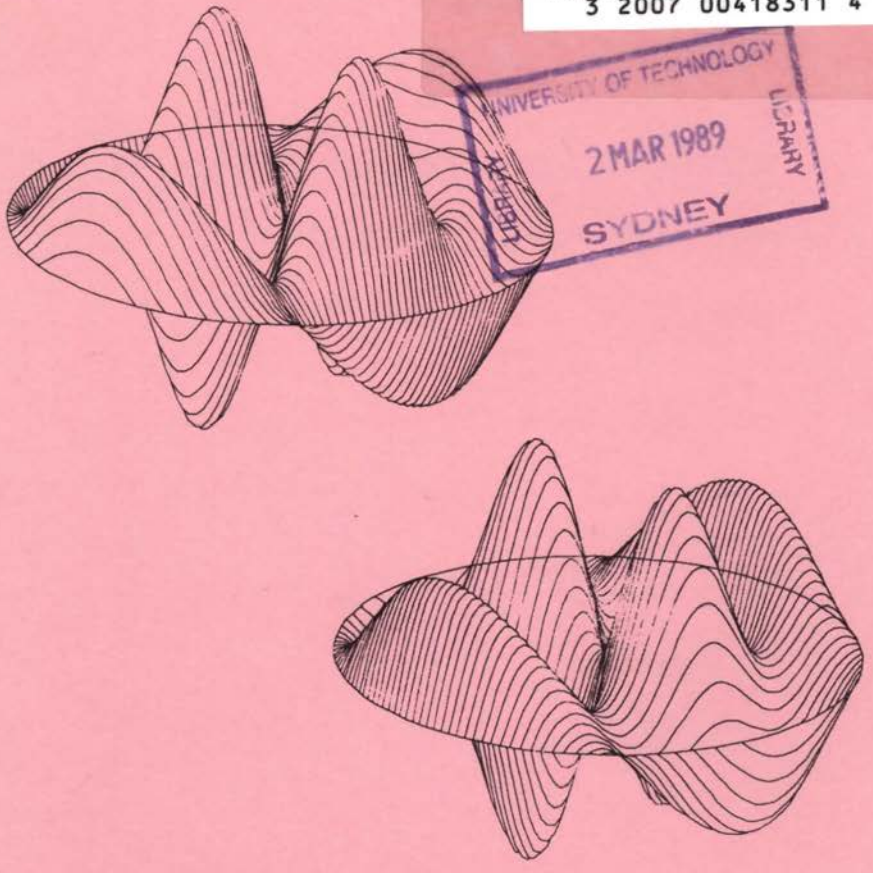
# UNIVERSITY OF TECHNOLOGY, SYDNEY

## SCHOOL OF MATHEMATICAL SCIENCES





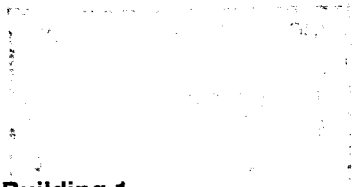




# HANDBOOK 1989

# UNIVERSITY OF TECHNOLOGY, SYDNEY

## SCHOOL OF MATHEMATICAL SCIENCES



**Location: Level 15 Building 1**

**Broadway**

**Telephone: 20930 Ext. 9959**

*Formerly The New South Wales Institute of Technology*

# TABLE OF CONTENTS

# SCHOOL OF MATHEMATICAL SCIENCES

THE SCHOOL OF MATHEMATICAL SCIENCES offers four degree courses, one of which leads to the award of BACHELOR OF APPLIED SCIENCE.

## BACHELOR OF APPLIED SCIENCE (MATHEMATICS)

This course is offered with the object of preparing professional people for employment in industry, commerce and education by providing thorough studies in basic mathematical and computing principles and their applications. These involve the latest techniques in Mathematics, Computing, Stochastic and Statistical Methods and Operations Research.

The course includes an in-depth treatment of a broad range of basic mathematical subjects with industrial applications as an objective. It aims to help the student acquire sufficient experience and understanding of those subjects to enable him or her to apply mathematical techniques and thinking to industrial and commercial problems. The course comprises studies in Mathematics, Statistics and Computing as well as electives from subjects offered by other Schools. Facility exists within the course to complete a double major in Computing and one of the following areas of applicable mathematics: Operations Research, Statistics or Applied Mathematics. The course is structured to permit a delayed choice of the mathematics area in which the student wishes to major. Within this framework a major in an application area is taken up in the third year. A major in Operations Research involves such subjects as Linear Programming, Simulation and Optimisation. The Statistics major aims to expose students to realistic statistical problems and it prepares them to cope with data and the associated uncertainty and variability. The option in Physical Applied Mathematics deals primarily with the modelling, analysis and synthesis of physical systems in Science and Engineering. 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 methods can be unified by a few basic geometric, analytic and algebraic ideas. The Modern Applied Mathematics major aims to develop these ideas and so provide the insight needed for the application of these methods in more complex problems. The Computing major, if elected, must be commenced in Stage 1.

The academic award for satisfactory completion of the course will be a bachelor's degree with the nomenclature: Bachelor of Applied Science, abbreviated to BAppSc. The degree is accredited with the Higher Education Board of New South Wales and registered with the Australian Council of Tertiary Awards.

## PROFESSIONAL RECOGNITION

Full recognition has been granted to the BAppSc(Mathematics) by:

- The Australian Computer Society (Level 1 Accreditation)
- The Australian Mathematical Society
- The Australian Society for Operations Research
- The Statistical Society of Australia
- The Institute of Mathematics and Its Applications

For membership application forms to join any of these societies or for information about them please contact the School Clerk.

## THE GRADUATE COURSES

The Graduate Courses available are: Graduate Diploma in Operations Research, Master of Applied Science (Operations Research) by Coursework and Report, Master of Applied Science (by Thesis) and Doctorate of Philosophy (joint program with Macquarie University). Full details of these Graduate Courses are found in the Graduate Studies Handbook available from Student Services or from the School's Graduate Assistant by ringing 218 9609.

## PRINCIPAL DATES FOR 1989

The academic year is divided into two semesters, each containing twenty weeks. The semesters are separated by a three week recess period. Principal dates throughout the year are as follows:

| | |
|---|---|
| 30-31 January & 6-10 February | Enrolment of re-enrolling students |
| 1-3 February | Enrolment of new students |
| 13 February | Autumn Semester classes commence for re-enrolling students |
| 20 February | Autumn Semester classes commence for new students |
| 20-24 March | Tutorial Week |
| 1-5 May | Tutorial Week |
| 12-30 June | Formal examination period |
| 3-21 July | Recess |
| 24 July | Classes commence for continuing students |
| 31 July | Classes commence for new Spring enrollees |
| 28 August - 1 September | Tutorial Week |
| 9-13 October | Tutorial Week |
| 20 November - 8 December | Formal examination period |

## GENERAL INFORMATION FOR STUDENTS

Students requiring information regarding admission, enrolments and attendance at the University should check the Calendar, on sale at the Bookshop, 11 Broadway, or contact the Student Services Unit located at the Broadway Campus on Level 3A of Building 1. The Unit offers services in the areas of student counselling, student health, course enquiries and general enquiries.

### Course Enquiries

Enquiries should normally be directed through the School Office, Level 15, Room 1523, where the School Clerk is located. The Clerk is available to assist students with any problems and advice regarding the course and may be contacted by phoning 218 9959.

Notices regarding Timetables, Enrolments and Examinations can be found at the School Office on Level 15, Room 1523.

### University Union

The Union Office and Reception Desk are located at Broadway, Building 1, Level 3. Enquiries about the Union facilities and activities should be directed to the Reception Desk.

### Library

The University library services are organised by the Information Resources Service located in Block A of the Markets Campus. Opening times during semester are from 8.30 a.m. - 10.00 p.m. Monday to Friday, 9.00 a.m. - 5.00 p.m. Saturday. (Sunday opening times to be advised by the Library.)

## ACADEMIC STAFF

***Head of School and Professor***

B S Thornton, DSc(Syd), PhD(NSW), FInstP, FBCS, FACS, CPhys, CEng, FRAeS

***Deupty Head of School***

Vacant

### MATHEMATICS EDUCATION UNIT

***Head of Unit and Associate Professor***

A G Shannon, AM, BSc, DipEd(Syd), MA, PhD, MLitt(UNE), FCP, FIMA, FACE, FRSM, Room 1533, ext. 9956

***Senior Lecturer***

J G Sekhon, BSc(WA), MSc(Lough), DipEd, PhD(UNE), FCollP, FIMA, MACE, Room 1531, ext. 9955

***Senior Tutor***

B W Stephenson, BAppSc(Maths)(NSWIT), DipEd(Syd), MA(Maths)(NSW), Room 1543, ext. 9981

***Honorary Associate***

J H Clarke, BSc, DipEd(NZ), PhD(Syd)
L Dintenfass, MSc, PhD (NSW), CChem, FRACI, MACPSM, MIE Aust, MBES, FCIA

### DEPARTMENT OF COMPUTING

***Head of Department and Professor***

B S Thornton, DSc(Syd), PhD(NSW), FInstP, FBCS, FACS, CPhys, CEng, FRAeS

***Senior Lecturers***

L C Botten, BSc(Hons), PhD(Tas), MAIP, MACS, MOSA, Room 1541, ext. 9972
K W Ozanne, BA(Melb), MSc(Lond), MACS, Room 1530, ext. 9954

***Lecturers***

T N Langtry, BA(Hons)(NSW), MAppSc(NSWIT), Room 1537, ext. 9991
R M Sorli, BSc(Syd), MAppSc(NSWIT), Room 1616B, ext. 9242

***Senior Tutor***

D R Porteus, BSc, DipEd (Tas), Room 1517A, ext. 9675

## DEPARTMENT OF OPERATIONS RESEARCH

***Head of Department and Professor***

B S Thornton, DSc(Syd), PhD(NSW), FInstP, FBCS, FACS, CPhys, CEng, FRAeS

***Director of Graduate Studies in Operations Research and Senior Lecturer***

C Malanos, BSc(App)(Qld), MSc(NSW), MACS, MASOR, Room 1616A, ext. 9982

***Lecturers***

B J Bamber, MSc(Syd), MEngSc(NSW), Room 1520, ext. 9986
J M Hogg, BSc(Syd), MSc(OpsRes)(NSW), MASOR, Room 1516, ext. 9985
R I Rozsasi, BSc(Syd), AFIMA, Room 1522, ext. 9988

***Senior Tutor***

L Groen, BSc(Syd), DipEd, GradDip(OpsRes)(NSWIT), MAppSc(UTS), Room 1543, ext. 9981

## DEPARTMENT OF STOCHASTIC AND STATISTICAL METHODS

***Head of Department***

Vacant

***Senior Lecturer***

S H Huxham, BSc, PhD(NSW), FSS, Room 1515, ext. 9984

***Lecturers***

E Lidums, BSc(Hons), MSc(Syd), Room 1513, ext. 9197
P Petocz, BSc(Hons), PhD(NSW), DipEd(Technical)(SCAE), MSS, Room 1540, ext. 9983

## DEPARTMENT OF MATHEMATICS

***Head of Department***

Vacant

***Senior Lecturers***

G L Cohen, MSc(Syd), PhD(NSW), FIMA, Room 1538, ext. 9969
G J McLelland, BSc, PhD(Syd), Room 1539, ext. 9970
B J Moore, MSc(Syd), PhD(Camb), Room 1532, ext. 9957
G H Smith, MSc(Rand), PhD(NSW), DipGeoscience(Macq), Room 1514, ext. 9971
W N-C Sy, BSc(Hons)(UNE), PhD(ANU), MAIP, MACS, MASOR, Room 1542, ext. 9569

***Lecturers***

Y K Yap, BSc(Malaya), MSc(IllIT), PhD(W'gong), AFIMA, Room 1521, ext. 9987

***Honorary Associate***

C Chiarella, MSc(Syd), MComm(Hons), PhD(NSW)

## ADMINISTRATIVE AND TECHNICAL STAFF

*Secretary to Head of School*
Vacant

*School Clerk*
Vacant

*School Secretary*
Leah Kilkelly

*Programmer - Systems Administrator*
Martin Caden, BAppSc(UTS)

*Computer Systems Support Officer*
Eric Lindsay

## PRIZES

### Statistical Society of Australia Prize in Statistics

In 1980 the Statistical Society of Australia NSW Branch established a prize for students in the Bachelor of Applied Science (Mathematics) course. This prize is to be awarded to the student with the highest weighted average mark for those subjects constituting the Statistics Major of the course. The recipient will be nominated by the Head of School of Mathematical Sciences. The prize is a cash award of $100.

### Foundation for Australian Resources Prize

The Foundation for Australian Resources is an independent non-profit organisation whose nominated beneficiary is the Faculty of Mathematical and Computing Sciences. The Foundation has made available since 1978 three prizes for students in the Bachelor of Applied Science (Mathematics) course. One prize will be given to the best graduating student, one to the outstanding first year full-time student, and one to the outstanding first year part-time student.

## 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 also through this society to

- improve the course,
- provide information for students about the course,
- organise social functions where both students and staff can have a good time.

For any of these things to be done successfully we need your participation (with a little help from staff as well).

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

## COMPUTING FACILITIES

The School of Mathematical Sciences makes extensive use of the University's central facilities which consist of an Amdahl 470V/8 system, with 16 Mbytes of central memory and 2.5 Gbytes of disc storage, running under Amdahl UTS/V, a derivative of AT & T System 5.2 Unix.

The School also owns and operates two powerful minicomputer systems. They are a HP-9000/550 triple processor system and a MIPS M800 each with 8 Mbytes of memory and having 404 Mbytes and 256 Mbytes of disc storage respectively. The systems are each capable of supporting 32 users and run under the HP-UX (ATT System 5.2 Unix) and UMIPS/V (ATT System 5.3 Unix) operating systems respectively.

Access to these systems is from three laboratories owned and operated by the School, as well as the public access laboratories operated by the Computer Services Division. Two of the School's laboratories are each equipped with twenty-four terminals, allowing direct connnect access to either the MIPS system or general access to all systems through the University's Ethernet local area network.

The third laboratory is equipped with 16 IBM PC-XT compatible microcomputers, each with a 20 Mbytes hard disc. These machines may be used as stand-alone systems or may be connected directly to the HP system or to the local area network.

Computer Graphics is well served in the School by a range of instruments including:

- HP 2397 colour graphics terminal,
- Tektronix 4014 monochrome terminal,
- IBM PC's emulating Tektronix 4014 monochrome terminals, and
- HP 7280a A1-sized drafting plotter.

At present the graphics software consists of an extensive library of Fortran subroutines which provide both 2D and 3D facilities, that has been written inhouse.

The School has also acquired a significant quantity of software running on the HP and MIPS systems and 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.

Teaching of computing and applications of computing is assisted by the use of a Sony projection television which is installed in one of the classrooms. This enables live demonstrations of both text and graphical output in lectures and tutorials, increasing the effectiveness of the teaching process.

## ATTENDANCE PATTERNS

A total of approximately 108 semester-hours of attendance at lectures and tutorials is required for the course. The 108 semester-hours may be taken according to one of four patterns:

- Six years on a part-time basis
- One year on a full-time basis, followed by four years on a part-time basis
- Two years on a full-time basis; followed by two years on a part-time basis
- Three years on a full-time basis

Attendance patterns are as follows:

**FULL TIME PROGRAM**

| | | | Hours per week | |
|---|---|---|---|---|
| | | | Autumn | Spring |
| **YEAR 1** | | | | |
| | 34100 | Algebra 1 | 4 | |
| | 34101 | Calculus 1 | 4 | |
| | 34107 | Computing 1 (& Laboratory) | 4 (3)* | |
| | | Electives | 6 | |
| | 34102 | Calculus 2 | | 4 |
| | 34214 | Algebra 2 | | 3 |
| | 34251 | Macro-Economic Models | | 3 |
| | 34141 | Statistics 1 | | 3 |
| | | Electives | | 5 |
| **YEAR 2** | | | | |
| | 34213 | Ordinary Differential Equations | 3 | |
| | 34212 | Vector Calculus | 3 | |
| | 34307 | Computing 2 (& Laboratory) | 2 (2)* | |
| | 34570 | Algebra 3 | 3 | |
| | 34480 | Introduction to Operations Research Models | 3 | |
| | | Electives | 4 | |
| | 33320 | Partial Differential Equations | | 3 |
| | 34419 | Complex Variables | | 3 |
| | 34342 | Statistics 2 | | 3 |
| | 34417 | Numerical Methods 1 | | 3 |
| | 34527 | Real Variables | | 3 |
| | | Electives | | 3 |
| **YEAR 3** | | | | |
| | | Major & Electives | | |

* The first number refers to the credit hours involved. The number in parentheses refers to the laboratory hours, which although compulsory, are not credited to the 108 semester-hours required for the degree.

## PART TIME PROGRAM

| | | | Hours per week Autumn | Spring |
|---|---|---|---|---|
| **YEAR 1** | | | | |
| | 34107 | Computing 1 (& Laboratory) | 4 (3)* | |
| | 34101 | Calculus 1 | 4 | |
| | 34100 | Algebra 1 | | 4 |
| | 34102 | Calculus 2 | | 4 |
| | | Electives | | 2 |
| **YEAR 2** | | | | |
| | 34214 | Algebra 2 | 3 | |
| | | Electives | 6 | |
| | 34251 | Macro-Economic Models | | 3 |
| | 34141 | Statistics 1 | | 3 |
| | | Electives | | 3 |
| **YEAR 3** | | | | |
| | 34212 | Vector Calculus | 3 | |
| | 34307 | Computing 2 (& Laboratory) | 2 (2)* | |
| | | Electives | 4 | |
| | 34213 | Ordinary Differential Equations | | 3 |
| | 34342 | Statistics 2 | | 3 |
| | 34480 | Introduction to Operations Research Models | | 3 |
| **YEAR 4** | | | | |
| | 33320 | Partial Differential Equations | 3 | |
| | 34527 | Real Variables | 3 | |
| | 34570 | Algebra 3 | 3 | |
| | 34417 | Numerical Methods 1 | | 3 |
| | 34419 | Complex Variables | | 3 |
| | | Electives | | 3 |
| **YEARS 5 & 6** | | | | |
| | | Major & Electives | | |

* The first number refers to the credit hours involved. The number in parentheses refers to the laboratory hours, which although compulsory, are not credited to the 108 semester hours required for the degree.

## MAJOR AREAS OF STUDY

Students are to choose one of the following as a major area of study: Operations Research, Statistics, Physical Applied Mathematics, or Modern Applied Mathematics. Students may in addition choose Computing to complete a double major.

## COMPUTING MAJOR

### FULL TIME PROGRAM

| | | | Hours per week Autumn | Spring |
|---|---|---|---|---|
| **YEAR 1** | | | | |
| | 34127 | Information Systems 1 | 3 | |
| | 34137 | Computer Systems 1 (& Laboratory) | 3 (2)* | |
| | 34117 | Commercial Computing 1 (& Laboratory | | 2 (2)* |
| | 34227 | Information Systems 2 | | 3 |
| **YEAR 2** | | | | |
| | 34217 | Commercial Computing 2 (& Laboratory) | 4 (3)* | |
| | 34407 | Computing 3 (& Laboratory) | | 3 (3)* |
| **YEAR 3** | | | | |
| | 34507 | Computing 4 (& Laboratory) | 3 (3)* | |
| | 34627 | Information Systems 3 | 3 | |
| | | Computing Elective | 3 | |
| | 34607 | Computing 5 (& Laboratory) | | 3 (3)* |
| | 34628 | Information Systems 4 (& Laboratory) | | 3 (3)* |
| | | Computing Elective | | 3 |

### PART TIME PROGRAM

| | | | | |
|---|---|---|---|---|
| **YEAR 1** | | | | |
| | 34117 | Commercial Computing 1 (& Laboratory) | | 2 (2)* |
| **YEAR 2** | | | | |
| | 34127 | Information Systems 1 | 3 | |
| | 34137 | Computer Systems 1 (& Laboratory) | 3 (2)* | |
| | 34227 | Information Systems 2 | | 3 |
| **YEAR 3** | | | | |
| | 34217 | Commercial Computing 2 (& Laboratory) | 4 (3)* | |
| **YEAR 4** | | | | |
| | 34407 | Computing 3 (& Laboratory) | | 3 (3)* |
| **YEARS 5 & 6** | | | | |
| | 34507 | Computing 4 (& Laboratory) | 3 (3)* | |
| | 34627 | Information Systems 3 | 3 | |
| | | Computing Elective | 3 | |
| | 34607 | Computing 5 (& Laboratory) | | 3 (3)* |
| | 34628 | Information Systems 4 (& Laboratory) | | 3 (3)* |
| | | Computing Elective | | 3 |

* The first number refers to the credit hours involved. The number in parentheses refers to the laboratory hours, which although compulsory are not credited to the 108 semester hours required for the degree.

## STATISTICS MAJOR

| | | Hours per week | |
|---|---|---|---|
| **YEAR 3** | **FULL TIME** | Autumn | Spring |
| **YEARS 5 & 6** | **PART TIME** | | |
| 34544 | Regression Analysis | 3 | |
| 34547 | Stochastic Processes | 3 | |
| 34642 | Statistics 3 | 3 | |
| 34545 | Design of Experiments | | 3 |
| 34343 | Theory of Probability | | 3 |
| 34548 | Industrial Statistics | | 3 |
| | Electives | 9 | 9 |

## OPERATIONS RESEARCH MAJOR

| | | | |
|---|---|---|---|
| **YEAR 3** | **FULL TIME** | | |
| **YEARS 5 & 6** | **PART TIME** | | |
| 34452 | Financial Modelling Techniques | 3 | |
| 34547 | Stochastic Processes | 3 | |
| 34630 | Simulation Techniques | 3 | |
| 34532 | Linear Programming | | 3 |
| 34636 | Decision Theory | | 3 |
| | OR Optimisation Elective | | 3 |
| | Electives | 9 | 9 |

## PHYSICAL APPLIED MATHEMATICS MAJOR

**YEAR 3** **FULL TIME**

| **YEARS 5 & 6** | **PART TIME** | Hours per week Autumn | Spring |
|---|---|---|---|
| 34621 | Mathematical Methods 1 | 3 | |
| 34418 | Numerical Methods 2 | 3 | |
| 34203 | Mechanics | 3 | |
| 34622 | Mathematical Methods 2 | | 3 |
| 34626 | Control Theory | | 3 |
| 34524 | Wave Theory | | 3 |
| | Electives | 9 | 9 |

## MODERN APPLIED MATHEMATICS MAJOR

**YEAR 3** **FULL TIME**

**YEARS 5 & 6** **PART TIME**

| | | | |
|---|---|---|---|
| 34528 | Modern Analysis | 3 | |
| 34571 | Algebra 4 | 3 | |
| 34572 | Fourier Analysis | 3 | |
| 34673 | Advanced Numerical Methods | | 3 |
| 34675 | Convexity and Optimisation | | 3 |
| 34677 | Integral Equations | | 3 |
| | Electives | 9 | 9 |

## ELECTIVES

There are 36 hours of electives (of which 30 hours are predetermined for students electing a Computing Major). These electives may be chosen from:

1. subjects from majors offered by the School of Mathematical Sciences other than a student's chosen major;
2. subjects offered by other Schools of the University; or
3. other electives offered by the School of Mathematical Sciences.

***Electives offered by this School:***

| | |
|---|---|
| 34418 | *Numerical Methods 2 |
| 34517 | *Commercial Computing 3 (& Laboratory) |
| 34531 | #Optimisation Techniques |
| 34553 | Multiple Regression Models |
| 34554 | Time Series Analysis |
| 34573 | History of Mathematics |
| 34633 | #Dynamic Optimisation |
| 34634 | #Network Optimisation |
| 34635 | Inventory Control |
| 34655 | Simultaneous Equation Models |
| 34667 | *Computer Graphics |
| 34668 | Computational Number Theory |
| 34681 | Special Applications in Operations Research |
| 34682 | *Special Applications in Computing (subject to the approval of Head of Unit) |
| 34683 | Special Applications in Statistics |
| 34684 | Special Applications in Physical Applied Mathematics |
| 34685 | Special Applications in Modern Applied Mathematics |
| 34691-7 | Project |
| 34699 | Seminar (Pascal) |

* Electives to be taken within the Computing Major (to be discussed with lecturer).

# Operations Research Optimisation Elective.

## SUB-MAJORS OFFERED BY THE DEPARTMENT OF PHYSICS

The Department of Physics offers three official sub-majors (A, B and C below) to Computing and Mathematics students.

Interested students should collect a more detailed handout "Sub-Majors in Physics for Mathematics and Computing Students", available from the Graduate Assistant, School of Physics and Materials in Room 1/1229. After perusing that handout, students may obtain further advice from:

Dr D Blair Room 1/1232 (ext. 9944).

### A. SUB-MAJOR IN PHYSICS (GENERAL)

This sub-major provides a grounding in general physics together with some advanced study in a specialised area selected by the student. The sub-major is of benefit to students contemplating a career in programming of scientific and engineering problems, applying mathematics to such problems, or high school teaching.

At least 18 semester hours are to be chosen as follows:*

| **Core subjects** | | | Semester hours |
|---|---|---|---|
| | 63211 | Physics 1 | 6 |
| | 63221 | Physics 2 | 6 |
| or | 63172 | Electricity and Magnetism | 3 |

**Elective subjects**

| | | | |
|---|---|---|---|
| | 63331 | Physics 3 | 4 |
| or | 63194 | Atomic Physics | 2 |
| | 63153 | Energy Technology | 3 |
| | 63366 | Nuclear Physics | 2 |
| | 63341 | Quantum Physics 1 | 3 |
| | 63332 | Electronics | 6 |
| | 63381 | Computational Analysis of Physical Data | 3 |

## B. SUB-MAJOR IN ELECTRONICS

This sub-major enables students, particularly Computing Science students, to complement their knowledge of software with a knowledge of hardware. It is useful to students contemplating a career in the area of microprocessors and computer interfacing.

At least 18 semester hours are to be chosen as follows:*

| **Core subjects** | | Semester hours |
|---|---|---|
| 63112 | Engineering Physics (Mechanical) | 6 |
| 63332 | Electronics | 6 |

**Elective subjects**

| | | |
|---|---|---|
| 63352 | Digital Electronics | 3 |
| 63342 | Principles of Instrumentation | 3 |
| 63361 | Microprocessors in Instrumentation | 3 |

## C. SUB-MAJOR IN ATOMIC AND NUCLEAR PHYSICS

This sub-major studies the principles governing the behaviour of matter at the microscopic level. The sub-major is useful for a career in programming of scientific and engineering problems, applying mathematics to such problems, or high school teaching.

At least 18 semester hours are to be chosen as follows:*

| **Core subjects** | | | Semester hours |
|---|---|---|---|
| | 63211 | Physics 1 | 6 |
| | 63172 | Electricity and Magnetism | 3 |
| | 63331 | Physics 3 | 4 |
| or | 63194 | Atomic Physics | 4 |
| | 63341 | Quantum Physics 1 | 3 |

**Elective subjects**

| | | |
|---|---|---|
| 63153 | Energy Technology | 3 |
| 63366 | Nuclear Physics | 2 |
| 63354 | Solid State Physics | 4 |

(Note: This sub-major replaces the sub-major in Atomic and Solid State Physics. Students who have started the older program should discuss their choice of subjects with the Department of Physics.)

* Where the Head, Department of Physics, considers that a student has a sufficiently strong background, he or she may enrol in an alternative sub-major program (in A, C, or in special circumstances B), covering somewhat more content in the same total number of semester hours.

# SUBJECT SYNOPSES

*33320* ***Partial Differential Equations***
Three semester hours
Prerequisite: 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.

*34100* ***Algebra 1***
Four semester hours

Complex numbers: de Moivre's theorem, Euler's formulae, loci in the Argand diagram. Polynomials. Systems of linear equations. Matrices and determinants: simple manipulative approach to eigenvalues and eigenvectors, diagonalisation; application to powers of a matrix, systems of linear difference equations. Vector Algebra and three dimensional coordinate geometry. Propositions and truth tables for conjunction, disjunction, negation, conditional, biconditional. Tautologies and contradictions. Logical equivalence and logical implication.

*34101* ***Calculus 1***
Four semester hours

Introduction to set theory. Limits and continuity. Differentiation. Mean-value theorem. Applications of differentiation. Integration. Fundamental theorem of calculus. Logarithm and exponential functions.

*34102* ***Calculus 2***
Four semester hours
Prerequisite: 34101 Calculus 1

Trigonometric and hyperbolic functions. Methods of integration. Applications of integration to areas, volumes and arc lengths. L'Hopital's rule. Improper integrals. Sequences and series. Tests for convergence. Power series. Maclaurin series.

*34107* ***Computing 1***
Four semester hours & three laboratory hours

Brief history of computing, algorithm analysis and flowcharting. Introduction to structured programming and design concepts (sequences, selection, loops). Techniques of programming, debugging and verification are introduced through the Pascal language. Areas covered include data types (simple, enumerated, arrays, sets and records) and declarations, input/output, control structures, procedures and functions (rules of scope), recursion, files. Strong emphasis is placed upon top-down modular design. Both mathematical and non-mathematical applications are presented and assessed.

*34117* ***Commercial Computing 1***
Two semester hours & two laboratory hours

Introduction to structured programming including elements and formal representation of program structure. An elementary course in batch-oriented COBOL incorporating sequential file processing, organisation and layout, divisions, simple environment division, data description and the data division (including condition name definitions). Procedure division: file manipulation (open, close, read, write), move, simple and iterative performs, arithmetic verbs, if statement and conditions. Data editing and report layout.

*34127* ***Information Systems 1***
Three semester hours

Concepts of information organisation. Discussion of system components and archetypes: systems and subsystems, the environment, interfaces, feedback loops, controlled and uncontrolled systems, batch and on-line systems. Organisational benefits of computer based systems including objectives, costs and risks. Batch, interactive and transaction processing. System development life-cycle, operational issues. Major applications of information systems emphasising common business data processing. Practical work will involve a simple accounting package.

*34137* ***Computer Systems 1***
Three semester hours & two laboratory hours

Binary arithmetic, data representation, hardware components, microprogramming. Machine instructions, addressing, introduction to assembly languages including simple programming applications. Tracing and debugging. Control structures, procedures, parameter passing, and associated machine level implementation. Operating systems, virtual machines. Compilers and interpreters. Linkers and loaders.

*34141* ***Statistics 1***
Three semester hours
Corequisite: 34102 Calculus 2

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

*34203* ***Mechanics***
Three semester hours
Prerequisites: 34213 Ordinary Differential Equations,
34212 Vector Calculus

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

*34212* ***Vector Calculus***
Three semester hours
Prerequisite: 34102 Calculus 2

Partial derivatives. Multiple integrals. Vector fields. Line and surface integrals. Integral theorems.

*34213* ***Ordinary Differential Equations***
Three semester hours
Prerequisite: 34102 Calculus 2

First order equations. Theory of linear equations. Use of auxiliary equation, undetermined coefficients and variation of constants. Laplace transforms. Power series methods. Singular points. Bessel and Legendre equations.

*34214* ***Algebra 2***
Three semester hours
Prerequisite: 34100 Algebra 1

Vector spaces. Subspaces. Basis and dimension. Euclidean spaces. Cauchy-Schwarz inequality. Orthogonality and orthonormal bases. Projection and Gram-Schmidt Process. Linear transformations and their matrix representations. Isomorphisms. Eigenvalues and eigenvectors. Diagonalisation. Quadratic forms and conic sections. Jordan Canonical form. Differential equations. Theorems of Gershgorin and Cayley-Hamilton.

*34217* ***Commercial Computing 2***
Four semester hours & three laboratory hours
Prerequisite: 34117 Commercial Computing 1,
34127 Information Systems 1

Elaboration of structured programming techniques. Continuation of COBOL including: conditions, data definition, representation and reference, tables, subscripts, indexing, perform ... varying verb, searching, sort and merge, file organizations and handling (sequential, indexed sequential, relative), report writer, declaratives, subprograms, copy and string processing verbs. Motivating case studies for this course include reporting, validation and update/maintenance programs.

*34227* ***Information Systems 2***
Three semester hours
Prerequisite: 34127 Information Systems 1

Organisational and timing concepts of mass storage devices (tapes and discs), including relevant modelling as practical work. Physical and logical file structures. Discussion of serial, sequential, indexed sequential and random file organisations, including the impact of these methods on timing, hit ratio, volatility, etc. Overflow handling for random files. Relevant experimental work is included. Aspects of security including physical aspects, breakpoint, recovery and backup, audit trails, etc.

*34251* ***Macro-Economic Models***
Three semester hours
Prerequisite: 34101 Calculus 1

Elementary theory of supply and demand is introduced. Dynamical models are developed by means of linear second order difference equations, which form the basic mathematical tool for the course. A simple dynamic macro-economic model consisting of an output and money market is then developed and the effects of various government stabilisation policies are investigated within the framework of the model. The main aim of the course is to introduce students to mathematical modelling in macro-economics.

*34307* ***Computing 2***
Two semester hours & two laboratory hours
Prerequisites: 34107 Computing 1,
34101 Calculus 1

Complete coverage of the ANSI standard of FORTRAN 77. Some emphasis is placed upon those features of FORTRAN 77 not present in earlier versions of the language, e.g. control structures, standardised file and character manipulation. Scientific applications including elementary numerical methods (quadrature, solution of nonlinear equations and systems of linear equations) are emphasised. Other applications, such as string manipulation, elementary sorting, are also covered.

*34342* ***Statistics 2***
Three semester hours
Prerequisite: 34141 Statistics 1

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

*34343* ***Theory of Probability***
Three semester hours
Corequisite: 34342 Statistics 2

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

*34407* ***Computing 3***
Three semester hours & three laboratory hours
Prerequisite: 34307 Computing 2

Dynamic data structures - stack, queue, list, tree, graph. Operations on and the use of these data structures for both iterative and recursive algorithms. Applications studied include searching (linear and binary) and sorting techniques (insertion, selection, bubble, shell, quicksort and heapsort) as well as text processing and hash addressing. Common operations such as traversal, insertion and deletion are covered in depth. The analysis of complexity and comparative performance of algorithms is introduced via best, worst and average case analyses.

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

Error analysis: discussion of the source and propagation of errors. Numerical linear algebra - Solution of linear equations: Gaussian elimination, pivoting, iterative methods. An introduction to the eigenvalue problem: power method. Solution of non-linear equations: fixed point and Newton's methods, analysis of convergence. Interpolation: Lagrangian, divided difference interpolation. Approximation of functions: Taylor series, method of least squares, orthogonal polynomials and economisation of power series. Numerical differentiation and quadrature: instability of numerical differentiation, Newton-Cotes and Gaussian integration, Richardson's extrapolation, analysis of convergence. Ordinary differential equations: series, Runge-Kutta, predictor-corrector techniques, analysis of convergence. This is substantially a methods course which requires the students to write a number of programs demonstrating the techniques described above.

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

Differential equations: boundary value problems (shooting method, finite difference techniques, analysis of convergence), finite difference methods, iterative methods (SOR algorithm). Numerical linear algebra - solution of linear equations using both direct and iterative techniques. The numerical eigenvalue problem: an analytic development of the algebraic eigenvalue problem with particular reference to normal matrices. Numerical techniques such as Jacobi's method and the QR decompositions are presented and analysed for convergence. The algorithm is implemented and numerous case studies examined.

*34419* ***Complex Variables***
Three semester hours
Prerequisites: 34102 Calculus 2,
34212 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.

*34452* ***Financial Modelling Techniques***
Three semester hours
Prerequisite: 34141 Statistics 1
34102 Calculus 2

Introduction of 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 under certainty, investment decisions under uncertainty; the debt-capacity decision; debt-maturity and timing decisions; dividend policy, internal financing and growth.

*34480* ***Introduction to Operations Research Models***
Three semester hours
Corequisite: 34141 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.

*34507* ***Computing 4***
Three semester hours & three laboratory hours
Prerequisite: 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 even 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 & three laboratory hours
Prerequisite: 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.

*34524* ***Wave Theory***
Three semester hours
Prerequisites: 34621 Mathematical Methods 1,
33320 Partial Differential Equations

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

*34527* ***Real Variables***
Three semester hours
Prerequisite: 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.

*34528* ***Modern Analysis***
Three semester hours
Prerequisite: 34527 Real Variables

Metric spaces. Completeness. Compactness. The fixed point theorem. Banach space. Linear mappings on a normed space. Hilbert space.

*34531* ***Optimisation Techniques***
Three semester hours
Prerequisites: 34532 Linear Programming,
34102 Calculus 2

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

*34532* ***Linear Programming***
Three semester hours
Prerequisite: 34480 Introduction to OR Models
Corequisite: 34214 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.

*34544* ***Regression Analysis***
Three semester hours
Prerequisite: 34342 Statistics 2

Simple linear regression. Multiple regression. Polynomial regression. General linear model. Multivariate normal distribution. Introduction to generalised linear models. Use of computer packages SAS, SPSS, MINITAB and GLIM.

*34545* ***Design of Experiments***
Three semester hours
Prerequisite: 34544 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.

*34547* ***Stochastic Processes***
Three semester hours
Prerequisite: 34342 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 process and renewal processes.

*34548* ***Industrial Statistics***
Three semester hours
Prerequisite: 34342 Statistics 2

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

*34553* ***Multiple Regression Models***
Three semester hours
Prerequisite: 34342 Statistics 2

Thorough study of the linear normal regression model including generalised least squares, nature and consequences of autocorrelation, dummy variables.

*34554* ***Time Series Analysis***
Three semester hours

Identification and estimation of univariate time series. Application of time series techniques to macro-economic forecasting.

*34570* ***Algebra 3***
Three semester hours
Prerequisites: 34214 Algebra 2,
34101 Calculus 1

Indexed sets, partitions, equivalence relations. Group theory: definitions, elementary properties, cosets and quotient groups, Lagrange's theorem. Ring Theory: definitions of rings and fields, subrings, ideals and quotient rings. Applications to polynomial fitting, finite differences.

*34571* ***Algebra 4***
Three semester hours
Prerequisite: 34570 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.

*34572* ***Fourier Analysis***
Three semester hours
Prerequisite: 34527 Real Variables

One-dimensional measure theory; the Lebesgue integral. Mean convergence. Convergence properties of Fourier series. Generalised Fourier series.

*34573* ***History of Mathematics***
Two semester hours

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

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.

*34621* ***Mathematical Methods 1***
Three semester hours
Prerequisites: 34419 Complex Variables,
34212 Vector Calculus
34213 Ordinary Differential Equations

Integral transforms. Green's functions. Integral equations. Asymptotic expansions. Introduction to calculus of variations.

*34622* ***Mathematical Methods 2***
Three semester hours
Prerequisite: 34621 Mathematical Methods 1

Vector integral theorems. Laplace's equation. Spherical harmonics. Legendre polynomials. Green's functions. Selected topics from mathematical physics.

*34626* ***Control Theory***
Three semester hours
Prerequisite: 34621 Mathematical Methods 1

Optimisation problems for dynamic systems. Pontryagin's maximum principle (heuristic derivation). Brief discussion of the second variation. Numerical solution of optimal control problem. Introduction to optimal filtering and prediction.

*34627* ***Information Systems 3***
Three semester hours & three laboratory hours
Prerequisites: 34227 Information Systems 2

The systems development lifecycle, tools for system and process representation, analysis of existing information systems, proposal formulation and feasibility analysis, logical and physical design, structured design, system implementation, project management.

*34628* ***Information Systems 4***
Three semester hours & three laboratory hours
Prerequisite: 34627 Information Systems 3

Database concepts and terminology. Logical data models: entities and attributes, entity/relation model, normalisation of data, data dictionaries. Database design philosophies: examination of the structure, performance and various commercial implementations of hierarchical, network and relational database models. DDL, DML and query facilities, 4GL's. Security and privacy considerations. Database administration. In order to consolidate the student's knowledge and appreciation of database systems a significant project is undertaken.

*34630* ***Simulation Techniques***
Three semester hours
Prerequisite: 34141 Statistics 1
Corequisite: 34307 Computing 2

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).

*34633* ***Dynamic Optimisation***
Three semester hours
Prerequisite: 34141 Statistics 1

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

*34634* ***Network Optimisation***
Three semester hours
Prerequisite: 34480 Introduction to Operations Research Models
Corequisite: 34532 Linear Programming

Applications of optimal network flows, shortest path, the max-flow min-cut theorem, Ford and Fulkerson's labelling method, relations to linear programming, the out-of-kilter algorithm, project management including Critical Path Method, PERT and consideration of project cost curves, applications of graph and network models to manpower planning, distribution systems, sequencing, communications.

*34635* ***Inventory Control***
Three semester hours
Corequisite: 34630 Simulation Techniques

Characterisation and development of optimal inventory policies for single-item and multi-inventory models. The determination problem. Determination of economic lot sizes. Survey of optimal policies, fixed multi-inventory models. The determination problem. Determination of economic lot sizes. Survey of optimal policies, fixed ordering and probabilistic review policies. Forecasting techniques including general exponential smoothing. Development and use of computer packages relevant to industrial and commercial situations.

*34636* ***Decision Theory***
Three semester hours
Prerequisite:34480 Introduction to Operations Research Models

Consideration of the general problem of decision making under risk and uncertainty. Bayesian decision analysis. Continuous prior distributions. Sampling. Utility. Game theory. Risk Analysis. Multiple objective decision making. Multiattribute utility.

*34642* ***Statistics 3***
Three semester hours
Prerequisite: 34342 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; mimax and Bayesian tests. Distribution Free Methods: estimation and hypothesis testing; further theory of inference.

*34644* ***Queueing Theory***
Three semester hours
Prerequisites: 34342 Statistics 2,
34630 Simulation Techniques

Basic techniques and models of queueing theory. Importance of the birth and death process. Random and Poisson arrivals and exponential service times. Special emphasis on the use of computer simulation.

*34655* ***Simultaneous Equation Models***
Three semester hours
Prerequisite: 34553 Multiple Regression Models

Identification and estimation of multiple input, multiple output models.

*34667* ***Computer Graphics***
Three semester hours & two laboratory hours
Corequisite: 34507 Computing 4

Hardware: capabilities of typical devices such as plotters and raster-scan devices. Elementary system software: point plotting and line drawing, transformations in two dimensions (scaling, translations, rotations), clipping and windowing. The design and implementation of a comprehensive two dimensional graphics package is used as a case study. Numerical algorithms for curve-drawing: interpolation, splines and contour graphs. Drawing in three dimensions: three dimensional transformations including perspective and coordinate systems. Hidden line routines. Standard software: available packages, introduction of standards.

*34668* ***Computational Number Theory***
Three semester hours
Prerequisite: 34307 Computing 2

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

*34673* ***Advanced Numerical Methods***
Three semester hours
Prerequisite: 34528 Modern Analysis

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

*34675* ***Convexity and Optimisation***
Three semester hours
Prerequisite: 34528 Modern Analysis

Geometric background; convex functions. Convexity in normed space. Hahn-Banach and Krein-Millman theorems.

*34677* ***Integral Equations***
Three semester hours
Prerequisite: 34528 Modern Analysis

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

*34681* ***Special Applications in Operations Research***
Three semester hours

*34682* ***Special Applications in Computing***
Three semester hours

*34683* ***Special Applications in Statistics***
Three semester hours

*34684* ***Special Applications in Physical Applied Mathematics***
Three semester hours

*34685* ***Special Applications in Modern Applied Mathematics***
Three semester hours

*34691-7* ***Project***
From one to seven semester hours

An investigation of a topic selected by the student with the approval of the Head of School or his designated representative. A formal report of the investigation must be submitted. Although this is a final year subject, consideration should be given to the selection of a topic during the preceding year.

*34698* ***Seminar***
Two semester hours

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.

*34699* ***Seminar (Pascal)***
Three semester hours

Pascal is a modern language with advanced data structuring facilities, program control statements and recursion. Structured design, programming and testing. Introduction to non-numeric (text) processing.

## INDEX