Faculty of Engineering and Information Technology

Contents

Faculty of Engineering and Information Technology

Dean: Professor Darrell Williamson, BE BSc ME *N'cle*, PhD *Harv*

Introduction

The Faculty of Engineering and Information Technology was established in 1993 and comprises the Department of Engineering and the Department of Computer Science.

The Faculty represents the commitment of the ANU to developments in engineering and information technology, and recognises the strength of the university's undergraduate and graduate programs in these disciplines. The Australian National University has a world-wide reputation in many fields including computing and engineering. Each of the two departments in the Faculty is a key participant in two Cooperative Research Centres funded jointly by the Australian Government and industry to carry out collaborative research.

Further information is available on the Faculty Web site: http://feit.anu.edu.au

Undergraduate Courses Offered

Degree course	*Usual course duration (yrs)*
Bachelor of Engineering	4
Bachelor of Software Engineering	4
Bachelor of Information Technology	3
Bachelor of Engineering/Bachelor of Science	5
Bachelor of Engineering/Bachelor of Information Technology	5
Bachelor of Engineering/Bachelor of Arts	5.5*
Bachelor of Asian Studies/Bachelor of Engineering	5.5*
Bachelor of Commerce/Bachelor of Engineering	5.5*
Bachelor of Engineering/Bachelor of Economics	5.5*
Bachelor of Commerce/Bachelor of Information Technology	4
Bachelor of Economics/Bachelor of Information Technology	4
Bachelor of Information Technology/Bachelor of Science (Forestry)	5

*may be completed in 5 years

Course Prerequisites

Bachelor of Engineering

ACT

(a) Advanced Mathematics Extended major/minor and Physics major or

(b) Advanced Mathematics Extended double major and Physics minor

NSW

(a) 3 unit Mathematics; and 2 unit Physics or 4 unit Science or

(b) 4 unit Mathematics and 3 unit Science

Bachelor of Information Technology

ACT

Satisfactory performance in a major in Advanced Mathematics

NSW

Satisfactory performance in 2 unit Mathematics

Bachelor of Software Engineering

ACT

Advanced Mathematics Extended major/minor

NSW

3 unit Mathematics

Bachelor of Engineering

(course code 4700)

Interdisciplinary Systems Engineering

The ANU Bachelor of Engineering degree course is a four-year, IEAust accredited undergraduate program that integrates selected areas of electrical and mechanical engineering with computer systems and engineering management to produce well-rounded and multi-skilled engineering professionals. The interdisciplinary systems engineering approach at ANU is underscored by technological trends which cut across boundaries between traditional disciplines of engineering and computer science.

Aims of the BE degree course

The aim of the BE degree course is to prepare students for successful careers as professional engineering managers, designers, analysts, educators and researchers.

Building on a foundation of basic science and engineering fundamentals, the four-year BE degree program in Interdisciplinary Systems Engineering focuses on:

- telecommunications systems
- manufacturing systems
- energy systems
- materials
- engineering management.

The program of study is the same for all students in the first three years, with specialisation opportunities in Year 4 through the selection of appropriate professional electives and project work.

It is the aim that the BE graduate: has a sound and broad knowledge of basic science and engineering; is able to communicate effectively with engineers and the general public; has the capacity to acquire in-depth discipline knowledge; is able to use common sense, scientific and engineering knowledge to identify, formulate and solve problems; is able to use a systems approach to engineering analysis, design, operation and management; is able to contribute to a multidisciplinary and multicultural team; is conscious of the social, cultural, global, environmental, legal and business aspects of en-

gineering, including a commitment to the principles of sustainable development; has an understanding of the responsibilities of an inclusive and socially aware engineering professional, including a commitment to the IEAust Code of Ethics, life-long learning and continuing professional development.

These attributes are engendered by: formal courses in basic science, engineering fundamentals, engineering management and law; final-year courses which introduce students to the cutting edge of selected disciplines; hands-on experience in the analysis, design and development of telecommunications, manufacturing, energy and management systems; final-year project work which is relevant to industry research, development, operations and management; emphasis in all units on the functions, goals and wider context of engineering; teaching and assessment processes which reflect the importance of written and oral communications, project and design work; small-group teaching that encourages collaborative learning and problem solving; group laboratory, analysis and design exercises; and a student seminar program.

Practical Experience
The Institution of Engineers, Australia (IEAust) specifies that students are required to complete at least 60 days of engineering work experience during the course through approved professional employment taken in the vacation periods. For details, see entry for ENGN4005 Practical Experience.

Bachelor of Engineering — course requirements

Year 1
ENGN1211 Discovering Engineering (6cp)
ENGN1212 Engineering Mathematics 1 (6cp) or MATH1013 or MATH1115
ENGN1213 Intro to Programming and Algorithms (6cp) or COMP1100
ENGN1214 Physics Fundamentals (6cp) or PHYS1001
ENGN1221 Electromechanical Technologies (6cp)
ENGN1222 Engineering Mathematics 2 (6cp) or MATH1014 or MATH1116
ENGN1223 Foundations of Software Engineering (6cp) or COMP1110
ENGN1225 Chemistry Fundamentals (3cp) or any 6 credit point 1000-series unit
ENGN1226 Modern Physics (3cp) or any 6 credit point 1000-series unit

Year 2
ENGN2211 Electronic Circuits and Devices (6cp)
ENGN2212 Engineering Mathematics 3 (6cp) or MATH2305 or MATH2405
ENGN2213 Computer Organisation (3cp) or COMP2300
ENGN2214 Mechanics of Materials (6cp)
ENGN2215 Introduction to Materials Science (3cp)
ENGN2221 System Dynamics (6cp)
ENGN2222 Thermal Energy Systems (6cp)
ENGN2223 Signals and Systems (6cp)
ENGN2224 Electronics (6cp)

Year 3
ENGN3211 Investment Decisions and Financial Systems (6cp) or COMM1020 or ASHY2012 or ASHY2014 or POLS1004 or ECHI1105 or ECHI1106
ENGN3212 Manufacturing Technologies (6cp)
ENGN3213 Digital Systems and Microprocessors (6cp)
ENGN3214 Telecommunications (6cp)
ENGN3221 Project and Operations Management (6cp)
ENGN3222 Manufacturing Systems (6cp)
ENGN3223 Control Systems (6cp)
ENGN3224 Energy Systems Engineering (6cp)

Year 4
ENGN4200 Individual Project (12cp)
ENGN4211 Engineering Law (3cp) or COMM1101 or ASHI2268 or POLS1002 or ECHI1105 or ECHI1106
ENGN4221 Systems Engineering Project (6cp)
ENGN4005 Practical Experience (0cp)

18 credit points selected from the engineering professional electives list (see Department of Engineering entry) and

9 credit points selected from the engineering professional electives list or from 3000-series or 4000-series units from any faculty.

The Bachelor of Engineering degree with Honours
Honours grades in the BE degree are awarded by the Faculty on the basis of a recommendation from the Head of Engineering and may be awarded with first class honours; second class honours, division A; or second class honours, division B.

The awarding of honours in engineering is based on meritorious performance over the entire four year program. The assessment of meritorious performance is based on the calculation of an average percentage mark (APM). The APM for Years 1, 2 and 3 respectively, is the average mark awarded in each ENGN1xxx, ENGN2xxx and ENGN3xxx unit. The APM for Year 4 is the average mark awarded in ENGN4211, ENGN4221 and in each completed unit from the engineering professional electives list.

The weighting factors 0.1, 0.2, 0.35 and 0.35 respectively, are used for the Years 1, 2, 3 and 4 APMs to give the overall APM.

The following table is indicative of the basis for the award of honours:

Overall APM	*Project Mark*	*Honours Award*
80%–100%	80%–100%	HI
70%–79%	70%–79%	H2A
60%–69%	60%–69%	H2B

Bachelor of Information Technology

(course code 3701)

The Bachelor of Information Technology is a three-year degree that prepares graduates to enter the computing industry work force as novice practitioners to develop software or to apply computing in human organisations. The graduate attains the technical knowledge of fundamentals of computer systems, programming languages, computer systems, computer applications, and information systems. The computing industry has always been subject to very rapid change, and so we also aim to prepare graduates to meet the changes in practice and in technology that will be met during their working careers. The graduate can enter the fields of software development and support, information systems development and support, or many other broad areas of choice in computing or general industry.

The BInfTech degree is organised to allow a flexible choice between an Information Systems stream and a Software Development stream. Both streams are founded on an introduction to computer programming, a broad perspective on the computing discipline and profession, and an introduction to the functional structure of computers. Both also require at least 18 credit points of mathematics, which is a means of developing the ability to work with abstractions, a fundamental requirement for understanding and applying ideas in computing.

In later years of the course, students can choose the Software Development stream, to develop the conceptual and practical skills for software development and the technology of computer systems, or the Information Systems stream to develop understanding of organisations, the management of computer systems applications in them, and the accompanying systems analysis and design.

Course requirements

The degree requires the completion of 144cp of units offered, or approved by, the Faculty of Engineering and Information Technology, including:

(a) completion of 90cp of IT units (including the IT units from Schedule 1 and the IT units from a major chosen from Schedule 2), comprising a total of:

- 18cp of 1000-series IT units, and
- 24cp of 2000-series IT units, and
- 42cp of 3000/4000-series IT units, and
- a further 6cp of IT units;

(b) completion of 18cp of mathematics-related units, including the mathematics units from Schedule 1 and 6cp of later year MATH/STAT/EMET units;

(c) completion of a further 12cp of 2000/3000/4000-series IT units;

(d) completion of a further 24cp of units offered within the university, including the non-IT units listed under the chosen major from Schedule 2;

(e) no more than 60cp of 1000-series units may be included.

IT units are:
COMP units
INFS units
ENGN1211 Discovering Engineering
ENGN3213 Digital Systems and Microprocessors
ENGN3214 Telecommunications

Schedule 1

COMP1100 Introduction to Programming and Algorithms
COMP1200 Perspectives on Computing or ENGN1211 Discovering Engineering
COMP1110 Foundations of Software Engineering
COMP2300 Introduction to Computer Systems
COMP3110 Software Analysis and Design
MATH1003 Mathematical Modelling 1 or MATH1013 Mathematics and Applications 1 or STAT1006 Quantitative Methods for Business and Economics 1
MATH1005 Mathematical Modelling 2 or MATH1014 Mathematics and Applications 2

Schedule 2

Information Systems

COMP2400 Relational Databases
INFS2024 Information Systems Analysis
INFS3024 Information Systems Management
COMM1101 Introduction to Commercial Law
12cp from:

a) COMM1010 Financial Accounting Fundamentals and COMM1020 Accounting and Financial Management
b) ECON1001 Economics 1
c) ECHI1005 Business and Economy in the Asia-Pacific Region and ECHI1006 Australian Economy

Software Development

COMP2100 Software Construction
COMP2110 Software Design
COMP3100 Software Engineering Group Project
COMM1010 Financial Accounting Fundamentals or ENGN3211 Investment Decisions and Financial Systems

The BInfTech with Honours

The BInfTech degree with honours requires an additional year of study after the pass degree of BInfTech. Admission is by invitation based on performance in your best 36 credit points of 2000 and 3000 series Information Technology and Mathematics units and generally requires an average performance at better than Credit level. The honours program includes advanced coursework and a major individual project worth 50% of the year. Honours grades are awarded on the result of the whole year's work.

BInfTech (3701:SD) possible enrolment pattern

	First semester	*Second semester*
Year 1	COMP1100 Introduction to Programming and Algorithms COMP1200 Perspectives on Computing MATH1003 Mathematical Modelling 1 COMM1010 Financial Accounting Fundamentals	COMP1110 Foundations of Software Engineering COMP2400 Relational Databases MATH1005 Mathematical Modelling 2 1000-elective (6cp)
Year 2	COMP2100 Software Construction COMP2300 Intro to Computer Systems 2000-series MATH/STAT/EMET 1000-elective (6cp)	COMP2110 Software Design 2000/3000/4000-series IT (12cp) 2000-elective (6cp)
Year 3	COMP3100 SE Group Project COMP3110 Software Analysis and Design 3000/4000-series IT (12cp) [1]	COMP3100 SE Group Project 3000/4000-series IT (12cp) [1] 2000/3000/4000-series IT (6cp)

[1] Some 3000/4000-series IT electives may have specific prerequisites that are not covered by the units specified in the table.

BInfTech (3701: IS) possible enrolment pattern

	First semester	*Second semester*
Year 1	COMP1100 Introduction to Programming and Algorithms COMP1200 Perspectives on Computing MATH1003 Mathematical Modelling 1 1000-elective (6cp) [1]	COMP1110 Foundations of Software Engineering COMP2400 Relational Databases MATH1005 Mathematical Modelling 2 1000-elective (6cp) [1]
Year 2	COMP2100 Software Construction COMP2300 Intro to Computer Systems 2000-series MATH/STAT/EMET 2000-elective (6cp)	INFS2024 Information Systems Analysis COMM1101 Intro to Commercial Law 2000/3000/4000-series IT (12cp)
Year 3	INFS3024 Information Systems Management COMP3110 Software Analysis and Design 3000/4000-series IT (12cp) [2]	3000/4000-series IT (18cp) [2] 2000/3000/4000-series IT (6cp)

[1] 1000-electives to be chosen from one of the following 12cp options: COMM1010/1020 or ECON1001 or ECHI1005/1006.
[2] Some 3000/4000-series IT electives may have specific prerequisites that are not covered by the units specified in the table.

Bachelor of Software Engineering

(course code 4708)

The Bachelor of Software Engineering is a four year degree which will be accredited by the Institution of Engineers, Australia. The course emphasises the development of professional skills in the technical area of software engineering, that is, the systematic application of analysis, design, and construction techniques for computer systems and applications.

The computing industry has grown very rapidly in the last 40 years, despite a widely acknowledged, continual state of crisis in our abilities to manage reliably the process of developing software. The need for a mixture of technical computing knowledge with the skills of the computer programmer, and the disciplined organisation and judgement of the professional engineer, has been seen as desirable for many years.

The introduction of the Bachelor of Software Engineering degree in 1999 was aimed to meet this need.

The BSEng graduate will acquire technical knowledge of the fundamentals of computer systems, programming languages, and the mathematical foundations of algorithms and data structures that are required to establish reliability and safety in software. Technical knowledge is honed by a selection of advanced technical topics. The principles and practices of the design and implementation of software are built up in a sequence of units combining theoretical study and practical laboratory exercises, individual projects, and group projects. Of no less importance is an introduction to the professional skills of a competent engineer: management, communication with others and teamworking in particular, and ethical and other responsibilities. Graduates will also build their own skills of individual software development in university studies and in practical work experience which is required during the course, and will learn a systems approach developed and exemplified in individual and group project work.

Mathematics is an essential component of the degree for developing the languages and ability for abstraction that is the core of the computing discipline, and to allow rigorous formal description of aspects of the software engineering process. Discrete mathematics also has significant applications in the modelling and rigorous description of software properties, computing processes and programming languages.

The best computing professionals are informed by knowledge of a wider field than computing alone. The course includes the choice of a major line of study in another discipline in the university which can broaden the understanding of the social and cultural responsibilities of the software engineer, and strengthen the ability to communicate with others, or may be used to specialise in further fundamental sciences, or in specialised engineering streams. Both develop the capacity for lifelong

learning by exposure to a broader range of ways of studying at university level.

Course requirements
The BSEng degree requires completion of 192 credit points including

(a) completion of 111cp of core BSEng units as follows:
COMP1100 Introduction to Programming and Algorithms
COMP1110 Foundations of Software Engineering
COMP2100 Software Construction
COMP2200 Technical Communication and Professional Context or
ENGN1211 Discovering Engineering
COMP2300 Introduction to Computer Systems
COMP2310 Concurrent and Distributed Systems
COMP2400 Relational Databases
COMP2600 Formal Methods in Software Engineering
COMP3100 Software Engineering Group Project
COMP3110 Software Analysis and Design
COMP3600 Algorithms
COMP4510 Individual Project Part I
COMP4520 Individual Project Part II
COMP1800, COMP2800, COMP3800 Art and Science of Computing I, II, III
COMP4800 Industrial Experience
ENGN3211 Investment Decisions and Financial Systems
ENGN4211 Engineering Law
MATH1013 Mathematics and Applications 1 or
MATH1115 Mathematics and Applications 1 Honours
MATH1014 Mathematics and Applications 2 or
MATH1116 Mathematics and Applications 2 Honours;

(b) completion of a further 33cp of Information Technology units, with at least 15cp of 4000-series units, selected from Tables A, B and C as follows:
- 18cp from Table A
- 9cp from Table B
- 6cp from Table C;

(c) completion of 2000-series mathematics units to the value of 6 credit points;

(d) completion of further Science or Engineering units to the value of 12cp, excluding those offered by Computer Science;

(e) completion of a further 30cp of units taken entirely in one Department, Division or School of the University, including at least 6cp of 3000- or 4000-series units;

(f) no more than 60cp of 1000-series units may be included.

IT units are COMP and INFS units, ENGN3213, ENGN3214.

Table A refers to Software Engineering units, Table B refers to Foundation units, Table C refers to Design units. The contents of Tables A, B and C may be changed from time to time.

Table A
COMP3120 Managing Software Development
COMP4100 Software Quality Management
COMP4110 Software Process

Table B
COMP3300 Operating Systems Implementation
COMP3310 Computer Networks
COMP3320 High Performance Scientific Computation
COMP3400 Internet, Intranet and Document Systems
COMP3410 Information Technology in Electronic Commerce
COMP3420 Database Systems
COMP3610 Principles of Programming Languages
COMP3700 Topics in Software Engineering I
COMP3710 Topics in Computer Science
COMP4120 Component-based Software Development
COMP4200 Milestone Papers in Computing
COMP4210 Usability and Design of the Human-Computer Interface
COMP4300 Parallel Systems
COMP4400 Advanced Databases
COMP4410 Document Technologies
COMP4420 Networked Scientific Data Analysis and Presentation
COMP4600 Advanced Algorithms
COMP4610 Computer Graphics
COMP4620 Machine Learning and Data Mining
COMP4630 Applications of Logic in Computing
COMP4700 Topics in Software Engineering II
COMP4710 Topics in Software Engineering III

Table C
COMP2110 Software Design

Bachelor of Software Engineering with Honours
Honours grades in the BSEng will be awarded on the basis of merit.

BSEng (4708) possible enrolment pattern

	First semester	*Second semester*
Year 1	COMP1100 Introduction to Programming and Algorithms MATH1013 Mathematics and Applications 1 ENGN1211 Discovering Engineering COMP1800 Art and Science of Computing I 1000-elective	COMP1110 Foundations of Software Engineering MATH1014 Mathematics and Applications 2 COMP2400 Relational Databases COMP1800 Art and Science of Computing I 1000-elective
Year 2	COMP2100 Software Construction COMP2300 Introduction to Computer Systems COMP2800 Art and Science of Computing II 2000-series MATH 2000-elective	COMP2110 Software Design COMP2310 Concurrent and Distributed Systems COMP2800 Art and Science of Computing II COMP2600 Formal Methods in Software Engineering 2000-elective
Year 3	COMP3100 SE Group Project COMP3110 Software Analysis and Design ENGN3211 Investment Decisions and Financial Systems COMP3800 Art and Science of Computing III Science/Engn elective	COMP3100 SE Group Project COMP3120 Managing Software Development COMP3600 Algorithms COMP3800 Art and Science of Computing III Science/Engn elective
Year 4	COMP4510 Individual Project Part I (6cp) COMP4100 Software Quality Management ENGN4211 Engineering Law 3000/4000-series IT (3cp) [1] 3000-elective (6cp)	COMP4520 Individual Project Part II (12cp) COMP4110 Software Process 3000/4000-series IT (6cp) [1]

[1] units to be selected from Table B. Please note that some 3000/4000-series IT electives may have specific prerequisites that are not covered by the units specified in the table.

BSEng engineering elective options
The Bachelor of Software Engineering (BSEng) program provides for students to choose: (a) 12cp Science or Engineering; (b) 30cp of units (which must include at least 6cp at 3000-series level). The following suggestions are highlighted for BSEng students who want to consider engineering-related areas:

Telecommunications
ENGN1214, ENGN1221, ENGN2211, ENGN2223, ENGN3214, ENGN4504, ENGN4512, ENGN4542, ENGN4543, ENGN4513

Robotics and Computer Vision
ENGN1214, ENGN1221, ENGN2211, ENGN2223, ENGN3213, ENGN3223, and choose 6cp from ENGN4509, ENGN4527, ENGN4528

Manufacturing and Computational Engineering
ENGN1214, ENGN1221, ENGN2214, ENGN2221, ENGN3212, ENGN3222, ENGN4515, ENGN4518 (or, with permission, ENGN4520)

Electronics and Semiconductors
ENGN1214, ENGN1221, ENGN2211, ENGN2224, ENGN3213, ENGN4506, ENGN4507, ENGN4519, and, with permission, ENGN4520.

BSEng students who are pursuing elective interests outside the Faculty of Engineering and Information Technology are advised to consult the relevant section of the ANU Undergraduate Handbook and the relevant Sub-Dean or Departmental course advisor.

Accreditation
The Bachelor of Engineering degree is accredited to the appropriate level by the Institution of Engineers, Australia (IEAust). The Bachelor of Software Engineering degree has been submitted for accreditation with IEAust and the Australian Computer Society.

All students who complete the BInfTech degree are eligible for associate membership of the Australian Computer Society.

Combined Courses
Detailed information about courses combined with the Bachelor of Engineering or the Bachelor of Information Technology degrees is provided in the Combined Courses section of this Handbook.

Note that there are no combined courses with the Bachelor of Software Engineering.

Status
Status towards undergraduate degree courses of the Faculty may be granted for studies completed elsewhere. Requests for status are assessed individually.

Computer Science

C.W. Johnson, BSc *Monash*, PhD *ANU*
Senior Lecturer and Head of Department

How do people understand and use computers? The subject matter of the computing discipline has many names, including software engineering, computer science, informatics, information systems, information technology, and computer programming. The discipline is only young, and the nature of the subject has been debated many times since the first electronic computers and the foundation of the first professional association in 1947. The nature of the discipline has changed in that time from a focus on computer hardware in a very small number of uniquely designed computers, and the highly specialised mathematical algorithms that were programmed into them, to the graphically interfaced, largely non-numerical, general purpose commodity computing of today's information technology industry. The focus of that industry has shifted from details of interaction with computers to the breadth of interaction with people, and so has the computing discipline broadened to include the ways in which its professional graduates apply computing to the information needs of organisations and individuals.

Information Technology is the common global term which covers all aspects of computing, data storage, and communications — the generality of equipment, systems and services that involve the use of computers, advanced telecommunications, and digital electronics. The IT industry is now reckoned to be the world's largest. Although the Department's name continues to refer to "Computer Science," it is a centre for the study of wider aspects of IT: software engineering, which is the profession of designing and constructing complex groups of programs; information systems, which involves the ways in which computer systems are meshed with organisations; as well as computer science, the systematic study of the fundamental algorithms and processes behind the technology. The department provides professional, technical, and service courses in these areas and introductory information technology for students in many areas of the university.

Department Aims and Objectives

The Department aims to produce graduates with a professional education in Software Engineering and a four year professional Software Engineering degree course has been offered since 1999. This includes technical, professional, communications skills, individual and group project work on a sound basis of mathematics and computer science. A pass degree or a degree with honours can be awarded after four years of study. The Faculty plans to gain professional accreditation for this course from the Institution of Engineers, Australia, as an engineering degree.

The Faculty also offers a three-year technical and professional degree course, the Bachelor of Information Technology, in combination with the Faculty of Economics and Commerce. BInfTech students can choose to specialise in a software development stream or an information systems stream. The BInfTech course can also be combined with courses in Commerce or with Economics for a four year combined degree program which aims to provide a professional, business-oriented education. It can be combined with the Bachelor of Engineering course for five years of study that includes more computing within a full multidisciplinary Engineering degree. It is also possible to combine the BInfTech course with the BSc (Forestry) degree.

Many of the same computer science and software development units can be taken within the more generalist Bachelor of Science degree. Students can thereby combine study of a Science subject with as much computing as they wish. The specialised Bachelor of Computational Science degree combines several of these units with mathematics.

A fourth year of honours study can be added to the BSc and the BInfTech. In all of these degrees, the Department aims to produce first class honours graduates who can enter postgraduate studies at leading international computer science laboratories. A Graduate Diploma in IT for Science graduates with little computing background is also available.

The Department has an active research program and educates Master of Philosophy and PhD students by research.

Introductory units

The Department offers several units that can be taken by students with no previous background in computing or information technology. COMP1900 is an information technology service unit offered to students in other faculties, which provides a university-level introduction to applied computing for students in any area who wish to use computers in their studies or their careers but do not necessarily need to study computer programming. COMP1200 provides a broad perspective on the field of computing for those with a deeper interest in the underlying science and technology, and it is a required part of the Information Technology degrees. COMP2200 introduces the communication skills and other professional background for the Software Engineering degree.

COMP1100 provides an introduction to computer programming, both as a service course and as a foundation for all further studies in information technology. It requires a prerequisite of secondary college advanced mathematics, but does not require any previous computing experience. COMP1110 provides further study of programming and software engineering, consolidating the study of constructing larger programs. It leads to further software development and software engineering studies.

COMP2400 can also be taken in first year, following COMP1100. It provides an introduction to the use of

databases and to their underlying technology. This unit can be used as part of a major in Commerce as well as contributing to Information Technology and Software Engineering degrees.

Further Information

Further information on the units offered and the structures of the courses is available from the Department's World Wide Web site, at http://cs.anu.edu.au.

UNIT DETAILS

Introduction to Programming and Algorithms COMP1100 (6cp) Group A

First semester
Thirty one-hour lectures. twelve two-hour tutorial/laboratory sessions.

Prerequisites: ACT Advanced maths major or NSW 2 unit maths or equivalent.

Incompatible with COMP1011, ENGN1002, ENGN1213

Syllabus: This unit is an introduction to the basic principles of programming from an object-oriented perspective. These principles are applied in a study of straightforward algorithms for searching and sorting. It provides a foundation for studies in computer science, information systems and software engineering. The following topics are covered: basic concepts of programming (data types, assignment, control structures, the procedural abstraction), basic concepts of object-oriented programming in Eiffel (class, object, attributes, rountines), the basic Eiffel library classes, straightforward algorithms for search and searching, object-oriented methods (class inheritance, assertions on rountines, design by contract). The unit has a strong practical emphasis, with required attendance at laboratory sessions.

Foundations of Software Engineering COMP1110 (6cp) Group A

Second semester
Twenty-six one-hour lectures and twelve two-hour tutorial/laboratory sessions

Prerequisites: COMP1100 or COMP1011

Incompatible with COMP2031, ENGN2003, ENGN1223

Syllabus: This unit introduces students to the tools and techniques for developing software systems of a size and quality of an industrially relevant nature. The unit teaches the fundamental strategies of abstraction, decomposition and reuse as methods for constructing such systems. Verification and validation techniques, with an emphasis on testing, are taught as a means to ensure that students are able to deliver software products of the quality required. In particular, the unit will cover: foundations and use of recursive algorithms in problem solving; structured data types, abstract data types and their applications; system life-cycle, modularisation, and construction of large systems. The unit will also introduce some of the theoretical fundamentals that underpin software engineering, including: logic and its application to specifications, and finite state automata.

Perspectives on Computing COMP1200 (6cp) Group A

First semester
Thirty one-hour lectures, twelve two-hour tutorial and laboratory sessions.

Prerequisites: none

Syllabus: This unit presents the important concepts in the computing discipline and places them in context, in order to introduce the nature of the computing profession and the education of a computing professional.

The unit covers the following topics, through case studies. Abstractions and the user view: the interactive machine, the stored-program machine, data, programming languages and virtual machines, computational objects. Applications of computer systems: personal computation, application software, information systems, knowledge-based systems, real-time control. Computer systems and their environment: the personal computer, networked computers and concurrency, the world-wide web. The nature of the computing discipline: mathematical theory, scientific experimentation and engineering design. Professional issues: the engineering of software systems, the client focus, professional ethics. Educational issues: curriculum issues, the ANU experience.

Art and Science of Computing I COMP1800 (0cp)

Full Year
About eight sessions of occasional seminars.

Prerequisites: Enrolment in BSEng or approval of Head of Department

Syllabus: The Art and Science of Computing I is a seminar-style program. It consists of about 4 events per semester, such as seminars from visiting or staff academics, or discussion or debate sessions on topical subjects. Other sessions might include learning and studying skills, talks from industry representatives, department and unit overviews, hot topics, and surveys. It aims to involve staff and students in debate on computing issues. Some sessions will be led by staff from areas such as the library, counselling, study skills, and other university resource centres.

Introduction to Information Technology Applications COMP1900 (6cp) Group A

First semester (may be offered in second semester also)

Twenty one-hour lectures, and six two-hour assessable laboratory sessions; plus one laboratory session for marking group project

Prerequisites: Not available to students enrolled in BInfTech or BSEng. Cannot be taken after successful completion of COMP1011, COMP1100 or INFS1014.

Syllabus: An introduction to the basic concepts and skills of computer literacy through modern applied information technology. Good data management and practices using files and folders; word processing using styles; data manipulation and display using spreadsheets; World Wide Web information searching; simple web site construction. Practical work will be done in supervised computer laboratory sessions.

Software Construction COMP2100 (6cp) Group B

First semester
Twenty-six one-hour lectures and twelve two-hour tutorial and laboratory sessions

Prerequisites: COMP1110 or COMP2031, and 12 credit points of 1000-level mathematics or mathematical statistics units including MATH1014 or MATH1005

Syllabus: This unit is about the implementation and test phases of the software construction process. It is based around an individual project lasting the whole semester. In this project, students build a substantial application, relevant to their experience as computer users. The project is closely specified, and involves a graphical user interface. During the semester, students follow part (or all) of the Personal Software Process, learning time-management, planning, and quality control.

The following topics are covered: programming to precise specifications; the implementation milieu (configuration control, programming standards, documentation standards, literate programming, use of integrated programming environments); code review and inspections; test planning and procedures (derived from specification and design documents); object-oriented (Eiffel), procedural (C), and scripting (Bash) languages; GUI interfaces; the Personal Software Process.

Software Design COMP2110 (6cp) Group B

Second semester
Thirty one-hour lectures and twelve two-hour tutorial and laboratory sessions.

Prerequisites: COMP1110 or COMP2031, and 12 credit points of 1000-level mathematics or mathematical statistics units including MATH1014 or MATH1005.

Incompatible with COMP2038

Syllabus: This unit is one of three units (COMP2100, COMP2110, COMP3110) which address constructive aspects of the software development process. It has a primary focus on the design phase.

The following topics are covered. Designing to specifications (ab initio design) and design recovery from source code (reverse engineering). The design milieu (notations, documentation standards, configuration control). Design techniques (structured, object-oriented, software architectures, design patterns). Design review and inspections. Design in the context of requirements change. Design metrics.

Technical Communication and Professional Context COMP2200 (6cp) [Not grouped for BSc]

First semester (will not be offered in 2001)
Twenty four lectures, twelve two hour design classes, and twelve tutorials

Prerequisites: Enrolment in BSEng or permission of Head of Department.

Incompatible with ENGN1211, SCOM1001

Syllabus: About one third of this unit is dedicated to technical communication (verbal and written) for computing professionals. The purpose is to equip students with the necessary skills to communicate technical information to customers and colleagues with the necessary clarity and simplicity.

The unit will also cover the various social and ethical responsibilities of the computing professional. These include professional ethics, concern for information security and privacy, whistle-blowing, the role of professional societies, social responsibilities, knowing one's own limitations, the continuity of professional advancement, the role of the professional in educating society, and technical consultancy in public policy issues.

Legal issues will form a third focus of the unit, including risks and liabilities and intellectual property.

Introduction to Computer Systems COMP2300 (6cp) Group B

First semester
Thirty one-hour lectures and nine two-hour laboratory/tutorial sessions.

Prerequisites: COMP1110 or COMP1011; and 6 credit points of 1000-level MATH, STAT, EMET units.

Incompatible with COMP1012.

Syllabus: An introduction to the hardware and software components of a modern computer system. Comparisons of different types of instructions sets and corresponding addressing modes. Emphasis on the relationships among instruction sets, fetch and execute

operations, and the underlying architecture. Introduction to the concept of interrupts, as well as the purpose and specifications of a control unit with respect to logic operations. Consideration of the physical implementation of large memory systems, together with the techniques of data storage and checking. Overall concepts of virtual memory, operating system functions, file systems and networks.

Virtual machines and the levels of machine organisation, the assembly and linking process and software libraries.

Concurrent and Distributed Systems — COMP2310 (6cp) Group B

Second semester
Thirty one-hour lectures, nine one-hour tutorials/laboratory sessions.

Prerequisites: COMP2100 or COMP2300 or COMP2031; 12 credit points of 1000-level mathematics or mathematical statistics units.

Incompatible with COMP2029, COMP2032

Syllabus: This unit is concerned with the issues that arise when computational processes are supported in a computer system. The scope is broad enough to include discussion of all the layers of a computer system — from the hardware to large information systems applications, and all sizes of computer system — from systems as small as a single processor, to systems as large as the entire Internet. The principal areas of study are processes and process coordination, concurrency support in operating systems and high level languages, and distributed systems. The following topics are addressed: operating system structure, process management, interaction between system components (processes, devices and processors), mutual exclusion, concurrent programming, semaphores and monitors, inter-process communication, distributed systems, crash resilience and persistent data, deadlock, transaction processing.

Relational Databases — COMP2400 (6cp) Group B

Second semester
Thirty one-hour lectures and six two-hour laboratory/tutorial sessions

Prerequisites: COMP1100 or COMP1011; and 6 credit points of 1000-level mathematics or mathematical statistics units.

Incompatible with INFS2051, INFS3055

Syllabus: Introduction to the basic goals, functions, models, components, applications, and social impact of database systems applications. The unit introduces the relational model and the database query language SQL. Entity-Relationship Diagrams are introduced as a tool for conceptual modeling. Effective mapping of a conceptual model to a relational schema requires some appreciation of role of integrity constraints, and the impact of DBMS access schemes and query optimisation techniques.

Formal Methods in Software Engineering — COMP2600 (6cp) Group B

Second semester
Thirty one-hour lectures, eight one-hour tutorials and four two-hour laboratory sessions.

Prerequisites: COMP1110 and 12 credit points of 1000-level mathematics or mathematical statistics including MATH1005 or MATH1014.

Incompatible with COMP1013.

Syllabus: This course presents some formal notations that are commonly used for the description of computation and of computing systems, for the specification of software and for mathematically rigorous arguments about program properties.

The following areas of study constitute the backbone of the unit. Predicate calculus and natural deduction, inductive definitions of data types as a basis for recursive functions and structural induction, formal language theory (particularly regular expressions, finite state machines and context free grammars), propositional programming language semantics and partial correctness, weakest preconditions and total correctness.

Art and Science of Computing II — COMP2800 (0cp)

Annual
About eight sessions of occasional seminars.

Prerequisites: COMP1800 and enrolment in BSEng or approval of Head of Department.

Syllabus: The Art and Science of Computing II is a seminar-style program. It consists of about 4 events per semester, such as seminars from visiting or staff academics, or discussion or debate sessions on topical subjects. Other sessions might include talks from industry representatives, department and unit overviews, hot topics and surveys. It aims to involve staff and students in debate on computing issues.

As for COMP1800 except that events in Art and Science of Computing II will be targeted to those students in second year.

Software Engineering Group Project — COMP3100 (12cp) Group C

Annual
Fifty one-hour lectures and 300 hours of group project work.

Prerequisites: 24 credit points of 2000-level COMP units including COMP2100, and COMP2110, and 6 credit points of 2000-level MATH or STAT or EMET units.

Incompatible with COMP3018.

Co-requisites: COMP3110.

Syllabus: This unit provides the student with project experience to complement the studies of the software development process in units COMP2100, COMP2110, COMP3110 and COMP3120.

Students work in small groups and participate in all the development phases (requirements analysis, design, construction, testing and documentation) of a nontrivial software system. As well, each group has to address the control of the development process by constructing and following a detailed software development management plan.

Software Analysis and Design COMP3110 (6cp) Group C

First semester
Thirty one-hour lectures and four or five two-hour laboratory sessions.

Prerequisites: 12 credit points of 2000-level COMP or INFS units including at least one of COMP2110, COMP2038, COMP2400, INFS2051 and INFS3055, and 12 credit points of 1000-level MATH or STAT units.

Incompatible with INFS2047, INFS2048, INFS3047, INFS3048.

Syllabus: This unit is one of three units (COMP2100, COMP2110, COMP3110) which address constructive aspects of the software development process. It has a primary focus on the software requirements and design phases. This unit provides a practical introduction to requirements analysis methods and design specification techniques that are either structured or object-oriented. The essential rationale for the requisite components of a number of such methods will be taught together with some techniques for their application. As always, the emphasis of applying any such method is to create, from a set of original requirements, a semi-formal representation or model of a system software specification that is unambiguous, consistent and understandable. The various techniques for achievement of such requirements and specifications often seem straight forward and even conceptually simple. However, despite the apparent simplicity of a technique, students will discover that a good deal of effort and diligence is required to produce accurate, meaningful, understandable and easily maintainable specifications. Software system requirements specifications are essential for creating and trading-off design specification alternatives. There are several representations available for specifying a software design. Some of these will be discussed and applied including some very recent approaches to design that allow for the inclusion of multiple architectural alternatives and simple verification. The latest design techniques place appropriate emphasis on accurate, semi-formal models, transformation rules and direct code generation. Whenever appropriate, computer-aided modeling tools will be used to reinforce the various concepts that are covered theoretically.

Managing Software Development COMP3120 (6cp) Group C

Second semester
Thirty one-hour lectures and five two-hour laboratory sessions.

Prerequisites: COMP3110, INFS2047 or INFS3047, and 6 credit points of 2000-level MATH or STAT or EMET units.

Syllabus: This unit addresses the control of the software development process. It is a companion unit to COMP2100, COMP2110 and COMP3110, which address constructive aspects of the process. COMP3120 addresses some of the initial tasks for effectively planning and managing the development process within which the techniques introduced in those units might be used.

The following topics are covered. Choosing or tailoring a software development life cycle. Constructing a software development plan. Applying techniques and tools for determining size, effort and cost of a software development. Constructing a schedule and determining resource requirements and allocations. Identifying, assessing and managing risks (including technical, schedule and resource risks). Choosing and using metrics for different purposes such as monitoring progress, controlling resources and estimating rework.

Operating Systems Implementation COMP3300 (6cp) Group C

Second semester
Twenty-six one-hour lectures and six one-hour tutorials and six three-hour laboratory sessions.

Prerequisites: COMP2300 and COMP2310, or COMP2030, and 6 credit points of 2000-level mathematics or mathematical statistics or econometrics units.

Incompatible with COMP3037.

Syllabus: This unit takes a detailed look at the services provided by, and the internals of, an existing operating system to see how each part is constructed and integrated into the whole. The lectures will also address recent literature describing advances in operating systems. The following topics are addressed: system programming and its facilities (including I/O, signals, job control, interprocess communication, sockets, transport layers, remote operations), system calls and their relation to the system libraries, process management and coordination,

implementation of message passing, memory management, interrupt handling, real-time clocks, device-independent input/output, serial-line drivers, network communication, disk drivers, deadlock avoidance, scheduling paradigms, file systems, security.

Computer Networks COMP3310 (6cp) Group C

First semester
Thirty one-hour lectures and six two-hour laboratory/tutorial sessions.

Prerequisites: 12 credit points of 2000-level COMP or INFS units including COMP2300 or both COMP2031 and COMP1012, and 6 credit points of 2000-level mathematics or mathematical statistics or econometrics.

Incompatible with ENGN4514, COMP3036

Syllabus: This unit studies the standard models for the layered approach to communication between autonomous machines in a network and the main characteristics of data communication (transmission protocols) for the lower layers. It introduces several application layer protocols from a distributed systems viewpoint, and considers alternative lower layer methods such as ATM, and problem areas in the Internet protocol suite.

The following topics are included: introduction to communication network architectures (protocol hierarchies, layered services, the OSI model); the physical layer (transmission media, signal representation, limits to data capacity); the data link layer (error detection and recovery, point-to-point protocols); the medium access layer (protocols for Local Area Networks and satellite communication); the network layer (routing algorithms, congestion control); internetworking (addressing, internetwork routing and protocols, quality of service); the transport layer (connection-oriented transport layer services and protocols); application protocols for distributed systems.

High Performance Scientific Computation COMP3320 (6cp) Group C

First semester
Thirty one-hour lectures and nine two-hour tutorial/laboratory sessions.

Prerequisites: 12 credit points of 2000-level COMP units including COMP2100 or COMP2031 or ENGN2003, and 6 credit points of 2000-level MATH, STAT or EMET units.

Incompatible with COMP3061, COMP3067.

Syllabus: This unit provides an introduction to High Performance Computing with an orientation towards applications in science and engineering. The dominant programming language in this application domain, FORTRAN95, will be taught within the context of numerical computing and the design and construction of sophisticated scientific software. The unit will study high performance computer architectures, including vector and parallel processors, and will describe how an algorithm interacts with these architectures. It will also look at practical methods of estimating and measuring algorithm/architecture performance.

The following topics will be addressed: the FORTRAN95 programming language; basic numerical computing from aspects of floating point error analysis to algorithms for solving differential equations; the engineering of scientific software; general high performance computing concepts and architectural principles; scalar and vector architectures and their memory structure; performance and programmability issues, and program analysis techniques for high performance computing; parallel computing paradigms and programming using the OpenMP standard; trends in HPC systems.

Internet, Intranet and Document Systems COMP3400 (6cp) Group C

First semester
Thirty one-hour lectures and six two-hour tutorial/laboratory sessions.

Prerequisites: COMP1100 or COMP1011; 12 credit points of 2000-level IT units; and 12 credit points of 1000-level MATH/STAT/EMET units.

Incompatible with INFS2052, INFS3056.

Syllabus: This unit studies the methods, software architecture, and standards for computer communications over networks, at the upper level, and examples of major applications, with the focus being on the Internet. The following topics are included. Introduction to open systems and the Internet reference model; foundations of Internet applications: electronic mail, file transfer application, MIME, hypertext transfer protocol, World Wide Web system architecture and operation. Standards, ISO and other standardisation, conformance and acceptance; information structure; static, dynamic and active pages; HTML, CSS, XML, SGML; mobile code, cgi scripts; a simple introduction to symmetric and public key systems; study of applications like PGP, SSL; E-Commerce; design/study of an internet based business system.

Information Technology in Electronic Commerce COMP3410 (6cp) Group C

Second semester
Thirty one-hour lectures and six two-hour tutorial/laboratory sessions

Prerequisites: COMP1100 or COMP1011; 12 credit points of 2000-series IT units; 12 credit points of 1000-series MATH/STAT/EMET units

Syllabus: This unit studies some of the current and potential applications of information technology in electronic commerce. Topics will be chosen from areas such as document representation (XML, XSL, DTD, CSS), knowledge discovery (search engines, meta-data, web-based data mining), data management (digital library, electronic document management), trading (spontaneous, deliberative, auctions) and security (encryption, public key, symmetric key, PKI, authentication, etc). Case studies will be used wherever appropriate. Other topics will be included to match developments and maturation of the area.

Database Systems COMP3420 (6cp) Group C

First semester (may not be offered in 2001)
Thirty one-hour lectures and twelve one-hour tutorials three two-hour laboratory sessions

Prerequisites: COMP1100; 12cp of 2000-series IT units including COMP2400; 12cp of 1000-series MATHS/STATS/EMET units.

Syllabus: This unit examines the design and use of databases in computer-based systems and investigates associated issues. Topics will include: conceptual modeling; security; privacy; statistical databases; distributed databases; data warehousing; web technology and databases.

Algorithms COMP3600 (6cp) Group C

Second semester
Thirty one-hour lectures and nine two-hour tutorial/ laboratory sessions.

Prerequisites: 12 credit points of 2000-level COMP units including COMP2100 or both COMP2031 and COMP2033; and 6 credit points of 2000-level MATH/ STAT/EMET units.

Incompatible with COMP3064.

Syllabus: This unit deals with the study of algorithms for solving practical problems, and of the data structures used in their implementation. Detailed analysis of the resource requirements of algorithms will be an important issue.

A large variety of algorithms are candidates for study. These include, but are not limited to, the following: greedy algorithms, dynamic programming, divide-and-conquer, exhaustive search, graph algorithms, advanced data structures such as binomial heaps and Fibonacci heaps, network flow algorithms, algorithms for string matching, parallel algorithms, heuristics and approximation algorithms, and an introduction to intractability. As well as studying the implementation, the mathematical tools used to study the resource usage of algorithms will be considered.

Principles of Programming Languages COMP3610 (6cp) Group C

First semester (may not be offered in 2001)
Thirty one-hour lectures, five one-hour tutorials and four two-hour laboratory sessions.

Prerequisites: COMP2600 or COMP1013; COMP2100 or COMP2031; 6 credit points of 2000-level mathematics, statistics or econometrics.

Incompatible with COMP3065, COMP3039, COMP3040.

Syllabus: This is an advanced course in programming languages for students who possess substantial knowledge of conventional languages. (Typically, this means non-trivial experience with several of Modula-2, Eiffel, Java, C, C++ and Ada).

The unit will provide an introduction to the major declarative paradigms of functional programming and logic programming. It will give the student some experience with Prolog and a representative functional language in problem domains where these paradigms are most suited. The theoretical underpinnings of each paradigm will be introduced, as will elementary aspects of implementation.

As well as exploring these new classes of languages, the unit will introduce the students to ideas that apply across the language landscape. Firstly, languages can only be defined rigorously when some systematic notation is used to assign meanings to each program and program fragment. The unit will discuss formal semantics in general and will focus on a widely used system — denotational or structured operational.

The requirement that a language be implementable means that some aspects of formal language theory become part of the programming languages area. The unit will approach the topic in so far as it supports the construction of language acceptors. It will also give introductions to topics that underpin run-time structures of language.

Topics in Software Engineering I COMP3700 (6cp) Group C

First and second semesters
Contact hours as appropriate

Prerequisites: Written approval of Head of Department of Computer Science. Minimal background is 18 credit points of 2000 series COMP or INFS units including COMP2100 and COMP2110 and 6 credit points of 2000-level MATH/STAT/EMET units.

Syllabus: This unit is available so that senior students can pursue, under supervision, topics that are not covered in the regular curriculum or to execute a project that will significantly increase their knowledge of software engineering theory or practice.

The activities in the course will be some combination of lectures, reading, writing and project work, as appropriate to the topic.

Topics in Computer Science COMP3710 (6cp) Group C

First and second semesters
Contact hours as appropriate

Prerequisites: Written approval of Head of Department of Computer Science. Minimal background is 18 credit points of 2000 series COMP or INFS units including COMP2100 and 6 credit points of 2000 series MATH/STAT/EMET units.

Syllabus: This unit is available so that senior students can pursue, under supervision, topics that are not covered in the regular curriculum or to execute a project that will significantly increase their knowledge of some aspect of computer science.

The activities in the course will be some combination of lectures, reading, writing and project work, as appropriate to the topic.

Art and Science of Computing III COMP3800 (0cp)

Annual
About eight sessions of occasional seminars.

Prerequisites: COMP2800 and enrolment in BSEng or approval of Head of Department.

Syllabus: Same as for COMP2800 except that events in Art and Science of Computing III will be targetted to those students in their final years.

Computer Science Honours COMP4001

Full Year

Prerequisites: Enrolment in the BSc Honours degree, with specialisation in computer science.

Syllabus: The program consists of a coursework component and a project component, of equal weight. The coursework component involves units in advanced aspects of the computing discipline, which in recent years have been drawn from: architecture of parallel systems, artificial intelligence, computational logic, algorithms, object oriented databases, programs for parallel computer systems, formal aspects of software engineering, software engineering project, document technologies, automated reasoning. The project component involves a substantial individual project under detailed academic supervision. A formal thesis is submitted (nominally 10,000 words), and a seminar is presented.

Information Technology Honours INFT4001

Full Year

Prerequisites: Enrolment in the BInfTech Honours degree.

The program consists of a coursework component and a project component, of equal weight. A student's individual course program is selected in consultation with the BInfTech honours coordinator.

The coursework component involves units in advanced aspects of the computing discipline and information systems. The coursework is drawn from the fourth year honours courses in Computer Science (see the COMP4001 unit description), Information Systems (see the entry in Faculty of Economics and Commerce), and other Science departments.

The project component involves a substantial individual constructive project under detailed academic supervision. Several formal project reports are submitted for assessment.

Software Quality Management COMP4100 (6cp) [Not grouped for BSc]

First semester
Thirty one-hour lectures and five two-hour laboratory sessions

Prerequisites: Enrolment in BSEng; COMP2600, COMP3100 and COMP3120

Syllabus: This unit introduces students to advanced topics on managing the quality of products to be delivered as part of the progression within a software development project. Several causal aspects of software (bad) quality will be introduced and discussed so that students can understand the context for undertaking risk and bad quality avoidance.

The focus will be on practical techniques for identifying and removing defects as well as implementing procedures to track the success or failure of risk and defect resolutions.

Software Process COMP4110 (6cp) [Not grouped for BSc]

Second semester
Thirty one-hour lectures and five two-hour laboratory sessions

Prerequisites: Enrolment in BSEng; COMP3100 and COMP3120

Syllabus: This unit covers advanced topics concerning software process improvement (SPI) frameworks and standards. There are several SPI frameworks/standards available, each one possessing its own merits and difficulties. Most are regarded as being more appropriate to large software development organisations where the assumed expenses of incorporated SPI initiatives typically provide significant return on investment. The content of COMP4110 will introduce the various well known frameworks and standards in the context of importance to organisations but then also discuss tailored versions of some SPI frameworks that are more suitable to small organisations or teams of software developers.

COMP4110 is intended to provide students with further important possible options for a career in software engineering. SPI is a relatively new area within the overall subject of software engineering and requires a relatively deep knowledge of most if not all facets of software engineering activities. Hence it is a course especially constructed for those who wish to pursue a career loaded with experiences and research.

Component-Based Software Development — COMP4120 (6cp) (Group C)

Not offered in 2001
Thirty one-hour lectures and twelve two-hour laboratory sessions

Prerequisites: 24 credit points of 3000 level COMP units

Syllabus: Component-based development is the construction of software systems out of pre-packaged generic elements. It involves the convergence of four distinct software themes

- the emphasis of software engineering on reuse;
- the widespread practice of building parts of applications (such as graphical user interfaces and databases) out of components;
- interconnection technologies: such as CORBA, COM and Enterprise JavaBeans, and
- the generalisation of object technology, which provides both the conceptual basis and the practical tools for building and using components.

This unit builds awareness of these themes and some experimental experience of representative elements of the technology.

Milestone Papers in Computing — COMP4200 (3cp) Group C

First semester
Thirteen one-hour lectures

Prerequisites: 30 credit points of 3000/4000-series IT units

Syllabus: Each week, students in this unit will read, discuss and review a landmark paper from one of the various disciplines of computer science. The papers will be chosen so as to expose the students to a broad array of topics. The unit will also introduce students to the resources, like the science citation index, necessary to research and evaluate the origins and impact of a paper.

Usability and Design of the Human-Computer Interface — COMP4210 (3cp) Group C

Second semester (may not be offered in 2001)
Fifteen one-hour lectures

Prerequisites: 12 credit points of 2000-level COMP or INFS units, including COMP2100 or COMP2300; and 6 credit points of 2000-level mathematics, statistics, or econometrics

Incompatible with COMP3043

Syllabus: This unit covers the principles behind the design of mechanisms for human-computer interaction (HCI) and develops competence in the specification and construction of user interfaces. Topics will be selected from: the human senses such as sight and touch, and their influence on user interface design; components of interaction (direct manipulation, form fill-in, menu selection and command language); characteristics of HCI; design methodologies; the impact of culture on HCI design; software internationalisation and localisation; user interface programming (graphical interfaces and software systems, the X Window System, interaction toolkits); user interface design tools; interface and application integration.

Parallel Systems — COMP4300 (6cp) Group C

Second semester
Twenty-six one-hour lectures, four one-hour laboratory/tutorials

Prerequisites: COMP2310; and 24 credit points of 3000-level COMP units, including either COMP3320 or COMP3600

Syllabus: A practically-oriented introduction to programming paradigms for parallel computers. Considers definitions of program efficiency on parallel computers, addresses the modeling, analysis and measurement of program performance. Description, implementation and use of parallel programming languages, parallel features of operating systems, library routines and applications.

Advanced Databases — COMP4400 (6cp) Group C

Not offered in 2001
Thirty one-hour lectures and nine two-hour laboratory sessions

Prerequisites: COMP2100 and COMP2300 and COMP2400; and 12 credit points of 3000-level COMP or INFS units

Incompatible with COMP3062

Syllabus: This unit extends the study of relational databases and introduces object-oriented database technology and related research issues.

Topics will include: assessment of conventional database technology; relational algebra; object-oriented modeling and languages; control concepts; physical database design.

Document Technologies COMP4410 (3cp) Group C

Second semester
Fifteen one-hour lectures and four two-hour laboratory sessions

Prerequisites: 24 credit points of 3000-level COMP units including COMP3400 and COMP3410

Syllabus: This unit introduces fundamental models, tools, and techniques for working with documents. It motivates this from theoretical and commercial perspectives including its pivotal role in building and using the World Wide Web. The unit has a strong practical component, exposing students to the computer science and software engineering aspects of building search systems and other document technologies.

Networked Scientific Data Analysis and Presentation COMP4420 (6cp) Group C

First semester
Twenty-six one-hour lectures and six two-hour laboratory sessions

Prerequisites: 24 credit points of 3000-level COMP units, including COMP3320; and either COMP3400 or COMP3310

Syllabus: Modern 'big' science and engineering projects often make use of computing systems which combine components of networking, real-time control, data management, data analysis and visualisation. The interface to all of the above is increasingly via a Web-based workbench. This unit adopts a case study approach to describing some of these systems. Sample applications include remote experimentation, scientific co-laboratories, graphical information systems (GIS), planning and management of industrial processes and financial information systems.

Individual Project Part I COMP4510 (6cp) [Not grouped for BSc]

First semester
Fifteen hours of lectures, seminars, and workshops

Prerequisites: Enrolment in BSEng and 24 credit points of 3000-level COMP units including COMP3100

Syllabus: This unit prepares students enrolled in the BSEng programme to undertake their individual project (see COMP4520). Topics will include: project plans; how to do research; technical writing; literature surveys and annotated bibliographies; preparing and presenting seminars.

Individual Project Part II COMP4520 (12cp) [Not grouped for BSc]

Second semester

Prerequisites: Enrolment in BSEng and COMP4510

Syllabus: Students undertake a self-contained software project supervised by a member of Faculty. The project is normally based on the project plan developed by the student as part of COMP4510. This unit is the `project execution' phase. Students are required to (i) give a seminar describing their project and progress; (ii) give a demonstration at the end of semester; and (iii) write a thesis documenting the project.

Advanced Algorithms COMP4600 (6cp) Group C

Second semester
Twenty-six one-hour lectures, together with occasional seminars

Prerequisites: 24 credit points of 3000-level COMP units including COMP3600

Syllabus: This unit is concerned with the study of algorithms for solving practical problems efficiently, and the theoretical analysis of their behaviour. There will also be a brief introduction to complexity theory, the formal study of algorithm performance. A large variety of algorithms are candidates for study. These include, but are not limited to, the following: greedy algorithms, dynamic programming, network flow algorithms, algorithms for string matching, parallel algorithms, graph algorithms and approximation algorithms.

Computer Graphics COMP4610 (6cp) Group C

First semester
Twenty-six one-hour lectures and six two-hour laboratory classes

Prerequisites: 24 credit points of 3000-level COMP units including COMP3600

Syllabus: Computer graphics are an intrinsic component of many modern software applications and are often essential to the success of these applications. The objective of this course is to familiarise the student with fundamental algorithms and data structures that are used in today's interactive graphics systems as well as programming and architecture of high-resolution graphics computers. The principles and practise of computer graphics are described from their mathematical foundations to the modern applications domains of scientific visualisation, virtual reality, computer games and film animation. The unit will include some practical experience of graphical software environments such as OpenGL, VRML and Java3D.

Machine Learning and Data Mining COMP4620 (3cp) Group C

Second semester
Fourteen one-hour lectures

Prerequisites: 24 credit points of 3000-level COMP units including COMP3600

Syllabus: This unit introduces the key algorithms and theory forming the core of machine learning. Motivations are developed from Artificial Intelligence and Data Mining. Practical application of the technology to real-world problems will also be a theme.

Applications of Logic in Computing — COMP4630 (6cp) Group C

Not offered in 2001
Thirty one-hour lectures, five one-hour tutorials and five two-hour laboratory sessions

Prerequisites: 24 credit points of 3000-level COMP units including COMP3610 and 6 credit points of 2000-level Mathematics or Mathematical Statistics units

Syllabus: Many areas of computer science rely on logic for their foundations. Artificial intelligence is a particular branch of computing where knowledge and reasoning are of central concern. Also, the use of formal methods in the specification, implementation and vertification of hardware and software products, requires that the developer be able to model objects using logic.

This unit will cover a variety of application areas in order to acquaint the student with concepts of logic that are applicable to computing topics as described above.

The unit has a strong theoretical emphasis, but gives the student practical experience with theorem proving tools, especially with those that support the engineering of computing systems

Topics in Software Engineering II — COMP4700 (3cp) [Not grouped for BSc]

First and second semesters
Contact hours as appropriate

Prerequisites: Written approval of Head of Department of Computer Science. Enrolment in Bachelor of Software Engineering, and a minimum of 24 credit points of 3000-series COMP, INFS or ENGN units.

Syllabus: This unit is available so that senior students can pursue, under supervision, topics that are not covered in the regular curriculum or to execute a project that will significantly increase their knowledge of software engineering theory or practice.

The activities in the course will be some combination of lectures, reading, writing and project work, as appropriate to the topic.

Topics in Software Engineering III — COMP4710 (6cp) [Not grouped for BSc]

First and second semesters
Contact hours as appropriate

Prerequisites: Written approval of Head of Department of Computer Science. Enrolment in Bachelor of Software Engineering, and a minimum of 24 credit points of 3000 or 4000-series COMP, INFS or ENGN units.

Syllabus: This unit is available so that senior students can pursue, under supervision, topics that are not covered in the regular curriculum or to execute a project that will significantly increase their knowledge of software engineering theory or practice.

The activities in the course will be some combination of lectures, reading, writing and project work, as appropriate to the topic.

Industrial Experience — COMP4800 (0cp)

First and second semesters
Prerequisites: Enrolment in BSEng and COMP3100.

Syllabus: Industrial Experience gives the student exposure to current professional practice. It consists of 60 days of work, organised by the student. Of those 60 days, 20 must be in a software engineering context, 20 must be in a professional context, and the remaining 20 may be in any employment.

Industrial Experience is usually undertaken outside study periods, and is graded satisfactory or unsatisfactory.

(Students must fulfil the requirements during the course of their degree; they normally enroll in COMP4800 in their final year and need to have satisfied the requirements by December in order to graduate at the ceremony the following April.)

Engineering

M. Green, BSc (Hons) *NSW*, PhD *ANU*
Senior Lecturer and Head of Department

Engineering is the art of transforming the resources of nature for the benefit of humanity. Its roots are traceable to the tools, huts, pottery and materials of the first humans. Its progress has relied on ingenuity, invention, teamwork and the accumulation of experience — skills which remain essential to this day.

Engineers have a responsibility to help solve our environmental problems. The Department of Engineering is at the forefront of renewable energy research, with a particular interest in photovoltaic solar cells and semiconductor technology. The ANU 'Big Dish' is the largest of its kind in the world. The Department's Centre for Sustainable Energy Systems holds several world records for solar cell efficiency. It is also developing a unique thermochemical solar energy system. The Centre has strong links with industry and several technologies are being commercialised.

Engineering is vital to the economic well-being of nations. The Department's advanced manufacturing and production systems research integrates the disciplines of materials, manufacturing, robotics and control with modern computer simulation to understand, improve and optimise manufacturing processes. Many projects are industrially focused and major elements of the work are carried out at the collaborating company's site. This provides a healthy cross fertilisation between the Department and some of Australia's largest manufacturing companies. Related interests include discrete-event modelling and control and active vision systems.

Telecommunications is the life-blood of modern commerce and government. And it helps keep us in touch with our family, our friends, and our colleagues — relationships which span the globe. The Department's activities are primarily in advanced digital mobile communications, especially coding and modulation schemes. Researchers in the Department are patenting decoders for some mobile and satellite applications which are currently the world's best and can achieve near optimal performance. Other areas of activity include signal processing, statistical learning theory and neural networks.

Materials are the stuff of life and advanced materials are increasingly part of everyday objects as well as space-age applications. The Department's work focuses on polymers and fibre composite materials. These can be carbon-fibre materials for use in aerospace, automotive or high-tech sporting goods. Or they can be wood-wool and cement composite boards for low-cost building materials in the Philippines. The environmental conditioning of composite materials — such as moisture resistance — is one area of interest. Other work includes rubber-toughened polymer alloys in collaboration with researchers in Japan.

The volatile environment faced by organisations today presents managers with continual challenges. Yet few managers understand the nature and impact of variation. The Department's Variation and Management Group carries out research, development work with industry and educational programs aimed at enhancing the capacity of organisations to understand variation and to achieve organisational goals under variable conditions. Industry-based Masters students form a significant part of the research effort.

The Department of Engineering offers a four-year, IEAust accredited Bachelor of Engineering degree course (see the Faculty of Engineering & Information Technology entry), Masters of Engineering, including Industry-based Masters by research and PhD degree programs. The Department has active collaborations with a wide range of other ANU Departments and Research Schools including RSISE, RSPhysSE, RSES, Department of Physics, Department of Forestry, as well as CSIRO and DSTO. The Department has strategic collaborative research relationships with Ford Australia, Telstra, Solarhart and Western Power. The Department participates in the Cooperative Research Centre for Sustainable Energy Systems. Graduates are employed in a wide range of organisations and companies both in Australia and overseas. Undergraduate scholarship support from Airservices Australia, ANUTECH, BHP Research, Boeing and Siemens Plessey is gratefully acknowledged.

The Department of Engineering building is located on the corner of University Avenue and North Road, opposite the ANU Sports Union, with the ANU Union, Library and other facilities all readily accessible.

For further information, visit the Department's Web site at http://engn.anu.edu.au

Unit Descriptions

Discovering Engineering ENGN1211 (6cp)

First semester
12 discovery/design classes (2 hours), 24 lectures and 12 tutorials

Convener: Dr Green

Prerequisites: Admission to the BE degree course or the BSEng degree course or approval of Head of Engineering.

Incompatible: COMP2200, ENGN1021

Syllabus: The unit introduces engineering using a discovery/design project supported by tutorial discussions, readings, lectures and seminars, which are directed towards beginning the process of developing in students a range of graduate attributes relevant to contemporary professional engineering practice. These include: communication; teamwork; problem identification and formulation; systems design; an understanding of the

social, cultural and environmental responsibilities of engineering practice; and an awareness of reflective and ethical professional practice.

Contemporary issues examined include: theories of technological change; gender and technology; technology, environment and sustainable development; deregulation and privatisation; workplace relations; occupational health and safety; risk; professionalism and ethics.

Technological systems examined include: telecommunications; information technology; energy; manufacturing; and aerospace.

Engineering Mathematics 1 ENGN1212 (6cp)

First semester
Fifty-two lectures, twelve tutorials

Lecturer: To be advised

Prerequisites: Admission to the BE degree course or approval of Head of Engineering

Incompatible: MATH1013, MATH1115, ENGN1014

Syllabus: Same as MATH1013

Introduction to Programming and Algorithms ENGN1213 (6cp)

First semester

Prerequisites: Admission to the BE degree course or approval of Head of Engineering

Incompatible: COMP1100, ENGN1002

Syllabus: Same as COMP1100

Physics Fundamentals ENGN1214 (6cp)

First semester
Thirty-six lectures, twelve tutorials and twenty-four hours of laboratory

Convener: Dr Baxter

Prerequisite: Admission to the BE degree course or approval of Head of Engineering

Incompatible: PHYS1001, ENGN1019

Syllabus: Same as first semester of PHYS1001. Introduction to classical physics, the mathematical description of natural phenomena: mechanics, electricity, magnetism and thermodynamics.

Electromechanical Technologies ENGN1221 (6cp)

Second semester
8 laboratory sessions (3 hrs), 24 lectures and 12 tutorials

Lecturer: Dr Williamson

Prerequisites: ENGN1214 and either ENGN1211 or COMP2200

Incompatible: ENGN1018, ENGN1016

Syllabus: This unit introduces the fundamentals of electrical, mechanical and electromechanical systems. Practical laboratory sessions to help students develop and integrate theoretical knowledge, physical applications and practical skills form a substantial part of the unit. Modeling and design skills are developed through group project activities. The laboratory and project work continue the process of developing teamwork skills and graphical representation skills, including graphical presentation of experimental data.

Electrical topics include: Resistors, capacitors, inductors; breadboards and simple circuit testing; voltmeter and oscilloscope operation; Kirchoff's laws; series and parallel circuits; Thevenin and Norton Equivalent circuits; loop and nodal analysis of circuits; transient and phasor analysis of RC and RL circuits; Direct current motors; basic telecommunications (including AM radio); laboratory technique (including notebook keeping); laboratory reporting and written technical communication; writing in a group.

Mechanical topics include: vector mechanics, statics and kinematics of planar and spatial rigid bodies, equivalent force systems, static equilibrium, static indeterminacy, friction, instant centres, and relative motion.

Electro-mechanical topics include: machine elements, linkages, gears, and feedback systems.

Engineering Mathematics 2 ENGN1222 (6cp)

Second semester
Fifty-two lectures, twelve tutorials

Lecturer: To be advised

Prerequisites: ENGN1212

Incompatible: MATH1014, MATH1116, ENGN1015

Syllabus: Same as MATH1014

Foundations of Software Engineering ENGN1223 (6cp)

Second semester

Prerequisites: ENGN1213 or COMP1100

Incompatible: COMP1110, ENGN2003, COMP2031

Syllabus: Same as COMP1110

Chemistry Fundamentals ENGN1225 (3cp)

Second semester
Twenty-four lectures and twelve hours of tutorial/laboratory

Lecturer: Dr Angus

Prerequisite: Admission to the BE degree course or the BSEng degree course or approval of Head of Engineering

Incompatible: CHEM1014, CHEM1015, ENGN1022

Syllabus: Introduction to essential concepts of chemistry. Electronic structure and chemical bonding. Quantum mechanics and atomic spectroscopy. Reaction rates, Arrhenius equation, activation energy of chemical reactions. Chemical equilibrium, equilibrium constants, Le Chateliers Principle. Theories of acids and bases, strong and weak acids and bases, Ka and Kb calculation of pH and extent of hydrolysis. Thermochemistry, enthalpy and the First Law of Thermodynamics. Entropy and Gibbs free energy, the Second Law of Thermodynamics. Electrochemistry, calculation of electrode cell potentials, operation of batteries.

Modern Physics ENGN1226 (3cp)

Second semester
Twenty-four lectures and twelve tutorials

Lecturer: Professor Bachor

Prerequisite: ENGN1214

Incompatible: PHYS1001, ENGN1020

Syllabus: Introduction to modern physics including waves, optics, quantum mechanics and solid state physics.

Electronic Circuits and Devices ENGN2211 (6cp)

First semester
Twenty-four lectures and thirty-two hours of laboratory work.

Lecturer: Dr James

Prerequisites: ENGN1221 or PHYS1001 (or ENGN1016); and ENGN1222 or MATH1014

Incompatible: ENGN2001

Syllabus: This unit provides an introduction to the analysis and design of electronic systems. Review of circuit theory fundamentals: Kirchoff's laws; nodal and loop analysis; network theorems, equivalent circuits, Thevenin's Theorem, maximum power transfer. Introduction to amplifiers and feedback, operational amplifiers, opamp circuits. First and second order dynamic analysis of RC, RL and RLC circuits, s-domain (Laplace transform) methods. AC analysis, complex currents, voltages and impedances, complex power. Frequency response, transfer functions, Bode diagrams. Two port networks, transformers. Diodes and diode circuits, rectifiers. BJT and FET transistors and circuits, DC and AC models and analysis amplifiers. Digital devices, digital logic, Karnaugh maps, cannonical forms, modular components. PSpice computer lab tutorials, hardware labs.

Engineering Mathematics 3 ENGN2212 (6cp)

First semester
Thirty-six lectures and ten tutorials

Convener: To be advised

Prerequisite: ENGN1222 or MATH1014 (or ENGN1015)

Incompatible: MATH2013, MATH2027, MATH2023, MATH2305, ENGN2004

Syllabus: Same as for MATH2305

Computer Organisation ENGN2213 (3cp)

First semester
Fifteen lectures and three 2 hour laboratory sessions

Prerequisites: ENGN1223 or ENGN1002, or COMP1110

Incompatible: ENGN1007, COMP1012, COMP2300

Syllabus: An introduction to the hardware and software components of a modern computer system. Comparisons of different types of instruction sets and corresponding addressing modes. Emphasis on the relationships among instruction sets, fetch and execute operations, and the underlying architecture. Introduction to the concept of interrupts, as well as the purpose and specifications of a control unit with respect to logic operations.

Mechanics of Materials ENGN2214 (6cp)

First semester

Lecturer: Dr Stachurski

Prerequisites: ENGN1221 or PHYS1001 (or ENGN1018)

Incompatible: ENGN2002

Syllabus: This unit introduces the mechanical properties of materials, focusing on their importance for the design of structures, mechanical systems and manufacturing systems. Small design exercises integrate design throughout the curriculum. The unit also includes an introduction to finite element modelling of mechanical structures and manufacturing processes.

Specific topics include: Hooke's law for isotropic materials, true stress/strain and engineering stress/strain; mechanical properties of materials and testing methods,

Young's modulus, tensile and compressive strength, fracture and yield strength, hardness and ductility. Operation of the universal testing machine, hardness tester and impact tester; creep testing and measurement of activation energy for creep; analysis of stress and strain in statically determinant structures; beam under simple tension, compression, torsion and pure bending; angle of twist of a circular shaft under torsion; stress distribution in a thin-walled pressure vessel; transformation of stress and strain using Mohr's circle; principal stresses and maximum sheer stresses; mechanisms of fracture and fatigue; energy methods in deformation; buckling. Other concepts developed include 3D stress-strain transformation, column buckling, beam deflection and energy methods.

Introduction to Materials Science ENGN2215 (3cp)

First semester
Twenty-six lectures, six tutorials, and nine hours of laboratory

Prerequisites: Admission to the BE degree course, the BSEng degree course or approval of Head of Engineering

Incompatible: ENGN1010.

Lecturer: Ms Fox

Syllabus: Introduction to materials for structural, electrical, magnetic, and optical engineering applications. Atoms, molecules, atomic bonding, atomic basis of elasticity. The crystalline state, crystal structures, imperfections, liquids, and glasses. Multiphase materials, phase rule, binary phase diagrams of iron-carbon, aluminium and ceramic examples. Kinetics, nucleation, atomic diffusion. Microstructures, TTT diagrams, heat treatment, hardening. Magnetism, hard and soft magnets, ceramic magnets. Piezo- and pyro electricity. Optical properties, environmental degradation and corrosion of materials.

System Dynamics ENGN2221 (6cp)

Second semester

Lecturer: Dr Kalyanasundaram

Prerequisites: ENGN2212 and ENGN1221 (or ENGN1018)

Incompatible: ENGN3006

Syllabus: This unit covers the dynamics of systems. First, we apply Newton's laws to mechanical systems, work-energy and impulse-momentum. Secondly, Lagrange's approach to dynamic equations of motions is developed and applied to a wide variety of practical engineering systems including electrical, electromechanical and vibration systems. An introduction to basic machine elements not covered earlier. Lastly, an introduction to discrete event dynamics, with special attention to their use in logistics, resource management and planning.

Thermal Energy Systems ENGN2222 (6cp)

Second semester

Lecturer: Dr Lovegrove

Prerequisites: ENGN1214 (or ENGN1019) and ENGN2212

Incompatible: ENGN2008

Syllabus: Energy systems are of major importance in society and are a significant engineering research activity at ANU. This unit emphasises a systems approach to engineering, integrating technical fundamentals with social and environmental issues through site visits and case studies of energy systems. Engineering science fundamentals include the first law of thermodynamics and fluid dynamics. The unit also introduces the second law of thermodynamics, the theory of heat transfer, and AC power principles.

Signals and Systems ENGN2223 (6cp)

Second semester
Thirty-six lectures, eight tutorials and eight laboratory sessions (2 hours)

Lecturer: Dr Williamson

Prerequisite: ENGN2211

Incompatible: ENGN3005

Syllabus: Input-output view of systems; block diagrams. Linear time-invariant systems and convolution. Fourier series and the Fourier transform. Filters. Frequency response of systems. Sampling. Applications of signals and systems concepts (e.g. basic analog modulation theory). Use of MATLAB to perform discrete time signal processing tasks.

An engineering introduction to probability and random variables; the importance of random signal in system studies–noise and signals in telecommunications, process variation analysis in manufacturing, for example. Understanding a random variables and random processes. What we can know (correlation, mean, variance, also in frequency domain), and what we cannot know (exact waveform). Analysis and simulation of how a linear time-invariant system responds to a random variable or process.

Electronics ENGN2224 (6cp)

Second semester

Lecturer: Professor Blakers

Prerequisite: ENGN2211

Incompatible: ENGN2007, ENGN3002

Syllabus: Design of electronic circuits. Design tradeoffs in simple amplifier design. Field-effect transistors and a miscellany of other electronic devices. Some further device physics and experimental testing of models. Computer aided-analysis of electronic circuits. Theoretical analysis of amplifier frequency response. Basic digital electronics components. Combinatorial circuit design. Flip-flops and simple state machine design.

Investment Decisions & Financial Systems ENGN3211 (6cp)

First semester

Lecturers: Dr Logan and Dr Shailer

Prerequisite: 12cp of 1000-series mathematics or statistics units

Incompatible: ENGN2005, ENGN2011, COMM1010, ASHY2012, ASHY2014, POLS1004, ECHI1105, ECHI1106

Syllabus: One segment of the unit will provide an introduction to the economic principles which underly decisions on private and public investment. These principles will be used to analyse relevant issues such as choice of capacity, pollution, public goods, safety standards and patents. Mathematical models will be used to inform the analysis.

The second of the two segments focuses on the recording of transactions and the generation of financial reports. Practical problems are included to motivate the lectures/workshops and provide some insight into practical accounting issues.

Manufacturing Technologies ENGN3212 (6cp)

First semester

Lecturer: Mr Abdallah

Prerequisite: ENGN2214 (or ENGN2002)

Incompatible: ENGN2006, ENGN2012

Syllabus: This subject introduces the elements of a number of basic manufacturing processes and associated materials behaviour required in the design of mechanical devices. The configuration of machine tools is discussed in the context of orthogonal cutting and the basics of materials deformation processes, including, casting, forging, sheet-metal forming and polymer processing, are developed. Graphical representation techniques include sectioning, conventional representations, dimensioning, tolerancing, and further develops computer-aided design skills (CAD). Also included are 24 hours of practical workshop experience with assorted hand and machine tools to produce a manufactured article.

Digital Systems and Microprocessors ENGN3213 (6cp)

First semester
Twenty-four lectures and thirty-two hours of laboratory work

Lecturer: Dr James.

Prerequisites: ENGN2211 and ENGN2213; or 12cp B-Group COMP units including COMP2300

Incompatible: ENGN3001, ENGN3008, COMP3020.

Syllabus: This unit provides an introduction to the analysis and design of digital systems and microprocessors. Review of combinational logic analysis and design. Systematic design methods. Analysis and design of synchronous sequential machines. Computer aided design and programming of digital electronic circuits using VHDL hardware description language and FPGA programmable logic devices. Microprocessor and microcomputer architecture. Microprocessor devices, their architecture and instruction sets. Hardware aspects of instruction execution. Assembler and C programming. Input/output, bus interfacing, interrupts. Co-design of digital hardware and microprocessor systems.

Telecommunication Systems ENGN3214 (6cp)

First semester
Twenty-six lectures, twelve tutorials and ten hours of laboratory

Lecturer: To be advised

Prerequisite: ENGN2223 (or ENGN3005)

Incompatible: ENGN3011

Syllabus: This unit is a first course in telecommunications. It aims to give an overview of a range of topics within telecommunication systems. It serves the dual role of being a terminating course for some students, as well as a preparatory course for two digital communications subjects offered in fourth year. The contents of the unit are:

(a) Analog modulation schemes: AM, DSBSC, SSB, FM and PM; FDM and FDMA concepts; Carrier frequency recovery and phase locked loop. AM \& FM broadcasting systems; TV systems; Analog cable systems; Analog Mobile System (AMPS).

(b) Partial digital systems: PAM, PCM, DPCM, Delta Modulation; TDM and TDMA; Frame synchronisation. Telephone systems (TDM); Digital Satellite systems (TDMA).

(c) Simple Digital Systems: Binary Modulation, QPSK, Binary FSK. TDMA/FDMA, phase recovery and timing recovery Digital Mobile Systems (IS54, GSM and Japanese system). Satellite Mobile Systems.

(d) Simple network concept: Telephone network, packet switch and circuit switch, simple concept of ISDN, ATM for optical fibre network. How does your telephone work? How does the mobile base-station find moving mobile phone user? (Visit Telstra Tower (Mechanic switch)).

(e) Key problems of all these systems: bandwidth, noise performance, delay, cost, and environment. The key information theoric limitations.

(f) The role of telecommunications in the discipline of systems engineering and in society more generally.

Project & Operations Management — ENGN3221 (6cp)

Second semester

Coordinator: Dr Cardew-Hall

Prerequisite: ENGN3211 (or COMM1020 or ASHY2012 or ASHY2014 or POLS1004 or ECHI1102) and ENGN1211 (or COMP2200 or ENGN1021)

Incompatible: ENGN3012

Syllabus: Introduction to the organisation and management of a business. The techniques covered apply to both ongoing operations and finite length projects.

Topics covered include: business organisation, strategic planning and goals; market research; small business operation and business planning; production management systems including just-in-time techniques; work measurement; total quality management; forecasting; inventory control; materials requirements planning; scheduling and control; facility location; project control; CPM and PERT methods; critical path analysis; staff planning and motivation.

Developing a project plan for the final year individual project will provide a context for students engaging with the subject and applying some of the ideas discussed.

Manufacturing Systems — ENGN3222 (6cp)

Second semester

Lecturer: Dr Lowe

Prerequisite: ENGN3212 and ENGN2221 (or ENGN2006 and ENGN3006)

Incompatible: ENGN2013

Syllabus: This unit develops a comprehensive overview of the analysis, design and technology of manufacturing systems, with the emphasis on production systems. Technologies considered include machine configuration and control, CNC technology, cellular and flexible manufacturing systems, robotics and automation, and an introduction to scheduling, operations research and process optimisation.

Using a case study approach, the unit will introduce basic statistical quality control, including probability distributions, regression analysis, variance, central limit theorem, significance and hypothesis testing. This leads on to statistical quality control and the design of experiments for manufacturing systems. An introduction to hard and flexible automation systems, and the arguments for both.

Control Systems — ENGN3223 (6cp)

Second semester

Lecturer: Mr Abdallah

Prerequisites: ENGN2223 and ENGN3213

Incompatible: ENGN3010

Syllabus: Introduction to control system analysis, design and implementation. Laboratory project work involving embedded microprocessor control of an electromechanical system provides a context for students to engage in the subject. The laboratory work will be supported by lectures, resource materials and tutorial discussion. Topics include: History, purpose, applications and classification of control systems; control objectives including stability, regulation, and tracking; root locus design of PI, PD and PID controllers; Bode diagrams and the Nyquist stability criterion; specification of transducers, basic types of transducers and their selection; embedded microprocessors and interfacing them with other systems.

Energy Systems Engineering — ENGN3224 (6cp)

Second semester

Lecturer: Dr Lovegrove

Prerequisites: ENGN2222 and ENGN3211 or (COMM1020 or ASHY2012 or ASHY2014 or POLS1004 or ECHI1105 or ECHI1106)

Incompatible: ENGN3003

Syllabus: This unit continues the study of energy systems and related environmental issues. The unit begins with a revision of the first law of thermodynamics and fluid dynamics. It continues with a thorough examination of the second law of thermodynamics, emphasising exergy analysis, and heat transfer. Also included are quantitative economic and environmental analysis of design choices and thermo-economic optimisation (energy systems engineering).

Practical Experience — ENGN4005 (0cp)

Second semester

Coordinator: Dr Stachurski

Prerequisites: Completion of Year 3

Syllabus: Twelve weeks of suitable full-time employment, a requirement which applies to all BE degrees throughout Australia. The training has two purposes:

- to expose the student to the workplace and workplace issues (such as human and industrial relations, job organisation, maintenance, safety and environmental issues).
- to provide direct insight into professional engineering practice.

It is the student's responsibility to obtain the employment, although the Department of Engineering will assist in providing lists of people to contact.

As a general rule, the ideal would be four weeks in any sort of employment; four weeks in employment in a technical industry of some kind; and four weeks of work with engineering staff in an engineering environment (preferably working with professional engineers). Minor variations of this scheme may be acceptable, but at least a reasonable portion must be within an engineering environment.

Students are required to submit reports on their work experience and will satisfy the requirements when their portfolio is acceptable to the Head of Engineering.

Students need to complete their work experience requirements by December of their final year in order to graduate at the ceremony the following April.

Individual Project ENGN4200 (12cp)

First semester

Coordinator: Dr Cardew-Hall

Prerequisite: ENGN3221 (or ENGN3012 and ENGN3014). The normal expectation is that students enrolling are completing their final year.

Incompatible: ENGN4000, ENGN4700

Syllabus ; Students undertake a self-contained engineering project supervised by a member of Faculty. The project is normally based on the project plan developed by the student as part of ENGN3221. This unit is the 'project execution' phase. Students are required to (i) give a seminar describing their project and progress; (ii) give a demonstration at the end of semester; and (iii) write a thesis documenting the project.

Engineering Law ENGN4211 (3cp)

First semester

Lecturer: Mr Flynn

Prerequisite: ENGN1211 (or COMP2200 or ENGN1021)

Incompatible: ENGN4003, COMM1101, ASHI2268, POLS1002, ECHI1105, ECHI1106

Syllabus: Sources and classification of law; professional engineering legislation, code of ethics, registration and discipline; negligence; contract law; employment law; patent law and submission; environmental law.

Systems Engineering Project ENGN4221 (6cp)

Second semester

Coordinator: To be advised

Prerequisite: ENGN3221, ENGN3222, ENGN3214, ENGN3223 and ENGN3224 (or ENGN3012, ENGN3003, ENGN3011, ENGN3010 and ENGN2013). The normal expectation is that students enrolling are completing their final year.

Incompatible: ENGN4017

Syllabus: This unit is designed to mimic an industrial design problem as closely as practical in a university setting. Students are assigned to teams and given an ill-defined problem statement. From the problem statement, the students are responsible for developing the full set of requirements and key performance indicators to guide the design. The students then proceed through a systems design process including conceptual design, subsystem requirements, and quantitative tradeoff analyses, using the full range of engineering science and professional skills developed during the degree course. The unit emphasises teamwork (both team leadership and membership), communication skills (formal and informal, written and oral), and team and personal management and a professional approach to engineering design.

Engineering Materials ENGN4501 (3cp)

Second semester

Prerequisite: ENGN2214 (or ENGN2002)

Syllabus: This subject develops a knowledge of the variety, properties and characteristics of engineering materials. Equilibrium phase diagrams and kinetic TTT diagrams for predicting microstructure in materials. Properties of cast irons, carbon steels, alloy steels, light alloys, other useful non-ferrous metals. Toughening mechanisms for materials. Ceramic materials, glass ceramics and glasses; forming of ceramics; structure and defects in ceramics. Synthesis, characterisation, structure and properties of polymers; polymer processing. Rubber elasticity. Fibre reinforced composites, glass and carbon fibres, fabrication of composites.

Digital Communications ENGN4504 (3cp)

First semester

Convenor: Dr Williamson

Prerequisite: ENGN3214 (or ENGN3011)

Syllabus: Random process. Structure and definition of digital communications systems. Complex envelope representation of bandpass signals and systems. Sampling theory and Nyquist criterion. Matched filters and correlator. Basic digital modulation techniques (ASK, MPSK, FSK, and MSK). Performance analysis and power spectra calculation for basic digital modulation techniques. Bandlimited channels and equalisation. Fundamentals of information theory. Basics of linear block codes and convolutional codes. Maximum a posteriori detection (MAP), maximum likelihood detection (MLSD) and the Viterbi algorithm (VA).

Power Electronics ENGN4506 (3cp)

Second semester

Lecturer: To be advised

Prerequisite: ENGN2224 (or ENGN3002)

Syllabus: This unit covers the important aspects of power electronic circuits, components and design. Topics include device characteristics, heat dissipation, failure modes and discrete transistor circuits. Power magnetic devices are examined, together with their associated drive circuitry and snubbers. Techniques for designing DC-power supplies, static power inverters and universal power supplies, DC-DC converters, and switch-mode power supplies are discussed.

Semiconductor Technology ENGN4507 (3cp)

First semester

Coordinator: Dr Cuevas

Prerequisite: ENGN2224 (or ENGN3002)

Syllabus: This is a strongly laboratory-oriented course that provides hands-on experience with the most common technologies used to fabricate electron devices: photolithography, epitaxy, oxidation, diffusion, ion implantation, thin film deposition, plasma deposition and laser technologies. Researchers from the Research School of Physical Sciences and Engineering participate in the unit, offering invited lectures and laboratory experiments in their particular field of expertise. Training in clean room operation and semiconductor processing equipment is provided. The physical grounds and mathematical models for the technologies mentioned above are used in a semiconductor device design exercise. The device is fabricated in the laboratory and its electrical performance is evaluated.

Robot Manipulators ENGN4509 (3cp)

First semester

Lecturer: Mr Abdallah

Prerequisite: ENGN2221 (or ENGN3006)

Syllabus: An introduction to robotics and spatial mechanics including some hands-on laboratory experience. Theory focusses on problems of kinematics and dynamics that are fundamental to the operation, design and control of robot arms: homogeneous coordinate transformations, spatial orientation representations, Denavit-Hartenberg link descriptions, forward and inverse kinematics, Jacobian rate and static force relations, singularities, recursive Newton-Euler and Lagrange dynamics algorithms and trajectory planning.

Composite Materials ENGN4511 (3cp)

First semester

Lecturer: To be advised

Prerequisite: ENGN2214 (or ENGN2002)

Syllabus: This course provides a broad overview of engineering composites with a specialisation towards fibre reinforced matrix materials. Emphasis is placed on composite constituents, interfaces, all aspects of composites manufacturing, processing and composite mechanics (geometric aspects, laminate theory, strength and fracture theory). Practical composites design, environmental aspects and specialised composites are also introduced, geared towards recent developments. Laboratory practice gives hand-on experience in laminate fabrication and knowledge of composite microstructures.

Digital Signal Processing ENGN4512 (3cp)

Second semester

Coordinator: Professor Williamson

Prerequisite: ENGN2223 (or ENGN3005)

Syllabus: This unit aims to develop an understanding of discrete time signal processing algorithms, technology and applications. Specification and properties of frequency-selective filters (low-pass, high-pass and band-pass filters, group delay, generalised linear phase, minimum phase). Fast Fourier transform. Finite impulse response filter design techniques, computer-aided filter design. Implementation of digital filters, analog-to-digital and digital-to-analog converters and DSP chips. Applications areas discussed include digital audio and video signal processing.

Finite Element Analysis ENGN4515 (3cp)

Second semester

Lecturer: Dr Kalyanasundaram

Prerequisite: ENGN3222 (or ENGN2006)

Syllabus: The subject introduces finite element analysis. Topics covered include principles of virtual work and energy methods for stress analysis; derivation of

stiffness matrices for one dimensional problems, plane stress and plane strain problems, axisymmetric problems and general three dimensional continuum elements; solution methods, effect of mesh densities and convergence criteria; variational approach for finite element formulation; use of commercial finite element software; application of finite element analysis to problems in solid mechanics and steady-state field problems.

Sustainable Energy Systems ENGN4516 (3cp)

Second semester
Twelve lectures, six tutorials and a field trip.

Coordinators: Dr Lovegrove and Dr Cuevas.

Prerequisites: ENGN3224 and ENGN3211 (or ENGN2005, ENGN2008 and ENGN3003).

Syllabus: The subject begins with a summary of Australia's energy usage patterns and then moves on to look at the environmental and social aspects of energy usage. Particular attention is given to greenhouse policy and restructuring of the electricity market. At a more technical level, the combined thermodynamic and economic approach to optimisation introduced in Energy Systems Engineering is reinforced and extended. All these concepts are applied to an examination of a broad range of energy technologies. A field trip to a range of energy system sites is included.

Characterization of Materials ENGN4517 (3cp)

First semester
Fifteen lectures and twenty hours of laboratory

Lecturer: Dr Stachurski

Prerequisite: ENGN2214 (or ENGN2002)

Syllabus: Image analysis and visualisation, stereoscopy, surfaces and spatial distributions, software, optical microscopy. Surface characterisation, focal place, Fraunhofer diffraction, Fourier transform, SEM AFM. Bulk characterisation, thermodynamics of microstructures, phase identification, TEM, EPMA. Mechanical characterisation, surface treatments, coatings, elastic, fracture and plastic properties, straining stage in SEM, pressure and temperature dependence.

Computational Engineering ENGN4518 (3cp)

Not offered in 2001
Eighteen lecture/tutorial classes and six laboratory sessions (2 hrs)

Lecturer: Dr Gardner

Prerequisites: ENGN2212 or 6cp B-Group Mathematics and COMP1110 or ENGN1213.

Incompatible: MATH3328

Syllabus: The subject teaches the fundamental building blocks of modern engineering simulation software. While keeping an eye on fundamental principles, the approach will be one of numerical experimentation using modern tools such as the interactive data language, IDL, and MATLAB. The unit will review floating point computation and then traverse topics from linear algebra, optimisation, eigenvalue systems, interpolation and calculus. Ordinary and partial differential equations and their applications will be considered. The emphasis is on looking 'under the hood' of modern software packages.

Semiconductor Materials and Devices ENGN4519 (3cp)

Second semester

Coordinators: Dr Cuevas and Dr Blakers

Prerequisite: ENGN2224 (or ENGN3002)

Syllabus: A good understanding of the fundamental properties of semiconductor materials and devices is necessary for the professional engineer or scientist to be able to follow the pace of such a fast changing field as microelectronics. This course provides a solid foundation for understanding the basic operation of microelectronic devices. In depth study of a particular device provides training in electronic device design and modelling, including aspects related to its ideal and practical performance, fabrication, and cost. Course topics include: physical models of semiconductor materials; current carriers: electrons and holes; fundamental electronic processes: carrier generation and recombination; electronic transport mechanisms: drift and diffusion; physics of the pn junction; optoeletronic devices; bipolar devices; field effect devices.

Special Topics in Engineering 1 ENGN4520 (3cp)

Prerequisite: Written approval of the Head of Engineering

Syllabus: Within this unit, topics may be offered from time to time to take advantage of the expertise of visitors to the University and academic staff in the IAS. Entry will be at the discretion of the Head of Engineering.

Special Topics in Engineering 2 ENGN4521 (3cp)

Prerequisite: Written approval of the Head of Engineering

Syllabus: Within this unit, topics may be offered from time to time to take advantage of the expertise of visitors to the University and academic staff in the IAS. Entry will be at the discretion of the Head of Engineering.

Special Topics in Engineering 3 ENGN4522 (3cp)

Prerequisite: Written approval of the Head of Engineering

Syllabus: Within this unit, topics may be offered from time to time to take advantage of the expertise of visitors to the University and academic staff in the IAS. Entry will be at the discretion of the Head of Engineering.

Special Topics in Engineering 4 ENGN4523 (3cp)

Prerequisite: Written approval of the Head of Engineering

Syllabus: Within this unit, topics may be offered from time to time to take advantage of the expertise of visitors to the University and academic staff in the IAS. Entry will be at the discretion of the Head of Engineering.

Solar Energy Technologies ENGN4524 (3cp)

First semester
Twelve lectures, six tutorials and six laboratory sessions (3hrs)

Coordinator: Dr Cuevas

Prerequisites: ENGN3224, ENGN2224 and ENGN3212 (or ENGN2008, ENGN2006 and ENGN3002).

Syllabus: Photovoltaic and solar thermal electric systems have become an important area of engineering and are a major research area in FEIT. They are an example of interdisciplinary systems engineering, where basic electronic materials science or thermodynamics and heat transfer are combined with power electronics, mechanical design, control systems and economic optimisation. The course will give an overview of the solar energy resource and examine two different approaches to conversion to electricity in detail. The physics and fabrication of silicon solar cells, including a discussion of the trade offs between cost, fabrication complexity and performance will be discussed. Computer modelling of solar cell operation using the program PC1D will be used to reinforce the physical understanding and as a tool for device design. The presentation of solar thermal systems will look at alternative approaches to concentration and conversion of energy, focal region flux prediction and measurement, plus modelling of steady state and dynamic thermal behaviour.

Optimal Filtering and Control Systems ENGN4526 (3cp)

First semester

Lecturer: To be advised

Prerequisites: ENGN3223 (or ENGN3010 and ENGN4503).

Syllabus: This unit provides an introduction to modern state-space and optimal control methods in the setting of discrete-time systems. Topics include: state-space models, controllability, observability and minimality; pole placement by state feedback; the linear quadratic regulator; observers, state-estimation and the Kalman filter; and linear quatratic gaussian (LQG) controller design.

Mobile Robotics ENGN4527 (3cp)

Second semester

Coordinator: Dr Zelinsky

Prerequisites: ENGN2221 and ENGN3223 (or ENGN3006, ENGN3010 and ENGN3008)

Syllabus: This subject presents the fundamentals of mobile robotics technology with an applications focus. Attention is devoted to field and service robot applications. Topics include locomotive mechanisms, robot perception (lasers, computer vision, sonar) position estimation, mapping, navigation, guidance, control and human-machine interfaces.

Computer Vision ENGN4528 (3cp)

Second semester

Coordinator: Mr Abdallah

Prerequisites: ENGN2223 (or ENGN3005)

Syllabus: This subject introduces the problems of computer vision and means for their solution. Topics include: image acquisition, sampling and quantisation; image segmentation, point, line and edge detection, and thresholding; geometric frameworks for vision, single view and two views; camera calibration; stereopsis, the correspondence problem and epipolar geometry; motion and optical flow; recognition, invariants, appearance and geometric-based identification; pose estimation in perspective images.

Gas Dynamics for Engineering Applications ENGN4529 (3cp)

First semester
Eighteen lectures, six tutorials and six hours of laboratory

Lecturer: Dr Houwing

Prerequisite: ENGN3224 (or ENGN3003)

Syllabus: The conservation laws for compressible flows are derived from first principles and applied to a number of important industrial and aerodynamic problems, including: subsonic and supersonic flight; supersonic combustion ramjet engines; compressible gas flows through ducts with friction and heat addition.

Engineering and Public Policy ENGN4530 (3cp)

Second semester

Lecturer: Dr Green

Prerequisites: ENGN3221 (or ENGN3012) and ENGN1211 (or ENGN1021)

Syllabus: The subject considers contemporary public policy issues as they relate to engineering and technology. Students are expected to complete a report and give a seminar on an appropriate engineering and public policy issue. Issues include: technology and social change, sustainable development, risk, deregulation and privatisation, occupational health and safety, privacy and censorship, gender and technology, globalisation, professionalism, and ethics. Technologies include: telecommunications, information technology, energy, manufacturing, materials, aerospace.

Logistics ENGN4532 (3cp)

Second semester

Coordinator: Dr Newell

Prerequisite: ENGN3221 (or ENGN3012)

Syllabus: This subject aims to develop an understanding of the factors that affect the performance of human-activity systems and their management. The impact of variation, in external conditions and internal operations, will be a particular focus. The subject involves hands-on work using computer-based simulations. Case studies are taken from production, manufacturing and service industries and from natural resource management. Specific topics covered include: probability and distributions, queueing theory, discrete event simulation, system dynamics, task networks and work flow, and the impact of variation.

Biomedical Engineering ENGN4533 (3cp)

First semester
Twenty lectures, nine tutorials and eight hours of laboratory.

Coordinators: Mr Dwyer, Mr Lising and Dr Lowe

Prerequisites: ENGN2215 and ENGN3223 (or ENGN1010 and ENGN3010 and ENGN3008) and written approval of Head of Department.

Syllabus: This unit aims to place biomedical engineering in a systems context and to introduce anatomy, physiology, biocompatibility, biological signal analysis, biomaterials, medical radiation, patient safety and medical device regulation using a case-study approach.

Intellectual Property Law ENGN4534 (3cp)

First semester

Lecturer: To be advised

Prerequisite: ENGN4211

Incompatible: LAWS3104

Syllabus: Introduction to intellectual property. What is intellectual property? Enforcement of rights. Copyright, trademarks, designs and patents. Intellectual property management. Commercialising intellectual property. University policy and practice and students' rights. Legal aspects of the Internet and electronic commerce.

Optical Fibre and Waveguide Transmission ENGN4542 (3cp)

Second semester, first term
15 lectures and 3 interactive tutorials and 10 hours of laboratory

Prerequisites: ENGN1214 and ENGN1226, or PHYS1001.

Recommended: ENGN4502 and ENGN4540, or PHYS2016 and PHYS3031.

Incompatible: ENGN4513, PHYS3018

Coordinator: Professor Love

Syllabus: The course provides an overview of optical transmission systems and then concentrates on transmission through the optical fibres and waveguides which form the connections between the light processing components of the systems. Course content includes: basic electromagnetic theory including Maxwell's equations, ray tracing, Snell's and Fresnel's laws; light propagation through single-mode and multimode fibres; pulse propagation; fabrication of fibres and planar waveguides; sources and detectors; birefringence; nonlinear effects; and numerical techniques

Devices for Optical Systems and Networks ENGN4543 (3cp)

Second semester, second term
15 lectures and 3 interactive tutorials and 10 hours of laboratory

Prerequisite: ENGN4542 or PHSY3018.

Incompatible: PHYS3019

Coordinator: Professor Love

Syllabus: This subject complements ENGN4542 by investigating the devices required for an optical transmission system using wavelength division multiplexing (WDM) to accommodate the exponential growth in Internet and other high-speed data flows. Course content includes: single-mode transmission systems; WDM; fibre attenuation; optical amplification and gain; dispersion compensation; add/drop wavelength filters; polarisation mode dispersion; fibre gratings; optical switching; fibre couplers; device integration; optical circuitry; and numerical and simulation techniques.