		Autumn	Spring
34802	Algebra 2	3	
34817	Vector Calculus	3	
34891	Numerical Methods A	3	
34803	Algebra 3		3
34815	Ordinary Differential Equations		3
	Electives (+)		3

Year 4		Autumn	Spring
34812	Analysis 2	3	
34821	Partial Differential Equations 1	3	
	Electives (+)	3	
34818	Complex Variables		3
34852	Statistics 2		3
	Electives (+)		3

Year 5		Autumn	Spring
	Mathematics Major (++)	6	
	Electives (+)	3	
	Mathematics Major (++)		3
	Electives (+)		6

Year 6		Autumn	Spring
	Mathematics Major (++)	3	
	Electives (+)	6	
	Mathematics Major (++)		6
	Electives (+)		3

(+, ++) See the corresponding notes in Section 6.2.1.

6.2.3. Majors

Students must complete at least one of the mathematics majors which are offered in the areas of Statistics, Operations Research, Modern Applied Mathematics and Physical Applied Mathematics. Each of these majors in mathematics comprises subjects totalling 18 semester hours duration. In addition, students may choose to complete the elective major in Computing.

6.2.3.1. Applied Mathematics Majors

Two applied mathematics major programs are offered - one in Physical Applied Mathematics and the other in Modern Applied Mathematics. In order to complete the requirements for either major, students must complete at least four subjects from the major of their choice and select the remainder from the alternative major.

Note: Students wishing to attempt either of the Applied Mathematics Majors are advised to consult with the Director of Undergraduate Studies prior to their enrolment.

Physical Applied Mathematics

Year 3 (Full-Time) **Years 5/6** (Part-Time)		Autumn	Spring
34922	Partial Differential Equations 2	3	
34924	Mechanics	3	
34927	Deterministic Optimal Control	3	
34916	Mathematical Methods		3
34925	Wave Theory		3
34992	Numerical Methods B		3

Modern Applied Mathematics

Year 3 (Full-Time) Years 5/6 (Part-Time)		Autumn	Spring
34904	Algebra 4	3	
34913	Modern Analysis	3	
34920	Integral Equations	3	
34914	Measure Theory		3
34995	Advanced Numerical Analysis		3
34996	Convexity and Optimisation		3

6.2.3.2. Operations Research Major

Year 3 (Full-Time)		Autumn	Spring
34930	Simulation Techniques	3	
34931	Linear Programming	3	
34936	Decision Theory	3	
34938	Financial Modelling Techniques		3
3493*	OR elective (*)		3
34961	Stochastic Processes 1		3

Years 5/6 (Part-Time)		Autumn	Spring
34930	Simulation Techniques	3	
34936	Decision Theory	3	
34961	Stochastic Processes 1	3	
34931	Linear Programming		3
34938	Financial Modelling Techniques		3
3493*	OR Elective (*)		3

* This subject may be selected from
34932 Optimisation Techniques
34934 Network Optimisation
34935 Inventory Control

6.2.3.3. Statistics Major

Year 3 (Full-Time)		Autumn	Spring
34953	Statistics 3	3	
34955	Regression Analysis	3	
34960	Theory of Probability	3	
34956	Design of Experiments		3
34957	Industrial Statistics		3
34961	Stochastic Processes 1		3

Years 5/6 (Part-Time)		Autumn	Spring
34953	Statistics 3	3	
34955	Regression Analysis	3	
34961	Stochastic Processes 1	3	
34956	Design of Experiments		3
34957	Industrial Statistics		3
34960	Theory of Probability		3

6.2.3.4. Computing Major

The Computing major is an elective major, and occupies the entire elective sequence of 36 semester hours. Listed below are attendance patterns for both full-time and part-time students.

Full Time Program

Year 1		Autumn	Spring
	Comm/IS Elective (#1)	3	
34771	Computing 1B		3
34781	Mathematical Foundations of Computing 1		3

Year 2		Autumn	Spring
34872	Computing 2	3	
	Comm/IS Elective (#2)	3	
34873	Computing 3		3

Year 3		Autumn	Spring
34982	Mathematical Foundations of Computing 2	3	
	Elective 1 (##)	3	
	Comm/IS Elective (#3)	3	
34984	Language Theory		3
	Elective 2 (##)		3
	Comm/IS Elective (#4)		3

Part Time Program

Year 1		**Autumn**	**Spring**
34781	Mathematical Foundations of Computing 1		3
Year 2		**Autumn**	**Spring**
	Comm/IS Elective (#1)	3	
34771	Computing 1B		3
Year 3		**Autumn**	**Spring**
	Comm/IS Elective (#2)		3
Year 4		**Autumn**	**Spring**
34872	Computing 2	3	
34873	Computing 3		3
Year 5 and 6		**Autumn**	**Spring**
34892	Mathematical Foundations of Computing 2	3	
	Elective 1 (##)	3	
	Comm/IS Elective (#3)	3	
34984	Language Theory		3
	Elective 2 (##)		3
	Comm/IS Elective (#4)		3

\# The subjects labelled as Comm/IS Elective are elective subjects oriented towards commercial processes or information systems. For 1991, the first two of these subjects will be:

#1 34127 Information Systems 1
#2 34217 Commercial Computing 2

The final two subjects, labelled #3 and #4, will not be offered in 1991.

\## In each semester of the final year(s) of study, students will undertake one subject from a choice of two, which will be nominated by the School and drawn from Group 1 for the Autumn Semester and from Group 2 for the Spring Semester. These groups are listed below.

Group 1

34975 Computer Graphics
34976 Neural Networks
34987 Cryptology

Group 2

34977 Formal Specification
34983 Mathematical Foundations of Computing 3
34985 Digital Image Processing

6.2.4. Other Elective Subjects

There are 36 semester hours in the BAppSc (Mathematics) program allocated to elective subjects outside of the Mathematics majors. Students may choose to complete these hours of study in a number of ways:

* by completing one additional mathematics major, leaving 18 unspecified elective hours to be completed in the case of most double majors, and 21 unspecified elective hours to be completed in the case of a double major in Statistics and Operations Research;

* by completing the Computing major, leaving no unspecified elective hours; or

* by completing a total of 36 hours of subjects offered by this School or by other Schools of the University. Common choices of subjects include those forming recognised sub-majors in other disciplines such as Finance, Economics and Physics. However, a student may elect to take any subject, provided that:

  (i) the student has satisfied the prequisites of the chosen subjects;
  (ii) the student's enrolment in a subject is approved by the School which offers that subject, and
  (iii) the student's choice of subjects is approved by the School of Mathematical Sciences.

In addition to subjects listed within the descriptions of the majors, the following subjects offered by the School of Mathematical Sciences may be taken as electives.

34573	History of Mathematics
34668	Computational Number Theory
34681	Special Applications in Operations Research
34682	Special Applications in Computing
34683	Special Applications in Statistics
34684	Special Applications in Physical Applied Mathematics
34685	Special Applications in Modern Applied Mathematics
34691-7	Project

6.3. Old Course

The BAppSc degree has been extensively revised and the new program will commence operation at the beginning of the 1991 academic year. Because of the School's desire to phase in the new course as quickly as possible, 1991 will be a transition year in which the bulk of the new subjects will be introduced. It is the School's intention to transfer existing students, currently enrolled in the old course, into the new course as quickly as possible, and for this reason a number of special arrangements have been made. These arrangements are detailed below and students who enrolled in the BAppSc in 1990, or earlier, should pay close attention to them. In summary:

* The previous first year full-time (and first and second years part-time) mathematics program has been completely replaced. Arrangements for students who have still to complete these subjects are described below.

* The previous second year full-time (years 3 and 4 part-time) mathematics program will be phased out at the end of 1991. To accommodate both full- and part-time students in this changeover period, a number of the subjects will be run in both semesters. Students affected by these changes are asked to pay particular attention to the relevant sections below.

* The mathematics majors in Applied Mathematics, Operations Research and Statistics, taught in the third year of the full-time program and the fifth and sixth years of the part-time program are largely unaltered.

* The revised Computing major, which extends over the entire degree program, will be phased in on a year by year basis, commencing with the introduction of the new first year curriculum in 1991. Students who are currently attempting this major are strongly advised to read the section headed **6.3.3.4 Computing Major** and consult, if necessary, Mr Tim Langtry (Room 1537) in connection with specific enquiries.

6.3.1. Full-Time Program

Year 1

Listed below is the relationship between the core mathematics subjects taught in the old course and suitable replacements from the new course.

34100 Algebra 1 has been replaced by *34701 Algebra 1*

34101 Calculus 1 has been replaced by *34710 Calculus*.

34107 Computing 1 has been replaced by *34770 Computing 1A*.

34102 Calculus 2 will operate for the last time during the Autumn Semester of 1991. Students who have not completed this subject by that time must then substitute *34711 Analysis 1*.

34214 Algebra 2 has been replaced by *34802 Algebra 2* (which is now scheduled in the second year of the new full-time program).

34251 Macroeconomic Models ceased operation at the end of the 1990 academic year. Students who have not completed this subject are advised to include the new subject *34700 Discrete Mathematics* in their program of study.

34141 Statistics 1 has been replaced by *34751 Statistics 1*.

Year 2

The second year program described below is a transition between the old and new courses.

		Autumn	Spring
34815	Ordinary Differential Equations (a)	3	
34817	Vector Calculus (b)	3	
34307	Computing 2 (c)	2	
34803	Algebra 3 (d)	3	
34740	Introduction to OR Models (e)	3	
	Electives (+)	4	
34821	Partial Differential Equations 1 (f)		3
34818	Complex Variables (g)		3
34852	Statistics 2 (h)		3
34417	Numerical Methods 1 (i)		3
34527	Real Variables (j)		3
	Electives (+)		3

Notes

(a) *34815 Ordinary Differential Equations* has replaced *34213 Ordinary Differential Equations*.

(b) *34817 Vector Calculus* has replaced *34212 Vector Calculus*.

(c) *34307 Computing 2* will be run during both Autumn and Spring Semesters of 1991. After that time, students who have still to complete this subject will need to substitute *34790 Numerical Computing*.

(d) *34803 Algebra 3* has replaced *34570 Algebra 3*.

(e) *34740 Introduction to OR Models* replaces *34480 Introduction to OR Models*.

(f) *34821 Partial Differential Equations 1* replaces *34320 Partial Differential Equations* from the Spring Semester of 1991 onwards. The former subject *34320* will be run, for the final time, during the Autumn Semester.

(g) *34818 Complex Variables* replaces *34418 Complex Variables*.

(h) *34852 Statistics 2* has replaced *34342 Statistics 2*.

(i) *34417 Numerical Methods 1* will operate for the final time during the Spring Semester of 1991. The replacement for this subject, *34891 Numerical Methods A*, will commence operation in the Autumn Semester of 1992.

(j) *34527 Real Variables* will be taught for the final time in both Autumn and Spring Semesters of 1991. For 1992 and onwards, students who have not completed this subject will need to substitute *34812 Analysis 2*.

Year 3	**Autumn**	**Spring**
Mathematics Major (++)	9	
Electives (+)	9	
Mathematics Major (++)		9
Electives (+)		9

(+) These electives may be chosen from subjects listed within the University Calendar and acceptable to the School of Mathematical Sciences. The most common choice of elective pattern is the Computing major. Electives are discussed fully in the Section 6.2.4 titled **Other Elective Subjects**.

(++) The mathematics majors in the third year consist of prescribed sequences of six 3 semester hour subjects taken from one of the four strands in Statistics, Operations Research and Physical and Modern Applied Mathematics.

6.3.2. Part-Time Program

This section describes the part-time program for students who enrolled in 1990 or earlier. Due to the magnitude of the course revision, many significant changes to the part-time couse have been necessary in order to facilitate a rapid transition between the old and new courses. Listed below is the suggested attendance pattern for students enrolled in each year of the part-time course, together with an indication of the student's enrolment in successive years of the transition. Students should read this section, together with its accompanying notes describing the changeover between subjects of the old and new courses, with considerable care.

Year 1

34710 Calculus has replaced *34101 Calculus 1*.

34770 Computing 1A has replaced *34107 Computing 1*.

34701 Algebra 1 has replaced *34100 Algebra 1*.

34102 Calculus 2 will be run for the final time during the Autumn semester of 1991. After that time, students who have not completed this subject will need to substitute *34711 Analysis 1*.

Year 2 (1991)
The suggested study program for part-time students is listed below.

		Autumn	Spring
34700	Discrete Mathematics (a)	3	
34802	Algebra 2 (b)	3	
	Electives (c)	3	
34790	Numerical Computing (d)		3
	Electives (e)		6

Notes

(a) *34251 Macroeconomic Models* ceased operation at the end of 1990 and will no longer be offered. Students who plan to proceed with the Computing major should now select *34700 Discrete Mathematics* as part of their program of study. Students with an interest in Finance would be advised to consider elective subjects from the Finance sub-major, which is described later in the document.

(b) *34802 Algebra 2* has replaced *34214 Algebra 2*.

(c) Students attempting the Computing major should select either *34127 Information Systems 1* or *34217 Commercial Computing 2* for this elective.

(d) The subject *34790 Numerical Computing* has replaced the earlier third year part-time course, *34307 Computing 2*.

(e) Students proceeding with the Computing major should select the subjects *34771 Computing 1B* and *34781 Mathematical Foundations of Computing 1* for these six hours of electives.

Later Year Enrolments

Year 3 (1992)

Autumn:	34751	Statistics 1
	34817	Vector Calculus
	34891	Numerical Methods A
Spring:	34740	Introduction to OR Models
	34803	Algebra 3
	34815	Ordinary Differential Equations

Year 4 (1993)

Autumn:	34812	Analysis 2
	34821	Partial Differential Equations 1
		Electives (i)
Spring:	34818	Complex Variables
	34852	Statistics 2
		Electives (ii)

(i), (ii) Students proceeding with the Computing major should select *34872 Computing 2* and *34873 Computing 3* as these electives.

Years 5,6 (1994, 1995)

By this time, the transition to the new course will be complete and students will have a complete choice of any subjects in the mathematics and computing majors of the new course.

Year 3 (1991)

The suggested program of study is listed below.

		Autumn	Spring
34307	Computing 2 (a)	3	
34817	Vector Calculus (b)	3	
	Electives (c)	3	
34417	Numerical Methods 1 (d)		
34815	Ordinary Differential Equations (e)		3
	Electives (f)		3

Notes

(a) *34307 Computing 2* will be offered in both Autumn and Spring Semesters of 1991. Thereafter, students will need to substiutute *34790 Numerical Computing*.

(b) *34817 Vector Calculus* has replaced *34212 Vector Calculus*.

(c) Students who are proceeding with the Computing major should choose *34217 Commercial Computing 2* for this elective.

(d) *34417 Numerical Methods 1* will cease operation at the end of 1991. Thereafter, students will need to substitute *34891 Numerical Methods A*.

(e) *34815 Ordinary Differential Equations* has replaced *35213 Ordinary Differential Equations*.

(f) Students proceeding with the Computing major should select *34407 Computing 3* for this elective.

Later Year Enrolments

Year 4 (1992)

Autumn:	34740	Introduction to OR Models
	34812	Analysis 2
	34821	Partial Differential Equations 1
Spring:	34803	Algebra 3
	34818	Complex Variables
	34852	Statistics 2

Years 5, 6 (1993, 1994)

Students in this cohort will attempt a mathematics major derived from the new course. Those pursuing the Computing major should consult with the Mr Tim Langtry (Room 1537) to derive an appropriate program.

Year 4 (1991)

The suggested program of study is listed below.

		Autumn	Spring
34320	Partial Differential Equations (a)	3	
34527	Real Variables (b)	3	
34803	Algebra 3 (c)	3	
34417	Numerical Methods 1 (d)		3
34818	Complex Variables (e)		3
	Electives (f)		3

Notes

(a) *34320 Partial Differential Equations* will run for the final time in the Autumn Semester of 1991. Thereafter, students will need to substitute *34821 Partial Differential Equations 1*.

(b) *34527 Real Variables* will be run during both semesters of 1991 and will cease operation at the end of the Spring Semester. Students who have not completed this subject by that time will need to substitute *34812 Analysis 2* thereafter.

(c) *34803 Algebra 3* has replaced *34570 Algebra 3*.

(d) *34417 Numerical Methods 1* will be taught for the final time during the Spring Semester of 1991. After that time, students will need to substitute *34891 Numerical Methods A*.

(e) *34818 Complex Variables* has replaced *34419 Complex Variables*.

(f) Students proceeding with the Computing major should select *34407 Computing 3* for this elective subject.

Years 5, 6 (1992, 1993)
Students in this cohort will attempt a mathematics major derived from the new course. Those pursuing the Computing major should consult with Mr Tim Langtry (Room 1537) to derive an appropriate program.

6.3.3. Majors

6.3.3.1. Applied Mathematics Majors

The Applied Mathematics majors described in Section 6.2.3.1 for the new course have been derived from those in the old course. The modifications which have been made are minor in nature and the curriculum listed for the new course applies to the old course. Students proposing to take subjects from either major are advised to consult with the Director of Undergraduate Studies prior to their enrolment.

6.3.3.2. Operations Research Major

The content of the Operations Research major has not been altered during the course revision. Only the subject numbers have changed and these are listed above in the description of the new course. Consult Section 6.2.3.2 for details.

6.3.3.3. Statistics Major

The content of the Statistics major has not altered as a result of the revision. Again, only subject numbers have changed and the attendance pattern and curriculum are listed in the corresponding section of the new course. Consult Section 6.2.3.3 for details.

6.3.3.4. Computing Major

The Computing major has been completely revised. The subjects of the revised major will be phased in over a number of years, with the new first year subjects being offered from 1991 onwards. The revised Computing major differs from the old Computing major in two ways:

* The relative weight of second year (full-time) subjects in the major has been increased and the relative weight of first year (full-time) subjects has been decreased, correspondingly.

* The relative numbers of semester hours of study devoted to computing science subjects and to commercial and information systems subjects have been altered.

For students following the normal full-time program of either the old or the new course, the changeover to the revised computing major is straightforward. However, due to the two-fold nature of the revision of this major, part-time students and full-time students

who are not following the prescribed full-time course and who wish to complete the Computing major are advised to consult Mr Tim Langtry (Room 1537) prior to completing their enrolment.

6.4. Sub-Majors

6.4.1. Finance

The School of Finance and Economics offers a sub-major in Finance, which consists of the following subjects from the core of the Bachelor of Business degree:

25110 Micreconomics
25314 Business Finance 1
25308 Financial Institutions and Markets
25207 Business Finance 2
25503 Investment Analysis and Portfolio Management

and any two of the following three subjects

25515 International Finance
25502 Current Issues in Finance
25410 Financial Statement Analysis

Interested students should contact the School of Finance and Economics before enrolment day for further information.

6.4.2. Physics

The Department of Physics offers two sub-majors to students of the Faculty of Mathematical and Computing Sciences. Interested students should collect a more detailed document *Sub-Majors in Physics for Mathematics and Computing Science Students*, available from the Department of Physics in Room 1/1229. After perusing that document, students may obtain further advice from :

Dr G.R. Anstis Room 1/1118 (218 9929)

Students should contact the Department of Physics staff if they are uncertain whther they have sufficient background knowledge for a particular subject.

Registration

Students undertaking an elective subject in physics should register with the Department of Physics (at the office of the Physics Sub-Major Coordinator), by completing a form within a few of days of enrolment day. Students will also need to enrol officially in the subject(s) on enrolment day.

Codes (used in the Tables below)
The codes listed below indicate the pattern of attendance and the availability of the subjects in each sub-major.

A: subject available in Autumn Semester
S: subject available in Spring Semester
Y: subject is available as a full year subject.

Note that for full-year subjects the parenthesised subject number must be used.

A. Sub-Major in Physics (General)

This sub-major provides the grounding in general physics which allows for the possibility for advanced study in a specialised area such as materials physics or solid state physics. The sub-major is of benefit to students contemplating a career in programming of scientific and engineering problems.
At least 18 semester hours of the following must be completed.

Basic Subjects			*Pattern*	*Semester Hours*
	63211 (63212)	Physics 1	A, S, Y	6
	63116	Physics for Electronics	A	6
or	63132	Engineering Physics (Civil)	A, S, Y	6
or	63172	Electricity and Magnetism	A, S	3
or	63221	Physics 2	A, S, Y	6

Notes:

(i) Physics 1 and Physics 2 may be taken simultaneously spread over 2 semesters provided a satisfactory HSC Physics result has been obtained.

(ii) Only one of the subjects Physics for Electronics, Engineering Physics (Civil), Electricity and Magnetism and Physics 2 may be taken.

Advanced Subjects		*Pattern*	*Semester Hours*
63152	Materials Physics	A, S	3
63231	Physics 3	A	3
63235	Applied Optics	A	3
63238	Electrotechnology	A	3
63243	Thermodynamics and Energy	S	3
63251	Nuclear Physics	A	3
63263	Applied Thermodynamics	S	3
63264	Solid State Physics	S	3
63332	Electronics 1	A	6
63341	Quantum Physics 1	S	3
63348	Applied Mechanics	S	3

B Sub-Major in Electronics

This sub-major enables students to complement their knowlegde of software with a knowledge of hardware. It is useful for students contemplating a career in the areas of microprocessors and computer interfacing.

At least 18 semester hours of the following subjects must be completed.

Core Subjects			*Pattern*	*Semester Hours*
	63116	Physics for Electronics	A	6
	63131	Engineering Physics	A, S, Y	6
	(63132)	(Civil)		
or	63172	Electricity and Magnetism	A, S	3
or	63221	Physics 2	A, S, Y	6
	(63222)			
	63332	Electronics 1	A	6
	63352	Electronics 2	S	3
or	31888	Logic Design 1		3

Elective Subjects			*Pattern*	*Semester Hours*
	63342	Principles of Instrumentation	S	3
	63361	Microprocessors in Instrumentation	A	3

7. Bachelor of Applied Science (Honours)

7.1. Overview

The honours year provides the opportunity for students to develop considerably their level of competence in the area of mathematics chosen as their major in the BAppSc (Maths) degree. The honours degree is offered only on a full-time basis and consists of advanced coursework (comprising 75% of the program) and a research project (comprising the remaining 25%). This project component provides the opportunity for students to utilise the expertise developed by their coursework in an area of application. Students who complete the honours year will, accordingly, be well prepared to enter the workforce at a high level or to undertake graduate studies.

Admission to the honours year will be assessed on a case-by-case basis according to the criteria listed in either category below:

* Students who are eligible to graduate from the BAppSc (Maths) degree at UTS with a credit average (i.e. weighted average mark of at least 65) or higher in the second year of the full-time core and in their chosen third year major, together with the satisfactory completion of the third year essay, will be eligible for entry to the honours year, subject only to the approval of the Head of the School of Mathematical Sciences;

* Students who have obtained qualifications equivalent to the BAppSc (Maths) degree will be considered for entry, upon application, by the Head of the School of Mathematical Sciences, on the basis of assessed potential to complete the honours course.

The honours course requires attendance for 18 hours per week over two semesters. Honours specialisations are offered in Mathematics, Statistics and Operations Research and consist of coursework subjects and a project whose weight is equivalent to three coursework subjects.

Students who elect to enter the honours year will need to make this decision prior to entering their third year of full-time studies. This is to enable them to take appropriate honours units in the third year which are prerequisites to some of the fourth year subjects. Consequently, such students will have to defer some of their third year electives until the fourth year of study.

Students proposing to attempt the honours degree should consult with the Honours Coordinator, Associate Professor Graeme Cohen (Room 1538), prior to the commencement of their third year of full-time studies. Students who are deemed eligible for admission will then be assigned an honours supervisor who will monitor their progress and supervise their fourth year research project, which will be assessed by a report and seminar. In addition, students will, in their third year, be required to complete an essay in an appropriate area of mathematics. This essay, which will take the form of a survey article, will also be prepared under the guidance of the honours supervisor. Its satisfactory completion is a prerequisite for the fourth year of study.

The assessment of the student's final result will be based on the two honours level subjects taken in the third year, the seven honours level subjects taken in the fourth year, the third year essay and the fourth year project. Grades of First Class, Second Class (Division 1), and Second Class (Division 2) will be awarded appropriately.

N.B. In view of the third year prerequisites for the honours year, it is not proposed to operate the fourth year of study in 1991. The fourth year program will commence in 1992.

7.2. Course Program

Listed below are the course programs for honours in Mathematics, Statistics and Operations Research. In view of the need to take certain honours units in the third year and delay various third year electives until the fourth year, both third and fourth year attendance patterns are listed.

7.2.1. Mathematics Honours

Programs for each of Physical Applied Mathematics and Modern Applied Mathematics majors are listed below.

7.2.1.1. Physical Applied Mathematics

Year 3		Autumn	Spring
34922	Partial Differential Equations 2	3	
34927	Deterministic Optimal Control	3	
34961	Stochastic Processes 1	3	
	Third year elective	3	
	Third year elective	3	
34013	Modern Analysis (Hons)	3	
34916	Mathematical Methods		3
34960	Theory of Probability		3
34992	Numerical Methods B		3
	Third year elective		3
	Third year elective		3
34014	Measure Theory (Hons)		3

Year 4		Autumn	Spring
	Third year elective	3	
34023	Partial Differential Equations 3	3	
34026	Fractal Geometry	3	
34062	Stochastic Processes 2	3	
34096	Convexity and Optimisation (Hons)	3	
34098	Project	3	
	Third year elective		3
34019	Functional Analysis		3
34028	Stochastic Optimal Control		3
34029	Nonlinear Dynamical Systems		3
34099	Project		6

7.2.1.2. Modern Applied Mathematics

Year 3		Autumn	Spring
34922	Partial Differential Equations 2	3	
34927	Deterministic Optimal Control	3	
34961	Stochastic Processes 1	3	
	Third year elective	3	
	Third year elective	3	
34013	Modern Analysis (Hons)	3	
34904	Algebra 4		3
34960	Theory of Probability		3
34995	Advanced Numerical Analysis		3
	Third year elective		3
	Third year elective		3
34014	Measure Theory (Hons)		3

Year 4		Autumn	Spring
	Third year elective	3	
34023	Partial Differential Equations 3	3	
34026	Fractal Geometry	3	
34062	Stochastic Processes 2	3	
34096	Convexity and Optimisation (Hons)	3	
34098	Project	3	
	Third year elective		3
34019	Functional Analysis		3
34028	Stochastic Optimal Control		3
34029	Nonlinear Dynamical Systems		3
34099	Project		6

7.2.2. Operations Research Honours

Year 3		Autumn	Spring
34931	Linear Programming	3	
34938	Financial Modelling Techniques	3	
34961	Stochastic Processes 1	3	
	Third year elective	3	
	Third year elective	3	
34013	Modern Analysis (Hons)	3	
34930	Simulation Techniques		3
34932	Optimisation Techniques		3
34936	Decision Theory		3
34960	Theory of Probability		3
	Third year elective		3
34014	Measure Theory (Hons)		3

Year 4		Autumn	Spring
33880	OR Models and Methodology	3	
	Third year elective	3	
34033	Dynamic Optimisation	3	
34062	Stochastic Processes 2	3	
34096	Convexity and Optimisation (Hons)	3	
34098	Project	3	
	Third year elective		3
	Third year elective		3
33857	Large Scale Mathematical Programming		3
33860	Corporate Financial Decisions and Investment Analysis		3
34099	Project		6

7.2.3. Statistics Honours

Year 3		Autumn	Spring
34953	Statistics 3	3	
34955	Regression Analysis	3	
34961	Stochastic Processes 1	3	
	Third year elective	3	
	Third year elective	3	
34013	Modern Analysis (Hons)	3	
34956	Design of Experiments		3
34957	Industrial Statistics		3
34960	Theory of Probability		3
	Third year elective		3
	Third year elective		3
34014	Measure Theory (Hons)		3

Year 4		Autumn	Spring
	Third year elective	3	
34062	Stochastic Processes 2	3	
34065	Time Series Analysis	3	
34067	Multivariate Statistics	3	
34096	Convexity and Optimisation (Hons)	3	
34098	Project	3	
	Third year elective		3
34066	Nonlinear Statistical Models		3
34068	Statistical Modelling		3
34069	Linear Models and Experimental Design		3
34099	Project		6

8. Subject Synopses

Note: The subject descriptions provided in this section pertain to subjects to be offered during 1991. In some cases, subjects have listed as their prerequisites certain subjects, from the old degree program, which are not prescribed below. Synopses of these subjects may be found in earlier editions of the School and Faculty Handbooks (which are available for perusal in the School Office).

33857 Large Scale Mathematical Programming
Three semester hours
Prerequisites: 34932 Optimisation Techniques

The subject introduces students to the solution of large scale problems using mathematical programming techniques and considers the use of these techniques in a number of case studies and research areas. Topics to be covered include: theory and computational methods for optimising large scale linear and nonlinear programs, exploitation of special structure, data handling, Dantzig-Wolfe decomposition. Bender's decomposition, surrogate programming; multidivisional problems, combinatorial problems, stochastic problems and dynamic problems.

33860 Corporate and Financial Decisions and Investment Analysis
Three semester hours
Prerequisites: 34938 Financial Modelling Techniques (or equivalent)
This subject introduces students to areas of current research in the field of finance theory. Topics to be covered include: Options - concepts and valuation models; current issues and developments. Capital structure and theory of the firm; the effects of personal and corporate tax; current issues. Dividend policy.

33880 Operations Research Models and Methodology
Three semester hours
Prerequisites: All subjects (or their equivalents) from third year major in Operations Research in the Bachelor of Applied Science (Mathematics) degree.

Recent case studies from the literature will be critically examined from the point of view of the OR methodology used rather than the OR techniques. Students will be encouraged to adopt an innovative approach to problem solving, and to develop alternative formulations of the problems and their solutions. Cases will be selected to cover the basic model archetypes (linear, network, dynamic and stochastic). At least one case study will involve the use of continuous and/or discrete event simulation using a high level language such as SIMSCRIPT II.5.

34102 Calculus 2
Four semester hours
Prerequisites: 34101 Calculus 1

Trigonometric and hyperbolic functions. Methods of integration. Logarithmic and exponential functions. L'Hôpital's rule. Improper integrals. Sequences and series. Tests for convergence. Power series. Maclaurin series.

34117 Commercial Computing 1
Two semester hours

Introduction to data processing in a business environment. Emphasis is given to a structured approach to program design and development. Practical work involves the implementation of elementary functions of business data processing in COBOL.

34127 Information Systems 1
Three semester hours

This subject focuses on the use of computer based systems in an organisational context. Typical computer-based systems, data processing and information systems, office support systems, personal computers, embedded systems. Organisational benefits of computer based systems, objectives, costs and risks. On-line, off-line, real-time systems. Batch, interactive and transaction processing. Description of data flows. Process flow charting. Introduction to simple business applications and system development life cycle. Operational issues.

34217 Commercial Computing 2
Four semester hours
Prerequisites: 34117 Commercial Computing 1
34127 Information Systems 1

Applications of COBOL to the programming of commercial systems. The students design, test and document an integrated, batch-oriented system.

34227 Information Systems 2
Three semester hours
Prerequisites: 34127 Information Systems 1

The organisation of records in serial and direct access files. Controls, security, recovery and audit requirements. Capacity and timing calculations. Data capture, entry and display.

34307 Computing 2
Two semester hours
Prerequisites: 34101 Calculus 1
34107 Computing 1

ANSI standard FORTRAN 77. Subroutine packages. File handling, use of terminals and editing. Elementary numerical methods; selection from numerical integration, linear equations, nonlinear equations, function evaluation.

34320 Partial Differential Equations
Three semester hours
Prerequisites: 34213 Ordinary Differential Equations

Solution of boundary value problems by separation of variables. Sturm-Liouville theory. Orthogonality and completeness of eigenfunctions. Special functions. Eigenfunction expansions.

34407 Computing 3
Three semester hours
Prerequisites: 34307 Computing 2

Programming techniques for the organisation and manipulation of data in main storage. Emphasis on methodology, i.e. top down approach, structured programming and controlled testing. Topics include: data structures such as lists and trees, sorting and searching techniques.

34417 Numerical Methods 1
Three semester hours
Prerequisites: 34214 Algebra 2
34307 Computing 2
Corequisites: 34213 Ordinary Differential Equations

Introduction to the numerical solution of problems in science and engineering using digital computers. Solution of linear and nonlinear equations. Interpolation and functional approximation. Numerical differer.tiation and integration. Numerical linear algebra. Solution of ordinary differential equations. Optimisation.

34418 Numerical Methods 2
Three semester hours
Prerequisites: 34417 Numerical Methods 1
34213 Ordinary Differential Equations

Advanced numerical methods. Boundary value problems. Approximation of functions. Solution of partial differential equations. Monte Carlo methods. Fast Fourier transforms.

34507 Computing 4
Three semester hours
Prerequiste: 34407 Computing 3

Data structures; implementation of stacks, queues, linked lists, trees etc. in FORTRAN. Sparse matrices: storage and manipulation. Simulation; design and implementation of a discrete event simulator. Recursion: implementation and elimination of recursion. Graphics: 2D function plots, histograms, pie charts, 3D function plots, wire frame shapes. Programming packages: design and implementation of user-friendly interfaces. Particular applications include rational, multiprecision and interval arithmetic and a symbolic polynomial manipulation package.

34517 Commercial Computing 3
Three semester hours
Prerequisites: 34217 Commercial Computing 2
34627 Information Systems 3

Programming techniques for the implementation of on-line systems: screen data entry, menu driven programs, system integrity. Experience in design, testing and maintenance.

34527 Real Variables
Three semester hours
Prerequisites: 34102 Calculus 2

The real number system. Countability. Limits, continuity and differentiability. The Riemann integral. Review of sequences and series. Taylor's theorem. Series of functions.

34573 History of Mathematics
Two semester hours
Prerequisites: by consent

The great mathematicians and the history of mathematics from a problem-solving point of view.

34607 Computing 5
Three semester hours
Prerequisites: 34137 Computer Systems 1
34507 Computing 4

Topics include: operating systems - structure, resource management and performance, case studies of IBM VM and Unix : user/system interface and JCL. Language structures and compilers : grammars, lexical analysis, parsing and code generation. Design and implementation of a small practical language.

34627 Information Systems 3
Three semester hours
Prerequisites: 34227 Information Systems 2

The system development life cycle. Tools for system and process representation. Analysis of existing information systems. Proposal formulation and feasibility analysis. Logical and physical design, structural design, system implementation, project management.

34628 Information Systems 4
Three semester hours
Prerequisites: 34627 Information Systems 3

Principles of database management and organisation. CODASYL and relational models. Experience in the use and evaluation of DDL (data description language) and DML (data manipulation language) for a database system.

34668 Computational Number Theory
Three semester hours
Prerequisites: 34307 Computing 2

Prime numbers, arithmetical functions, congruences. Factorisation and primality testing, applications to cryptography. Quadratic residues. Continued fractions.

34681 Special Applications in Operations Research
Three semester hours
Prerequisites: by consent

34682 Special Applications in Computing
Three semester hours
Prerequisites: by consent

34683 Special Applications in Statistics
Three semester hours
Prerequisites: by consent

34684 Special Applications in Physical Applied Mathematics
Three semester hours
Prerequisites: by consent

34685 Special Applications in Modern Applied Mathematics
Three semester hours
Prerequisites: by consent

34691-34697 Project
One to seven semester hours
Prerequisites: by consent

An investigation of a topic selected by the student with the approval of the Director of Undergraduate Studies or his or her designated representative. A formal report must be submitted and a seminar presented. Although this is a final year subject, consideration should be given to the selection of a topic in the preceding year.

34698 Seminar
Two semester hours
Prerequisites: by consent

Group studies of selected topics which may vary from year to year. Topics may include hybrid computation, theory of oscillations, nonlinear differential equations or aspects of computer science and operations research.

34700 Discrete Mathematics
Three semester hours

Graphs, paths, trees. Set operations. Indexing and recurrence relations. Propositional and predicate calculus. Semi-groups, lattices and Boolean algebras. Permutations, combinations, partitions, counting and allocation problems.

34701 Algebra 1
Three semester hours

Complex numbers: polar form; de Moivre's theorem; exponential form; regions in the complex plane. Polynomials: remainder and factor theorems; synthetic division; Descartes' Rule of Signs; relations between roots and coefficients. Systems of linear equations: Gaussian elimination; homogeneous systems. Matrices: matrix algebra; elementary matrices; inverse matrix; application to systems of linear equations; LU decompostion. Determinants: definition and properties; methods of evaluation; Cramer's Rule; adjoint form for inverse matrix; characteristic equation. Vectors: algebra of vectors; dot and cross products; triple products; application to trigonometry.

34710 Calculus
Six semester hours

Graphical introduction to limits, continuity and differentiation. Graphical introduction to the Mean Value Theorem. Applications of differentiation. Riemann integration and the Fundamental Theorem of Calculus. Applications of integration to areas, volumes, lengths of curves and surface areas. Logarithmic and exponential functions. Trigonometric and inverse trigonometric functions. Hyperbolic and inverse hyperbolic functions. Methods of integration. Improper integrals.

34711 Analysis 1
Three semester hours
Prerequisites: 34710 Calculus
Convergence of sequences, limit theorems. Point sets; the least upper bound axiom, nested interval property and Bolzano-Weierstrass theorem; application to sequences. Limit of a function; limit theorems; continuity; discussion in terms of sequences. Properties of continuous functions on a closed interval. Differentiation; the Mean Value Theorem. Taylor's Theorem with remainder; L'Hôpital's rule. Infinite series; convergence tests for series of positive terms; absolute and conditional convergence; alternating series. Improper integrals; convergence tests. Power series and radius of convergence. Taylor and Maclaurin series; associated numerical problems.

34740 Introduction to Operations Research Models
Three semester hours
Corequisites: 34751 Statistics 1

Formulation of OR problems, construction of models, linear programming, network models, dynamic optimisation, stochastic processes, Bayesian decision analysis, inventory control, waiting line models, simulation, multiple objective decision making, heuristic problem solving.

34751 Statistics 1
Three semester hours
Corequisites: 34711 Analysis 1

Descriptive statistics. Probability. Random variables; expectation; standard distributions. Inference on means and variances. Distribution-free tests. Goodness-of-fit tests. Linear regression.

34770 Computing 1A
Three semester hours
Corequisites: 34700 Discrete Mathematics

An introduction to a disciplined approach to problem-solving methods and algorithm development using a modern imperative programming language (Modula-2). The course will

cover the essential syntactical features and rules of the language, including sequencing, selection, iteration and decomposition. In addition, modern design techniques involving procedural and data abstraction, and programming from specifications, will be introduced via a range of case studies and programming exercises. An initial repetoire of essential algorithms will be accumulated over the semester. The practical course will involve supervised laboratory classes in which students will learn practical techniques for program specification and design, coding, debugging, testing and documentation using good programming style.

34771 Computing 1B
Three semester hours

Prerequisites:	34700 Discrete Mathematics
	34770 Computing 1A
Corequisites:	34781 Mathematical Foundations of Computing 1

This subject continues the development of programming skills initiated in the subject 34770 Computing 1A. Topics include: further investigation of the Modula-2 language: sets, multi-dimensional arrays, variant records, pointers, internal modules; formal specification and verification methods; recursive programming; iterative and recursive implementation of simple structured types. Functional programming: basic data types, functions, lists, iteration and recursion; inductive proof methods.

34781 Mathematical Foundations of Computing 1
Three semester hours

Prerequisites:	34700 Discrete Mathematics
	34770 Computing 1A

The aim of this subject is to introduce the logical and mathematical principles of automatic computation. Topics include: historical overview of computing machinery; introduction to deterministic finite automata; design of combinatorial circuits and clocked sequential circuits; the von Neumann architecture; elementary data types, representation of values and realisation of operators; registers, arithmetic and logic units, data path; the fetch-execute cycle. Introduction to the theory of computation: algorithms as function definitions; the halting problem, Church's thesis; introduction to the lambda calculus.

34790 Numerical Computing
Three semester hours

Prerequisites:	34710 Calculus
Corequisites:	34770 Computing 1A
	34711 Analysis 1

Simple program design techniques. Coverage of the elements of ANSI standard FORTRAN including control structures, subroutines and functions, arrays, formatted I/O, file handling, and string manipulation. An introduction to numerical methods including: a treatment of errors, simple algorithms for solving nonlinear equations in one variable (bisection and Newton's methods), linear equations in several variables (Gaussian elimination, iteration) and

algorithms for performing numerical integration (trapezoidal and Simpson's rules, extrapolation). Non-numerical applications include sorting, searching, and text processing.

34802 Algebra 2
Three semester hours
Prerequisites: 34701 Algebra 1

Vector spaces: Euclidean and general vector spaces; subspaces; linear independence; basis and dimension; row and column space; inner product spaces; the Gram-Schmidt process; change of basis. Linear transformations. Eigenvalues and eigenvectors: diagonalisation; similarity; symmetric matrices; applications to quadratic forms, conic sections, powers of a matrix and difference equations. Complex vector spaces: complex inner product spaces; unitary, normal and Hermitian matrices.

34803 Algebra 3
Three semester hours
Prerequisites: 34802 Algebra 2

Sets, relations, functions, order relations, po-sets and lattices. Semi-groups, monoids. Groups. Abelian and non-abelian groups. Elementary category theory. Theorems of Lagrange, Cayley, Sylow. Direct products. Fundamental theorem of abelian groups. Normal sub-groups, co-sets, quotient groups. Groups of finite order. Elementary morphism theory. Rings, ideals, quotient rings, integral domains and fields. Elementary field theory. Introduction to coding theory.

34812 Analysis 2
Three semester hours
Prerequisites: 34711 Analysis 1
Corequisites: 34821 Partial Differential Equations 1

The aim of this subject is to present the analytic theory required to handle boundary value problems by Fourier series methods. Topics include: Cauchy sequences; cluster points of sequences; convergence of Cauchy sequences; sequential compactness of the real line; continuous and uniformly continuous functions; further properties of continuous functions on a closed interval; Mean Value Theorem and Fundamental Theorem of Calculus; sequences and series of functions; uniform convergence; continuity, integrability and differentiability of series of functions; Weierstrass M-test; power series; Fourier series; applications to ordinary differential equations and boundary value problems.

34815 Ordinary Differential Equations
Three semester hours
Prerequisites: 34710 Calculus
Corequisites: 34802 Algebra 2

First order equations. Theory of linear equations. Auxiliary equations and undetermined coefficients. Variation of parameters. Laplace transforms, step functions, convolution.

Eigenvalues and matrix exponentials. Qualitative properties of solutions. Phase plane. Stability. Linear and nonlinear systems. Predator-prey problems.

34817 Vector Calculus
Three semester hours
Prerequisites: 34710 Calculus

Partial derivatives. Multiple integrals. Vector fields. Line and surface integrals. Green's, Gauss' and Stokes' theorems.

34818 Complex Variables
Three semester hours
Prerequisites: 34817 Vector Calculus

Analytic functions of a complex variable. Cauchy's integral theorem. Laurent series. Singularities of analytic functions. The residue theorem. Contour integration. Conformal mapping.

34821 Partial Differential Equations 1
Three semester hours
Prerequisites: 34815 Ordinary Differential Equations
Corequisites: 34817 Vector Calculus

Solution of boundary value problems by separation of variables. Sturm-Liouville theory. Fourier series. Two dimensional problems. Infinite domain problems. Fourier integrals and Fourier transforms. Green's function methods. Laplace transform methods for elementary boundary value problems.

34852 Statistics 2
Three semester hours
Prerequisites: 34751 Statistics 1

Random variables. Moments. Moment generating functions. Bivariate distributions. Transformations of random variables. Order statistics. Sampling distributions. Central Limit Theorem. Applications to estimation. Multivariate Normal distribution.

34872 Computing 2
Three semester hours
Prerequisites: 34700 Discrete Mathematics
34771 Computing 1B

The aim of this subject is to develop further a disciplined approach to the specification, design, implementation and testing of software using imperative and functional languages. Topics

include: abstract data types (ADTs) (list, stack, queue, dequeue, tree, graph, etc); formal specification of ADTs; static and dynamic implementations in an imperative language; requisite features of Modula-2; introduction to order notation and efficiency considerations; algorithm analysis (examples include searching and sorting algorithms). Functional programming: functional implementation of ADTs; recursion and induction on lists.

34873 Computing 3
Three semester hours
Prerequisites: 34711 Analysis 1
34872 Computing 2
Corequisites: 34802 Algebra 3

The course will consolidate and extend the work on specification of abstract data types, together with advanced implementation issues. Systematic techniques of algorithm design and analysis, together with associated mathematical methods, will deal with issues of complexity, efficiency and program verification. A wide range of advanced applications will be examined via case studies, both in formal lectures and practical assignments. In addition to existing imperative and functional languages, an object-oriented language will be introduced and employed in practical assignments in the implementation of flexible and reliable software.

34891 Numerical Methods A
Three semester hours
Prerequisites: 34711 Analysis 1
34790 Numerical Computing
Corequisites: 34802 Algebra 2

Solution of nonlinear equations, including some revision from 34790 Numerical Computing. Analysis of convergence. Error analysis. Lagrange interpolation, cubic splines, Bezier curves. Numerical differentiation and integration: Newton-Cotes adaptive methods, Gaussian quadrature, methods involving Richardsonian extrapolation. Approximation theory: least squares and orthogonal polynomials, economisation of power series using Chebyshev polynomials, rational approximations. Vector and matrix norms. Numerical linear algebra: LU factorisation, iterative methods - Jacobi and Gauss-Seidel methods. Householder reduction, QR algorithm. Initial value problems for ordinary differential equations: introductory material including Taylor series methods, open Runge-Kutta methods and multistep methods. This course is heavily oriented towards practical applications.

34904 Algebra 4
Three semester hours
Prerequisites: 34803 Algebra 3

Polynomials in splitting fields; Euclidean constructions; finite fields: normal extensions, Galois fields, primitive and cyclotomic polynomials; latin squares; modular arithmetic; elements of graph and coding theories.

34913 Modern Analysis
Three semester hours
Prerequisites: 34802 Algebra 2
34812 Analysis 2

Metric space axioms. Open and closed sets. Interior and closure. Sequences in a metric space. Sequential compactness. Contraction mapping theorem. Application to existence theorems for differential equations. Continuous mappings between metric spaces. Normed linear spaces. Banach spaces. Bounded linear maps. Operators and functionals. Dual spaces.

34914 Measure Theory
Three semester hours
Prerequisites: 34913 Modern Analysis

Measures and outer measures. Measure spaces. Lebesgue measure on the real line. Measurable functions. Step functions. Definition of the abstract Lebesgue integral. Monotone convergence theorem. Dominated convergence theorem. Probability spaces. Independence. Borel-Cantelli lemmas. Laws of large numbers.

34916 Mathematical Methods
Three semester hours
Prerequisites: 34922 Partial Differential Equations 2
34924 Mechanics

Theory of distributions. The Fourier transform and applications to partial differential equations. Introduction to the calculus of variations. Euler-Lagrange equations. The brachistochrone problem. Eigenvalue problems. Lagrangian and Hamiltonian mechanics. Lagrange's equations of motion. Hamilton's principle. The principle of least action.

34920 Integral Equations
Three semester hours
Prerequisites: 34913 Modern Analysis

Existence theory for Fredholm and Volterra integral equations using contraction mappings. Compact integral operators. Green's functions.

34922 Partial Differential Equations 2
Three semester hours
Prerequisites: 34818 Complex Variables
34821 Partial Differential Equations 1

Bessel's equation and Bessel functions. Boundary value problems in partial differential equations involving Bessel's equation. Legendre's equation and Legendre's associated equation. Legendre functions and associated Legendre functions. A thorough treatment of Laplace transforms. Inverse Laplace transforms using complex variable methods.

34924 Mechanics
Three semester hours
Prerequisites: 34815 Ordinary Differential Equations
34817 Vector Calculus

Kinematics and dynamics of a particle. Projectile motion. Oscillations. Conservative forces and central forces. Theory of planetary motion.

34925 Wave Theory
Three semester hours
Prerequisites: 34922 Partial Differential Equations 2

Acoustic waves in fluids. Waves on a liquid surface. Elastic waves in solids. Electromagnetic waves.

34927 Deterministic Optimal Control
Three semester hours
Prerequisites: 34815 Ordinary Differential Equations
34817 Vector Calculus
34913 Modern Analysis

Introduction to optimal control problems involving ordinary differential equations. Linear problems and bang-bang controls. Nonlinear problems and Pontryagin's maximum principle. Necessary conditions. Sufficient conditions. Various endpoint conditions. Calculus of variations. Dynamic programming. Infinite horizon problems. Applications to optimal economic growth and to optimal investment and consumption decisions.

34930 Simulation Techniques
Three semester hours
Prerequisites: 34751 Statistics 1
Corequisites: 34790 Numerical Computing

Introduction to techniques of simulation as used in operations research. Special consideration is given to input data analysis, verification, validation and the employment of computer languages for discrete event simulation (GASP, SEESIM, SIMSCRIPT II.5).

34931 Linear Programming
Three semester hours
Prerequisites: 34740 Introduction to OR Models
Corequisites: 34802 Algebra 2

Formulation of linear programming problems. The simplex method and its variants. Duality theory, degeneracy and post optimal analysis. Applications to industrial systems including transportation problems, production scheduling, management games and optimisation problems.

34932 Optimisation Techniques
Three semester hours
Prerequisites: 34711 Analysis 1
34931 Linear Programming

A unified treatment of the solution of models derived from real-life situations. Derivation and application of Kuhn-Tucker theorem. Selected algorithms of nonlinear programming will be treated.

34934 Network Optimisation
Three semester hours
Corequisites: 34931 Linear Programming

Shortest path problems. Minimal spanning tree problems. The transportation problem. The transshipment problem. The assignment problem. The travelling salesman problem. Maximum flow problems. Multiple sources and sinks. Out-of-kilter algorithm. OOK applications. Project planning and scheduling. CPM cost models.

34935 Inventory Control
Three semester hours
Corequisites: 34930 Simulation Techniques

Forecasting techniques. Economic order quantity. Production lot size. Quantity discounts. Shortage Models. Stochastic inventory models. Single period model. Safety stock approach. Service level approach. ABC classification. Dynamic EOQ. Silver-Meal heuristic. Use of dynamic optimisation and linear programming. Simulation models. Classical optimisation methods. Materials requirements planning.

34936 Decision Theory
Three semester hours
Prerequisites: 34740 Introduction to OR Models

Prior analysis. Decision trees. Decision criteria. Certainty equivalents. Value of information. Posterior analysis. Using experimental information. Using sample information. Preposterior

analysis. Normal prior distributions. Beta prior distributions. Risk analysis. Risk premiums. Preferences. Game theory. Classical vs Bayesian methods.

34938 Financial Modelling Techniques
Three semester hours
Prerequisites: 34711 Analysis 1
34751 Statistics 1

Introduction to some stylised models of the standard problems of financial management and the mathematical techniques for their solution. Models covered include asset and liability management, planning day-to-day operations and the firm's financing and investment decisions. Topics include the concept of net-present value, the present value of income streams; the capital budgeting problem - investment decisions under uncertainty; the debt-capacity decision; debt maturity and timing decisions; dividend policy, internal financing and growth.

34953 Statistics 3
Three semester hours
Prerequisites: 34852 Statistics 2

Estimation: point estimation; maximum likelihood; method of moments; sufficiency; completeness; exponential class of distributions. Hypothesis testing: decision problems; Neyman-Pearson lemma; best tests; uniformly most powerful tests; sequential probability ratio test; minimax and Bayesian tests. Distribution free methods: estimation and hypothesis testing; further theory of inference.

34955 Regression Analysis
Three semester hours
Prerequisites: 34852 Statistics 2

Simple linear regression. Multiple regression. Polynomial regression. Diagnostics and model building. Introduction to generalised linear models. Use of computer packages such as SAS, SPSS, MINITAB and GLIM, and the use of APL.

34956 Design of Experiments
Three semester hours
Prerequisites: 34955 Regression Analysis

Design and analysis of experiments. Completely randomised, randomised blocks and latin square designs. Factorial experiments. Hierarchical experiments. Introduction to confounding, split plots, fractional replication, incomplete blocks, analysis of covariance. Use of computer packages MINITAB, SPSS, SAS and GLIM.

34957 Industrial Statistics
Three semester hours
Prerequisites: 34852 Statistics 2

Sampling inspection; acceptance sampling; inspection by variables. Control charts; cumulative sum charts. Order statistics. Sequential tests. Reliability models.

34960 Theory of Probability
Three semester hours
Corequisites: 34852 Statistics 2

Probability axioms. Combinatorial analysis. Conditional probability and independence. Random variables. Expectations. Limit theorems.

34961 Stochastic Processes 1
Three semester hours
Prerequisites: 34852 Statistics 2

Random walks. Markov chains: classification of states; limit results for irreducible recurrent chains; absorption probabilities. Discrete state Markov processes: Poisson process; pure birth process; birth-death processes; application to queueing problems. Stationary processes; moving average and autoregressive models. Introduction to Wiener processes and renewal processes.

34975 Computer Graphics
Three semester hours
Prerequisites: 34891 Numerical Methods A

Hardware: capabilities of typical devices such as plotters and raster scan instruments. Standard system software including point plotting and line drawing (Bresenham's algorithm), transformations (scaling, translations, rotations) in two dimensions, clipping and windowing. Area filling algorithms: flood-fill, raster scan. Three-dimensional drawing: transformations, projections (orthogonal and perspective), homogeneous coordinates, floating horizon hidden surface algorithm. Curve and surface interpolation: cubic splines, Bezier curves and surfaces, B-splines. Graphic standards: GKS, PHIGS.

34976 Neural Networks
Three semester hours
Prerequisites: 34751 Statistics 1
34790 Numerical Computing
34802 Algebra 2
34817 Vector Calculus

Fundamental concepts: theories of mind and brain (ancient to modern), cybernetics (deterministic systems, feedback, communication, control, adaptation), brain theory (neurons, brain structures, representation), rise of connectionism (the Von Neumann bottleneck, the

parallel distributed processing paradigm). Neural network models and learning algorithms: associative nets (Hebbian learning), the Perceptron (error-correcting rule), multi-layer networks (back-propagation, Boltzmann machines), interactive activation and Grossberg models (competitive learning), Barto model (reinforcement learning). Applications: travelling salesman problem, NETtalk (a network that learns to talk).

34977 Formal Specification
Three semester hours
Prerequisites: 34982 Mathematical Foundations of Computing 2

An introduction to the mathematical basis of formal specification theory, including linguistic systems and models of specification systems. Software development by linguistic transformations. A comparative study of the principles and practices of important formal specification methods used in modern software construction, including algebraic specification, the Vienna Development Method and Z.

34982 Mathematical Foundations of Computing 2
Three semester hours
Prerequisites: 34803 Algebra 3
34873 Computing 3

This subject consists of an introductory but systematic survey of the logical, algebraic and categorical foundations of formal program semantics, together with associated verification methods. Operational and denotational semantics, and the axiomatic methods of Floyd, Hoare and Dijkstra will be introduced. The theoretical basis of algebraic semantics will be fully established and its implications considered. The lambda and combinatorial calculi will be considered within the context of the semantics of functional programming languages.

34983 Mathematical Foundations of Computing 3
Three semester hours
Prerequisites: 34982 Mathematical Foundations of Computing 2
Corequisites: 34984 Language Theory

An important aim of this mainly theoretical subject is to develop an appreciation of current directions in research on the nature of computation, and acquaint students with sources of information in this field. The course will consider additional topics in the denotational semantics of applicative and imperative programming languages, in greater depth than its prerequisite subject. Further topics in algebraic semantics will include initial and final algebra approaches to specification of data types, as well as the initial algebraic specification of languages. Selected topics in the theory of computation will include computability, Turing machines, the Church-Turing thesis, decidability, complexity issues, completeness and tractability.

34984 Language Theory
Three semester hours
Prerequisites: 34982 Mathematical Foundations of Computing 2

The aim of this subject is to provide students with skills sufficient for the design and implementation of simple problem-oriented languages and environments. Topics include: Chomsky's categorisation of grammars; regular and context-free grammars and languages; finite state recognisers; parsing strategies; recursive descent and table-driven parsers; operational semantics and program transformation; language design; translation and implementation of a simple, block-structured imperative language; issues in the implementation of functional languages (combinator compilation, strict and lazy evaluation, supercombinators).

34985 Digital Image Processing
Three semester hours
Prerequisites: 34790 Numerical Computing
34802 Algebra 2

Preliminaries: human vision, digital image models, image geometry and transformations, display devices. Image transforms: the Fourier transform, convolution, cross correlation and autocorrelation, basic transform theorems. The discrete Fourier transform and its properties: fast Fourier transform implementation, aliasing, leakage. The 2-dimensional transform and its associated implementation. Image enhancement and restoration: histogram modification techniques, low, high and band-pass filters, image sharpening and smoothing, pseudo-colouring. Models of degradation, inverse filtering, removal of linear blur, frequency modification. Image segmentation: point, line and edge detection, the Hough transform, thresholding and region segmentation.

34987 Cryptology
Three semester hours
Prerequisites: 34790 Numerical Computing

The subject gives students an elementary understanding of cryptology, including an emphasis on factorisation and primality testing, relevant to public key cryptosystems. Topics covered include: divisibility and prime numbers; the fundamental theorem of arithmetic; congruences; applications; Fermat's Theorem. Applications to primality testing and factorisation; Fermat's and Pollard's "p-1" methods. Multiplicative functions; Euler's function, sum and number of divisors; perfect numbers. Cryptology: block ciphers, exponentiation ciphers, public key cryptography, knapsack ciphers. Continued fractions, application to factorisation.

34992 Numerical Methods B
Three semester hours
Prerequisites: 34790 Numerical Computing
34821 Partial Differential Equations 1

Solution of ordinary differential equations, including some revision from earlier work. Initial value problems: Single step and multi-step methods. VSVO, extrapolation and implicit methods. Stiff differential equations and methods appropriate thereto. Stability theory. Boundary value problems: shooting, finite difference and finite element methods. Differential eigenvalue problems. Solution of partial differential equations: finite difference and finite element methods. Optimisation: methods for unconstrained nonlinear optimisation, steepest descent, damped Newton-Raphson and matrix updating techniques. Overdetermined systems.

34995 Advanced Numerical Analysis
Three semester hours
Prerequisites: 34913 Modern Analysis

Differentiation in normed linear spaces. Mean Value Theorem and Taylor's Theorem. Product spaces and partial differentials. Nonlinear equations and the Newton-Kantorovich method.

34996 Convexity and Optimisation
Three semester hours
Prerequisites: 34913 Modern Analysis

Convex sets in a linear space. Affine sets and hyperplanes. Algebraic interior and closure. Separation theorems. Geometric Hahn-Banach theorem. Convex functions. Epigraphs. Subdifferentiability and differentiability. Duality. Polars. Support functions. Linear and convex programming. Kuhn-Tucker conditions.

34013 Modern Analysis (Honours)
Three semester hours
Prerequisites: 34802 Algebra 2
34812 Analysis 2

As for 34913 Modern Analysis. Additional Content: Topological spaces. Continuous functions. Compactness. Separation properties.

34014 Measure Theory (Honours)
Three semester hours
Prerequisites: 34013 Modern Analysis (Honours)

As for 34914 Measure Theory. Additional content: The pi-lambda theorem. Fubini's theorem. Hahn decompostion. Radon-Nikodym theorem and conditional probability.

34019 Functional Analysis
Three semester hours
Prerequisites: 34014 Measure Theory (Honours)

Banach spaces. Bounded linear transformations. Spectrum. Dual space. Adjoint operator. Hahn-Banach theorem. Compact operators. Riesz theory. Fredholm integral equations. Fredholm alternative. Application to potential theory. Hilbert spaces. Operators and adjoints. Riesz representation theorem. Orthogonality. Orthonormal bases. Abstract Fourier theory. Self-adjoint operators. Projections. Compact operators. Spectral theory for compact operators. Application to Sturm-Liouville theory. Fourier series.

34023 Partial Differential Equations 3
Three semester hours
Prerequisites: 34922 Partial Differential Equations 2

First order equations. Classification of second order linear equations. Wave equation. D'Alembert's formula. Poisson's formula. Huygen's principle. Heat Equation. Maximum principles. Regularity of solutions. Nonlinear problems. Laplace's equation. Properties of harmonic functions. Green's functions. Method of images. Integral equations. Fredholm theory. Application to Dirichlet and Neumann problems. Introduction to scattering theory. Scattering of plane waves by cylinders.

34026 Fractal Geometry
Three semester hours
Prerequisites: 34014 Measure Theory (Honours)

Review of relevant aspects of metric space theory, compactness, and contraction mappings. The space of fractals. Collage Theorem. Chaotic dynamics on fractals. Fractal dimension; theoretical and experimental determination. Fractal interpolation. Julia sets; attractors of iterated function systems, applications to Newton's method. Parameter spaces and Mandelbrot sets. Measures on fractals. Application to computer graphics.

34028 Stochastic Optimal Control
Three semester hours
Prerequisites: 34927 Deterministic Optimal Control
34062 Stochastic Processes 2

Formulation of stochastic control problems. Examples of controls. The Hamilton-Jacobi-Bellman equation. Necessary and sufficient conditions. Reduction to Markov controls. Dynamic portfolio strategies. The optimal portfolio selection problem. Discussion of solutions in various particular cases.

34029 Nonlinear Dynamical Systems
Three semester hours
Prerequisites: 34815 Ordinary Differential Equations
34013 Modern Analysis (Honours)

Review of linear systems. Nonlinear systems. Phase plane analysis. Linearisation. Local stability and instability. Global asymptotic stability. Stable and unstable manifolds. Limit cycles and strange attractors. Introduction to chaos theory. Asymptotic methods. The methods of Poincaré and Lindstedt. The method of averaging. Applications to finance.

34033 Dynamic Optimisation
Three semester hours
Prerequisites: 34790 Numerical Computing
34931 Linear Programming
34961 Stochastic Processes

Bellman's principle of optimality. Recursive relations. Resource allocation. Production scheduling. Equipment replacement. Multi-stage processing. Two or more state variables. Continuous state variables. Application to linear and non-linear programming. Computational feasibility. Stochastic dynamic optimisation. Optimisation over an unbounded horizon. Markovian decision processes. Approximation in policy space with discounting.

34062 Stochastic Processes 2
Three semester hours
Prerequisites: 34960 Theory of Probability
34961 Stochastic Processes 1
34014 Measure Theory (Honours)

Formal definitions of probability space and stochastic processes. Martingales. Riemann-Stieltjes integration. Brownian motion and related processes. Stochastic calculus and stochastic differential equations. Financial applications.

34065 Time Series Analysis
Three semester hours
Prerequisites: 34960 Theory of Probability
34961 Stochastic Processes 1

Systematic treatment of stochastic difference equations. Model selection and dynamic specification. Heteroscedastic disturbances. Maximum likelihood estimation. Simultaneous equation models.

34066 Nonlinear Statistical Models
Three semester hours
Prerequisites: 34955 Regression Analysis
34065 Time Series Analysis

Nonlinear regression; least squares estimation; hypothesis testing. Use of SAS. Multivariate nonlinear regression. Nonlinear simultaneous equation models; method of moment estimators.

34067 Multivariate Statistics
Three semester hours
Prerequisites: 34955 Regression Analysis

Multivariate normal distribution: definition; moments; characteristic function; estimation of mean and covariance matrices; Wishart distribution; Hotellings' T2. Multivariate linear regression. Principal components. Factor analysis: different models - Spearman, Burt, Thurstone; geometric models; unit rank; invariance.

34068 Statistical Modelling
Three semester hours
Prerequisites: 34956 Design of Experiments

Revision of linear models and exponential families. Generalised linear models. Applications including logistic regression and contingency tables. Modelling using statistical distributions; continuous distribution models; discrete distribution models.

34069 Linear Models and Experimental Design
Three semester hours
Prerequisite 34956 Design of Experiments
34067 Multivariate Statistics

The subject provides the linear model theory for experimental design models and presents advanced experimental designs. Topics include: linear models - the linear model of less than full rank. The analysis of variance. Completely randomised and randomised block designs. Response surfaces. Incomplete block designs. Repeated measures designs.

34096 Convexity and Optimisation (Honours)
Three semester hours
Prerequisites: 34013 Modern Analysis (Honours)

As for 34996 Convexity and Optimisation. Additional content includes: application of Kuhn-Tucker theorem to calculus of variations. Introduction to applications in optimal control theory.

34098 Project (Honours)
34099 Project (Honours)

34098 (Autumn)	Three semester hours
34099 (Spring)	Six semester hours
Prerequisites:	Admission to the BAppSc(Hons) program

Students will perform an independent investigation of an area of the mathematical sciences chosen in consultation with a supervisor who will be appointed by the Head of School. The project commences in the Autumn Semester of the honours year and students will enrol in the three semester hour unit 34098. The project continues in the Spring Semester with the six semester hour unit 34099. At the end of the Spring Semester identical results will be awarded for both 34098 and 34099 (based on assessment consisting of the presentation of a report and seminar).

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