The University campus is undergoing significant enhancement, with construction of the new multi-million dollar Law and Management building well underway. It will provide state-of-the-art facilities for our staff and students.

Research is the University’s lifeblood and we continue to produce research and researchers who are providing genuine answers to some of the key problems being faced by industries, governments and nations. One of New Zealand’s major research organisations, the University of Waikato plays a key role in the regional economy and makes significant contributions to the national innovation system. We have six research institutes which enable our postgraduate students to continually contribute to regional, national and global research. This emphasis on producing meaningful research flows through to our students, who are committed to making a real difference for their employers.

To prepare students for the increasingly competitive job market, we provide work experience while they study, and many courses have components that mirror real-life situations so students are prepared for the challenges they face in the workplace. This creates graduates who are work-ready and attractive to employers.

The University of Waikato continues to provide a dynamic, culturally diverse and inspiring environment for our student population. When you graduate from this university you will be well prepared for the challenges that lie ahead.
Our aim is to prepare you for a wide variety of careers, equipping you with the skills for academic and professional success. We offer three and four-year degree undergraduate programmes that are professionally oriented, based on strong theoretical foundations. Our papers and qualifications are relevant and up-to-date in what is a rapidly changing technological and social environment.

World-class research underpins unique collaborations within our Faculty, across campus, and with the wider world. These collaborations bring together creative minds, unique technologies, and degree structures tailored to your interests and skills.

A qualification in computer science, mathematics, statistics, or computer graphic design can open many doors. Both in New Zealand and overseas, our former students are using their training to assume leadership roles in educational institutions and industry.

We welcome all of our potential new students, and look forward to seeing them complete their studies and go on to future success in their careers.

Professor Geoff Holmes
DEAN, FACULTY OF COMPUTING & MATHEMATICAL SCIENCES
The information contained in this handbook is correct at the time of printing (September 2015). However, it is subject to a continuous process of review and improvement. A new handbook is produced in August/September every year and students should use the latest handbook available. The University’s document of authority for information contained in this handbook is the 2016 University of Waikato Calendar.
## 2016 Teaching and Assessment Periods

<table>
<thead>
<tr>
<th>NZ Secondary School Dates</th>
<th>Week</th>
<th>Starting</th>
<th>University Teaching Periods</th>
<th>Holidays and Other Important Dates</th>
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<td>1</td>
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<td>9</td>
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<td>A Semester cont.</td>
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</table>
DEAN
Professor Geoff Holmes
BSc(Hons) PhD S’ton

DEPUTY DEAN
Associate Professor Stephen Joe
BSc(Hons) MSc Massey PhD NSW

ASSOCIATE DEAN — RESEARCH
Associate Professor Sean Oughton
BSc(Hons) Well PhD Del

ASSOCIATE DEAN — SOFTWARE ENGINEERING
Professor Steve Reeves
BSc(Hons) PhD Birm FBCS ITCP FIITP

ASSOCIATE DEAN — ACADEMIC
Associate Professor Tony McGregor
BSc(Hons) MSc Massey PhD Waik
FACULTY OFFICE

This is the first stop for advice on degree planning and enrolment queries.

FACULTY REGISTRAR
Emma McIntyre
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Email mike@waikato.ac.nz

DEPARTMENT OF COMPUTER SCIENCE
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Web www.cs.waikato.ac.nz

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Phone +64 7 838 4021
Fax +64 7 858 5095
Email cs@waikato.ac.nz
Web www.cgd.waikato.ac.nz

DEPARTMENT OFFICES

Through these offices you can contact the lecturers and co-ordinators for each of your papers.
It is University policy to provide equal opportunities in both education and employment for all people regardless of factors that are irrelevant to their abilities, thereby deriving benefit from the overall pool of talent that exists in New Zealand society and contributing to its enrichment.

The Faculty is also committed to a policy of selection and appointment on the basis of merit. The interpretation of merit is comprehensive, and includes a diverse range of areas of experience and personal qualities as well as formal qualifications.

We seek a higher proportion of both Māori and people with disabilities in all areas of University life, and a more equal representation of genders, particularly at graduate level. There is recognition, too, that socio-economic situation and ethnic origins significantly affect access to university study. The University actively encourages participation from under-represented groups through student recruitment policies and student support services.

The Faculty assists high achieving school leavers wishing to study at Waikato by offering:

- Challenge exams which, if passed, provide credit for key papers in mathematics and statistics, and earn direct entry to 200 level papers;
- First year scholarships through the Computer Science Scholarship Exam and also for an outstanding Statistics, Mathematics and Computer Graphic Design student (see pages 176-181);
- Prizes awarded by the Dean for the top 10 students in Levels 100, 200 and 300;
- Opportunities for excellent undergraduates to work during the summer in research labs; and
- Summer School papers to assist those wanting to accelerate their progress through a degree.
UNDERGRADUATE QUALIFICATIONS
STUDENTS INTERESTED IN COMPUTER GRAPHIC DESIGN SHOULD APPLY FOR THE BCGD.
BACHELOR OF COMPUTER GRAPHIC DESIGN (BCGD/BCGD(HONS))
Three-year degree
For those who achieve a high standard in the BCGD, it is possible to complete the BCGD(Hons) graduate qualification with a fourth year of study.

STUDENTS INTERESTED IN COMPUTER SCIENCE, MATHEMATICS OR STATISTICS SHOULD APPLY FOR EITHER THE BCMS OR THE BSC.
BACHELOR OF SCIENCE (BSC/BSC(HONS))
Three-year degree with majors in:
Computer Science
Mathematics
Statistics
For those who achieve a high standard in the BSc, it is possible to complete the BSc(Hons) graduate qualification with a fourth year of study.

BACHELOR OF COMPUTING AND MATHEMATICAL SCIENCES (BCMS/BCMS(HONS))
Four-year degree with majors in:
Computer Science
Mathematics

Transfers between the BSc and BCMS are easy and common. The advantage of the BCMS is access to an honours qualification (for strong students) and the higher level specialisations available in the fourth year.

STUDENTS INTERESTED IN A PROFESSIONAL ENGINEERING QUALIFICATION IN SOFTWARE ENGINEERING SHOULD APPLY FOR THE BE(HONS).
BACHELOR OF ENGINEERING (HONOURS) (BE(HONS))
Four-year degree
Software Engineering (other programmes are available through the Faculty of Science & Engineering)

OTHER UNDERGRADUATE QUALIFICATIONS.
UNDERGRADUATE CERTIFICATE IN SCIENCE (CERT(SC))
UNDERGRADUATE DIPLOMA IN SCIENCE (DIP(SC))
The Certificate and Diploma are available for students interested in Computer Science, Mathematics or Statistics and who are only after a short term commitment.
**WHO ARE DIPLOMAS AND CERTIFICATES SUITABLE FOR?**

- Students who want an introductory programme in Computer Science, Mathematics, or Statistics.
- Students with no background in their chosen area of study, although a diploma is suitable for those with some background or relevant experience in an area of study.
- Students who want to work towards a degree programme part-time, or who would like to work through a degree programme in stages.

**CERTIFICATE (SCIENCE) PLANNER 1 year 120 points**

A Certificate is equivalent to the first year of study of a bachelors degree. Candidates must complete 120 points at 100 level or above.

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**DIPLOMA (SCIENCE) PLANNER 1 year 120 points**

A Diploma is equivalent to the second year of a bachelors degree. Candidates must complete 120 points at 100 level or above, including 80 points at 200 level or above.

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*If 200 level papers are selected you can take one fewer paper.

**Regulations for all these qualifications can be found in the 2016 University of Waikato Calendar or on the following website:** [calendar.waikato.ac.nz/regulations/index.html](calendar.waikato.ac.nz/regulations/index.html)
If you gain University Entrance you are eligible to apply to enrol in the BCMS and BSc without any additional requirements. Note however, that for most students MATH102 Introduction to Algebra and STAT121 Introduction to Statistical Methods, are strongly recommended papers. Students who do not have an adequate background in mathematics will be required to enrol in bridging papers.

The BCGD and the BE(Hons) have additional entry requirements (check the undergraduate degree information on pages 20 and 52 in this handbook for additional information).
UNIVERSITY ENTRANCE FROM BURSARY
Three C grades or higher in the New Zealand University Entrance Bursaries and Scholarships examinations (NZUEBS) plus Higher School Certificate (HSC).

ADMISSION AT ENTRANCE LEVEL OR WITH CREDIT FROM PREVIOUS STUDY
New Zealand citizens and permanent residents who have studied overseas at secondary school or at tertiary level (in New Zealand or overseas) should apply for Admission at Entrance level. We will assess your study to determine whether it is an acceptable equivalent to the New Zealand University Entrance qualification.

Students who successfully complete the Certificate of University Preparation are eligible for admission at Entrance Level.

DISCRETIONARY ENTRANCE
STUDENTS UNDER 20 WITHOUT UNIVERSITY ENTRANCE
If you are 16 years of age or over and a New Zealand citizen or permanent resident, you may be eligible to apply for Discretionary Entrance.

Students are assessed on the basis of their academic background and an adviser’s recommendation. If you are still at school, or have left school recently, your school principal must be your adviser. If you have left school please contact the Future Students team at the University. Email info@waikato.ac.nz or phone 0800 WAIKATO (0800 924 528).

SPECIAL ADMISSION
STUDENTS AGED 20 AND OVER
If you left school without University Entrance and will be 20 years of age or over by the first day of the semester in which you are applying to enrol, you may apply for special admission.

FACTORS CONSIDERED WHEN GRANTING SPECIAL ADMISSION
Any other relevant study you might have undertaken; your general life experience and preparedness for university study; and if you have successfully completed a bridging course.

Members of the Faculty staff are available by appointment to discuss special admission.
ENGLISH LANGUAGE REQUIREMENTS FOR UNDERGRADUATE STUDY IN THE FACULTY OF COMPUTING & MATHEMATICAL SCIENCES (FCMS)

All students whose application for admission is on the basis of study completed overseas where the medium of instruction is not English, are required to provide evidence of a satisfactory level of competence in the English Language.

A TOEFL iBT score of 79-80 (with a writing score of 20) or an IELTS score of 6.0 or above (with at least 6.0 in the writing band) or a PTE Academic overall score of 57 (and no less than 57 for Writing) is considered to be evidence of such competence. Other evidence is considered on a case-by-case basis.

Undergraduate students with less than 7.0 in IELTS or less than 100 in TOEFL iBT or less than 65 in PTE will be required to enrol in (and pass) the paper ESLA101 Academic Writing and Research in their first semester of enrolment.

International students seeking admission via the University of Waikato Pathways College may be accepted on the basis of a B grade or higher at level 7 of the Pathways College English Language programme.

A higher standard of English will be required of students wishing to enter graduate study programmes.

All international students should apply through Student and Academic Services.

CODE

The University of Waikato has agreed to observe and be bound by the Code of Practice for the Pastoral Care of International Students. Copies of the Code are available from the New Zealand Ministry of Education website at www.minedu.govt.nz/international

IMMIGRATION

Full details of immigration requirements, advice on rights to employment in New Zealand while studying, and reporting requirements are available from Immigration New Zealand, and can be viewed on their website at www.immigration.govt.nz
ELIGIBILITY FOR HEALTH SERVICES AND MEDICAL AND TRAVEL INSURANCE

Most international students are not entitled to publicly funded health services while in New Zealand. International students (including group students) must have appropriate and current medical and travel insurance while in New Zealand.

Full details on entitlements are available through the Ministry of Health and can be viewed on their website at www.moh.govt.nz

ACCIDENT INSURANCE

The Accident Compensation Corporation provides accident insurance for all New Zealand citizens, residents and temporary visitors to New Zealand, but you may still be liable for all other medical and related costs. Further information can be viewed on the ACC website at www.acc.co.nz

THE STUDENT CENTRE

The Student Information Centre, The University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand

Phone +64 7 838 4176 or 0800 WAIKATO (0800 924 528)
Fax +64 7 838 4370
Email info@waikato.ac.nz or international@waikato.ac.nz
COMPUTER GRAPHIC DESIGN
The Bachelor of Computer Graphic Design combines highly creative design and visual communication papers with computer programming papers from our Computer Science department. The intention is to empower a new generation of designers with the ability to redefine the boundaries of graphic design by working across mediums and linking powerful visual communication with effective, innovative use of technology.

This style of qualification is in increasing demand both within New Zealand and internationally. This follows the now widespread use of computers in the design profession, and the enormous growth of the internet, the world wide web, and electronic commerce, entertainment, education and interactivity. The qualification meets the ever-increasing demand for high quality cross media design expertise. The structure of the programme has been developed in collaboration with the design industry, with an eye to both international and local markets seeking students with on and offline media experience.

In the first year, students have the opportunity to develop a firm foundation in the core elements and principles of design, in both two and three dimensions. They also learn essential techniques that will assist them in broadening their visual and verbal skills. The second year offers motion graphics and the chance to explore the relationship between visual communication and screen-based technologies. By the time students enter the third year they are ready to push the boundaries of visual communication, taking on the more professional challenges of internship as well as complex, cross media projects.

**CAREER OPPORTUNITIES**

The skills students will gain from this programme can lead to work in a variety of areas including:

- Advertising
- Branding and Corporate Identity
- Interactive Media
- Motion Graphics
- Multimedia Content Creator
- GUI Design
- User Experience
- Web Design and Development.
CGD STAFF

SENIOR LECTURERS

Tomas Garcia Ferrari tomasgf@waikato.ac.nz
Specialist in Communication Design Theory UBA Argentina
Typography; interaction design; design thinking; complexity.

Keith Soo ceks@waikato.ac.nz
DipMM NAFA BCGD(Hons) MCGD UCOL/Waik
Motion graphics; interaction design; graphic design; creative solutions.

LECTURERS

Simon Laing simonl@waikato.ac.nz
BCGD(Hons) MCGD UCOL/Waik
Interactive media; graphic design.

Claire Timpany ctimpany@waikato.ac.nz
BCGD(Hons) MCGD UCOL/Waik
Publication and interaction design; typography.

Emmanuel Turner eturner@waikato.ac.nz
PGDipCGD Wang MCGD UCOL/Waik
Internet design; technology and culture.

Nicholas Vanderschantz vtwoz@waikato.ac.nz
BCGD(Hons) MCGD UCOL/Waik
Typography in learning and education; photography; internet design.

ANZEL MARAIS
CGRD360 – DEGREE PROJECT
If you have University Entrance you are eligible to apply for this degree. Ideal NCEA subject credits would include Art (Design, Painting, Photography, Sculpture or Printmaking), or Graphics and Design. Because of the computer programming component in the degree, if you do not have at least 14 credits in NCEA Level 2 Mathematics you may be offered a supporting mathematics paper. A good standard of English is also important.

A selection process applies and you must submit 10 portfolio pieces. Submit your portfolio with your application form. The portfolio pieces are submitted to demonstrate your creative and visual communication abilities. You may be required to attend an interview in Hamilton with CGD teaching staff.

Each application will be considered on a case-by-case basis. If necessary we can give you advice on suitable bridging papers.

BCGD applicants are required to submit a portfolio with their enrolment application. We will not be evaluating your design abilities as these skills will be taught during the degree. We are interested in seeing your creative ideas, originality, curiosity and imagination, and how you implement this within your creative visual work.

The portfolio of creative work (at least 10 items, max 20) should include finished pieces and pieces still under development. We would like to see work in progress or work developed during planning a project as well as finished work to help us understand your creative-thinking process.

The items might include:

- Drawings
- Computer-generated images
- Sketches
- Photography
- Websites
- Animation
- Painting
- Sculpture
- Fashion
- Digital story-telling
- Etc.

You can submit your portfolio as digital files on a USB stick or by email. Please do not submit originals. Original pieces can be photographed and submitted as digital files by email, with individual works clearly labelled.

Each of the 10 or more pieces should be accompanied by a title for each piece and a short (100 word max.) description of the work and its purpose and process of production.
# BACHELOR OF COMPUTER GRAPHIC DESIGN (BCGD)

## BCGD Degree Planner: 3 Years, 360 Points

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<td>200 level*</td>
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<tr>
<td>300 level</td>
<td>CGRD343, COMP344, COMP350, CGRD360</td>
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<td>300 level**</td>
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</tr>
</tbody>
</table>

*Chosen from COMP223 Information Discovery, COMP233 Internet Applications, COMP258 Programming Usable Systems, or COMP278 Interactive Computing.

CGD PAPERS
100 LEVEL

Computer Graphic Design papers provide specialised professional education in computer graphic design, a creative process that utilises art and technology to communicate ideas. The papers offered comprise a core of basic design material and skills, together with contemporary computer software, understanding and experience and a context of design history and liberal arts.

CGRD141-16A (HAM)
DESIGN 1
15 points

This paper explores topics related to creativity using basic elements and principles of design to raise students’ aesthetic awareness and develop their critical judgement. The process also teaches students to look at, see and interpret their environment in original ways. Students will work in both traditional and digital media.

Corequisite Paper(s) COMP125
Restricted Paper(s) CGRD161
Assessment Internal assessment/Final examination ratio 1:0

CGRD142-16B (HAM)
DESIGN 2
15 points

This paper follows closely from CGRD141 by allowing students to apply their learning in set projects and assignments. The emphasis is on process, creativity and developing confidence and personal expression. The paper also provides an introduction to typography.

Corequisite Paper(s) COMP126
Prerequisite Paper(s) CGRD141
Restricted Paper(s) CGRD161
Assessment Internal assessment/Final examination ratio 1:0

Note(s) This paper is only available to BCGD students.

CGRD151-16B (HAM)
A HISTORY OF VISUAL COMMUNICATION
15 points

Students consider the role of visual communication design in society and culture, from the evolution of writing to the revolutions of 20th century modernism, through the study of visual images and critical theory.

Assessment Internal assessment/Final examination ratio: 1:0
CGRD171-16B (HAM)
DESIGN PROCESSES AND THE CONSTRUCTION OF MEANING
15 points
This paper will develop students’ knowledge of the design process in order to analyse and create meaningful experiences.

Assessment Internal assessment/Final examination ratio 1:0

COMP103-16A (HAM) & 16B (HAM)
INTRODUCTION TO COMPUTER SCIENCE 1
15 points
Please see page 53 for more information.

COMP125-16A (HAM)
VISUAL COMPUTING
15 points
Please see page 54 for more information.

COMP126-16B (HAM)
COMPUTING MEDIA
15 points
Please see page 54 for more information.
CGRD224-16A (HAM)
VISUAL DESIGN FOR INTERACTIVE MEDIA
20 points

This paper is a practical study of computer graphic design principles; covering topics such as graphic design techniques, typography, colour, digital images, designing for computer displays and the web.

Prerequisite Paper(s) One of CGRD141 or COMP126
Restricted Paper(s) COMP224 and CGRD241
Assessment Internal assessment/Final examination ratio 1:0

CGRD241-16A (HAM)
COMPUTER GRAPHIC DESIGN 1
20 points

This paper challenges students to combine their typographic skills and their knowledge of principles of design in order to practically solve design problems. A combination of exercises and assignments involving research and basic visual communication using type and image will synthesise these design skills. Throughout the paper the arrangement of typography is treated formally and expressively within specified guidelines.

Prerequisite Paper(s) CGRD142 and COMP126.
Assessment Internal assessment/Final examination ratio 1:0

Note(s) This paper is only available to BCGD students.

CGRD242-16B (HAM)
COMPUTER GRAPHIC DESIGN 2
20 points

This paper will enable students to experiment with the application of design principles and research to problem-solving exercises and assignments and synthesise design skills with computer-based applications. It will enable students to operate with skill and expertise the range of software that will be required for completion of assignments and be aware of hardware structure and the functions of its components in relation to specific hardware.

Prerequisite Paper(s) CGRD241
Assessment Internal assessment/Final examination ratio 1:0

Note(s) This paper is only available to BCGD students.
CGRD252-16A (HAM)
STUDIES IN VISUAL COMMUNICATION
20 points
In this paper students explore critical themes in visual communication design from the 1960s onwards. Topics are variable and may include New Zealand identity; propaganda design; new media and new models of communication.

Prerequisite Paper(s) CGRD151 or CGRD161
Restricted Paper(s) CGRD353
Assessment Internal assessment/Final examination ratio 1:0

COMP223-16A (HAM) & 16B (HAM) & 16S (HAM)
INFORMATION DISCOVERY
20 points
Please see page 58 for more information.

COMP233-16B (HAM)
INTERNET APPLICATIONS
20 points
Please see page 59 for more information.

COMP258-16A (HAM)
PROGRAMMING USABLE SYSTEMS
20 points
Please see page 60 for more information.

COMP278-16A (HAM) & 16B (HAM) & 16S (HAM)
INTERACTIVE COMPUTING
20 points
Please see page 60 for more information.
CGRD343-16A (HAM)  
COMPUTER GRAPHIC DESIGN 3  
20 points
This paper enables students to apply design elements and principles to multiple digital and physical projects. Students will be encouraged to bring skills gained in other papers to their projects. Students will also undertake an exploration of typography created by electronic means and targeted for existence in electronic space as an integral component of time based media production.

Prerequisite Paper(s) CGRD242  
Assessment Internal assessment/Final examination ratio 1:0

CGRD344-16B (HAM)  
COMPUTER GRAPHIC DESIGN 4  
20 points
This paper enables learners to apply principles of design and design elements to systematic information hierarchies, environmental graphics, advanced publications and multimedia documents. This paper will allow students to explore the relationship between theory and practice, including their own practice, as well as provide methodology and support for research in design.

Prerequisite Paper(s) CGRD343  
Assessment Internal assessment/Final examination ratio 1:0

CGRD350-16A (HAM)  
INTERN PROJECT  
20 points
This paper will induct the design student into the professional environment where the student applies two and three dimensional computer graphic design skills, research methodology and production skills to allocated projects. The relationship between the student and the client is monitored and guided by an adviser who also supervises and guides the student in designing and co-ordinating aspects of the project.

Prerequisite Paper(s) (CGRD242 or CGRD224 or COMP224) and at least one of COMP223, COMP233, COMP258 or COMP278  
Assessment Internal assessment/Final examination ratio 1:0

Note(s) This paper is available to BCGD and BMCT (Design Media) students; admission for students in other degree programmes is by permission of the Chairperson of Computer Science.
CGRD353-16A (HAM)
ADVANCED STUDIES IN VISUAL COMMUNICATION
20 points

In this paper students explore critical themes in visual communication design from the 1960s onwards. Topics are variable and may include New Zealand identity; propaganda design; new media and new models of communication.

Prerequisite Paper(s) CGRD151
Restricted Paper(s) CGRD252
Assessment Internal assessment/Final examination ratio 1:0

CGRD360-16B (HAM)
DEGREE PROJECT
20 points

This paper is an opportunity for students to plan, develop and carry out a small scale design project with relative independence. Students are encouraged to collaborate with peers in the learning environment and with members of the professional design industry and/or academic community. An adviser will supervise and guide the student through their project. This paper should form part of your final semester of study.

Prerequisite Paper(s) CGRD343 and CGRD350
Restricted Paper(s) CGRD361
Assessment Internal assessment/Final examination ratio 1:0

Note(s) This paper is only available to BCGD students.

CGRD361-16B (HAM)
PORTFOLIO PREPARATION
20 points

This paper is an opportunity for students to develop and refine a professional portfolio showcasing their graphic design work.

Restricted Paper(s) CGRD360
Assessment Internal assessment/Final examination ratio 1:0

Note(s) This paper is only available to GradCert(CGD) or GradDip(CGD) students. Enrolment in this paper is limited to 10 students.
COMP324-16A (HAM)
INTERACTION DESIGN
20 points
Please see page 64 for more information.

COMP325-16B (HAM)
HUMAN–COMPUTER INTERACTION
20 points
Please see page 64 for more information.

COMP333-16A (HAM)
WEB APPLICATIONS DEVELOPMENT
20 points
Please see page 65 for more information.

COMP336-16B (HAM)
GRAPHICS AND COMPUTER GAMES
20 points
Please see page 65 for more information.

CGRD143
GRAPHIC DESIGN STUDY

CGRD161
EFFECTIVE VISUAL COMMUNICATION

CGRD165
GRAPHIC DESIGN STUDY

CGRD166
GRAPHIC DESIGN STUDY
COMPUTER SCIENCE
INTRODUCTION

The Computer Science Department is well recognised both nationally and internationally, especially for its various contributions to open source software development. The Department enjoys a high international academic profile for its work in such areas as broadband communication, data compression, digital libraries, formal methods, human-computer interaction, machine learning and software engineering.

The computing facilities in the Department are among the best in New Zealand, ranking from phones and tablets for mobile application development to cluster computers for massively parallel processing.

There are no specific subjects you need to study at secondary school to study Computer Science at Waikato. However, some first-year papers have specific prerequisites so check the paper list carefully. NCEA Computing/Digital Technologies and Mathematics are very useful. Each year we also award up to 10 scholarships to the best performing High School students as determined by our yearly Scholarship exams.

WHAT IS COMPUTER SCIENCE?

Computer Science deals with the theory, design, analysis, implementation, efficiency and application of processes that transform information. The fundamental question underlying all of computer science is, “What can be automated?” Computer use in entertainment, industry, business, education and government is widespread, and the need for qualified professionals with a computing background continues to grow.

Computer Science majors learn about software systems and how people and computers interact. You’ll learn how to create new software, how to ensure that the software works well and does what it’s supposed to, and how to make that software easy for people to use.

EXAMPLE CAREERS

Web Architect: design and construct an organisation’s internet presence. A web architect will understand how to support a company’s brand and business strategy through its website, and will be able to implement the website design that she/he creates.

Software Developer: create new software and modify existing software systems. A software developer will write, test, and debug new computer programs.

Usability Engineer: work with software developers to ensure that software is easy to use, quick to learn, and useful. A usability designer ensures that technology fits human needs, by learning what users need and using that knowledge to create better software interfaces.

Network Architect: design and manage computer networks for a Telco, ISP or large retail company. This includes technology selection and design, provisioning the network, security management and performance analysis.
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Professor Bernhard Pfahringer

ADMINISTRATOR
Bronwyn Webster bronwyn@waikato.ac.nz

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Mark Apperley mapperle@waikato.ac.nz
BE PhD Auck FIITP
Human-computer interaction; interaction design; information visualisation; smart environments; energy informatics.

Geoff Holmes geoff@waikato.ac.nz
BSc(Hons) PhD S’ton
Machine learning; data mining.

Bernhard Pfahringer bernhard@waikato.ac.nz
MEng PhD Vienna Tech
Machine learning; data mining; AI; programming languages.

Steve Reeves stever@waikato.ac.nz
BSc(Hons) PhD Birm FBCS ITCP FIITP
Formal methods; mathematical foundations of computer science; functional and logic programming.

Ian Witten ihw@waikato.ac.nz
MSc Calg MA Camb PhD Essex CEng MIEEE FACM FRSNZ
Programming by example; interactive systems; text compression; machine learning; digital libraries.

ASSOCIATE PROFESSORS
David Bainbridge davidb@waikato.ac.nz
BEng(Hons) Edin PhD Cant
Digital Libraries; multimedia information retrieval; document image analysis; mobile interfaces.

Sally Jo Cunningham sallyjo@waikato.ac.nz
BA BS Tennessee PhD Louisiana FIITP
Digital libraries; human-computer interaction.

Eibe Frank eibe@waikato.ac.nz
Dipl-Inf Karlsruhe PhD Waik
Machine learning; data mining; text mining.
Steve Jones stevej@waikato.ac.nz
BSc(Hons) PhD Stirling
Digital libraries; interactive information retrieval; small screen interaction.

Tony McGregor tonym@waikato.ac.nz
BSc(Hons) MSc Massey PhD Waik
Digital communications especially network measurement; operating systems.

Masood Masoodian masood@waikato.ac.nz
BSc(Hons) Massey PhD Waik
Interaction design; human-computer interaction; information visualisation.

SENIOR LECTURERS
Judy Bowen jbowen@waikato.ac.nz
MSc PhD Waik
Formal methods; human-computer interaction.

Annika Hinze hinze@waikato.ac.nz
Dipl.Math.Techn. TU Berlin PhD FU Berlin PGCertTT Waik
Information systems; alerting systems; databases; women in computer science.

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Waikato-Maniapoto, Ngati Porou, MA PhD Waik
Māori language with computing/internet/digital libraries; traditional navigation.

Ryan Ko ryan@waikato.ac.nz
BEng(Hons) PhD Nanyang MIEEE MACM
Cloud computing security; cloud data provenance; cyber security; linked data analysis; exploratory visualisation.

Matthew Luckie mluckie@waikato.ac.nz
BMS(Hons) PhD Waik
Computer networks; computer architecture; operating systems.

Robi Malik robi@waikato.ac.nz
MSc PhD Kaiserslautern
Model checking; finite-state machines; discrete-event systems.

Michael Mayo mmayo@waikato.ac.nz
BA(Hons) Otago PhD Cant
Data mining; image recognition; computational finance.
Richard Nelson  richardn@waikato.ac.nz
BE(Hons) ME PhD Cant
Computer networks; mobile networking; network applications.

David Nichols  d.nichols@waikato.ac.nz
BSc(Hons) PhD Lanc PGCertTT Waik CEng MBCS CITP
Human-computer interaction; digital libraries; information science.

Bill Rogers  coms0108@waikato.ac.nz
MSc Waik
Programming languages; graphics; machine learning.

Tony Smith  tcs@waikato.ac.nz
MSc Calg PhD Waik
Machine learning; natural language processing; computational biology.

LECTURERS
Vimal Kumar  vkumar@waikato.ac.nz
B.Tech Calg PhD Missouri
Wireless sensor networks; sensor clouds; network security; cloud computing.

Shaoqun Wu  shaoqun@waikato.ac.nz
BSc MSc (Hons) PhD Waik
Computer assisted language learning; mobile language learning; supporting language learning in MOOCs; digital libraries; natural language processing; computer science education.

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J. Stephen Downie
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Mark Hall
BCMS(Hons) PhD Waik

John Rose
AB(Hons) WReserve PhD Caltech

Lloyd A. Smith
BMus MS PhD N.Texas

Craig Taube-Schock
BSc MSc Calgary PhD Waik

HONORARY PROFESSOR

Robert Spence
BSc PhD DIC DSc Lond DrRCA FIEEE FREng
**BCMS DEGREE PLANNER** Computer Science 4 years 480 points

<table>
<thead>
<tr>
<th>100 level</th>
<th>200 level</th>
<th>300 level</th>
<th>400 level (non honours)</th>
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<td>COMP103</td>
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* BCMS regulation 8 requires 50 points from subjects in the field other than the major including at least 20 points above 100 level. STAT121 will help satisfy these requirements and is strongly recommended in its own right. It also helps students keep their options open for changing to another major with the Faculty if desired.

Candidates must also include 50 points from a Faculty or School of Studies other than the Faculty of Computing & Mathematical Sciences, with at least 20 points above 100 level.

Elective papers may be replaced by papers at a higher level.
BACHELOR OF COMPUTING AND MATHEMATICAL SCIENCES (HONS)
(BCMS(HONS))

BCMS(HONS) DEGREE PLANNER Computer Science 4 years 480 points

**100 level**
- **COMP103**
- **COMP104**
- **MATH102**
- **STAT121** or **STAT111**

**Outside FCMS paper**

**200 level**
- **COMP200** and **COMP203**
- **COMP202** and **COMP204**
- **COMP235**

**200 level or above**

**300 level**
- **COMP3XX**
- **COMP3XX**
- **COMP3XX**

**300 level**

**500 level**
- **COMP520 45 points**
- **COMP5XX**
- **500 level**
- **500 level**

**Compulsory paper**

* BCMS(Hons) regulation 10 requires 50 points from subjects in the field other than the major including at least 20 points above 100 level. STAT121 will help satisfy these requirements and is strongly recommended in its own right. It also helps students keep their options open for changing to another major with the Faculty if desired.

Candidates must also include 50 points from a Faculty or School of Studies other than the Faculty of Computing & Mathematical Sciences, with at least 20 points above 100 level.

**ADMISSION TO HONOURS PROGRAMME**

To be eligible for the honours programme candidates will require an average grade of B+ in at least 80 points at 300 level in Computer Science papers. This does not apply to double major students, who will be treated separately.
### BACHELOR OF SCIENCE (BSC)

**BSC DEGREE PLANNER** Computer Science 3 years 360 points

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<td>MATH102</td>
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<td>Compulsory paper</td>
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*Science Papers should be recognised papers offered by the Faculty of Science & Engineering or the Faculty of Computing & Mathematical Sciences (except COMP123 and MATH168) and PHIL102, PSYC102 and PSYC103. These papers must be taken across four science subjects. STAT121/111 will help satisfy these requirements and is strongly recommended in its own right.*

### BACHELOR OF SCIENCE (HONS) (BSC(HONS))

**BSC(HONS) DEGREE PLANNER** Computer Science 1 year 120 points

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<td>COMP5XX 15 points</td>
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<tr>
<td>500 level</td>
<td>500 level 60 points</td>
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Candidates must include at least 30 points in research (COMP591), as prescribed in the subject entry in the 2016 University of Waikato Calendar. Candidates may take up to 30 points from outside the field of the degree. Where a candidate fails a paper, they will not be permitted to repeat the paper or take an alternative paper. A candidate who fails a paper will not be permitted to proceed with the degree.

**ADMISSION TO HONOURS PROGRAMME**
Candidates will require an average grade of A- in at least 80 points at 300 level in Computer Science.
DOUBLE MAJORS

DOUBLE MAJOR
Able students may wish to consider doing a BSc/BCMS(Hons) double major with one major in Computer Science and the other major in Mathematics, or some other subject.

For further details about a double major, contact the Faculty Reception (cms@waikato.ac.nz).

For a BSc double major, students must complete:
- 120 points at 100 level
- 120 points at 200 level – 60 points in each major
- 120 points at 300 level – 60 points in each major.

DOUBLE MAJOR IN COMPUTER SCIENCE AND MATHEMATICS
Flexible double major programmes in Computer Science and Mathematics are available. Students with this qualification should be very attractive to employers, but it is also ideal for students interested in areas such as artificial intelligence, formal methods, the theory of algorithms, and data mining.

BSC DOUBLE MAJOR DEGREE PLANNER Computer Science and Mathematics 3 years 360 points

100 level

- MATH101
- MATH102
- COMP103
- COMP104
- Compulsory paper
- STAT121* OR STAT111

100 level

- MATH251 AND MATH252
- MATH253 AND MATH255
- MATH2XX 20 points
- COMP200 AND COMP203
- COMP202 AND COMP204

200 level

- MATH3XX OR COMP340

300 level

- MATH311
- MATH3XX
- COMP3XX
- COMP3XX
- COMP3XX

*Science papers should be recognised papers offered by the Faculty of Science & Engineering and PHIL102, PSYC102 and PSYC103.
SPECIALISATION IN APPLIED COMPUTING

The following specialisation of the BSc major in Computer Science is available.

**APPLIED COMPUTING (BSC ONLY)**

Computers are applied in a wide range of applications, from the database systems used to manage corporate data, the advanced graphics seen in modern games consoles, to the huge variety of internet applications now available. The Applied Computing specialisation concentrates on using existing tools and software libraries to build systems in the database, internet, game and multimedia areas.

**BSC DEGREE PLANNER Computer Science, Applied Computing 3 years 360 points**

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<tr>
<th>100 level</th>
<th>200 level</th>
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<td>COMP103</td>
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<td>COMP315</td>
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<td>COMP126</td>
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<td>STAT121 OR STAT111</td>
<td>COMP258</td>
<td>COMP3XX**</td>
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</table>

Science papers should be recognised Science papers, which are offered by the Faculty of Science & Engineering, and the Faculty of Computing & Mathematical Sciences (except COMP123 and MATH168), PHIL102, PSYC102 and PSYC103.

* 40 points of 200 level papers from a single subject other than Computer Science.

**Recommended papers could be:**

100 Level PHIL102 and two 200 Level Philosophy papers, or
100 Level MCOM102 and two 200 Level Management Communication papers, or
100 Level MSYS121 and two 200 Level Management Systems papers, or
100 Level SMST102 and two 200 Level Screen and Media papers.

** These two papers must be selected from COMP321 Practical Data Mining, COMP324 Interaction Design, COMP325 Human–Computer Interaction, COMP329 Database Systems and COMP336 Graphics and Computer Games, unless a double major is being completed or the Graphics and Games theme is being followed.
THE UNIVERSITY OF WAIKATO

THEMES
To help you choose your 300 level papers within the Applied Computing specialisation (in addition to COMP333 and COMP315), here are several suggested themes:

DATABASES AND DATA MINING
COMP321 Practical Data Mining
COMP329 Database Systems
and one of: COMP324 or COMP325

INTERNET APPLICATIONS
One of: COMP324 or COMP325

HCI AND USABILITY
COMP224 Visual Design for Interactive Media and
COMP324 Interaction Design
COMP325 Human-Computer Interaction

GRAPHICS AND GAMES
COMP224 Visual Design for Interactive Media and
COMP223 Information Discovery (Computer Games module) and
COMP336 Graphics and Computer Games or
SMST319 Games Studies
and one of: COMP324 Interaction Design or
COMP325 Human-Computer Interaction

BUT WAIT, THERE’S MORE...
There are several focus areas in Computer Science that may interest you:
Artificial Intelligence
Computer Technology
Data Mining
Games and Multimedia
Information Systems
Interaction Design
Internet Applications
Networks
Software Development.
ARTIFICIAL INTELLIGENCE

Researchers in Artificial Intelligence are working to develop computer systems that match or exceed the capabilities of the human brain in, for example: learning, the representation of knowledge, reasoning, speech recognition and the use of language, and vision. This has led to many practical developments in the computer industry, including data mining and natural language interfaces to commercial software. This focus area will enable you to understand and use and even build your own Artificial Intelligence techniques.

Compulsory papers from degree planner on page 35 for BCMS and page 37 for BSc, plus:

100 LEVEL
Recommended to also take:
MATH101 Introduction to Calculus (15 points)
PSYC103 General and Experimental Psychology (15 points)

200 LEVEL
Recommended to also take:
PHIL210 Minds and Machines (20 points)

300 LEVEL
Recommended to also take:
COMP313 Topics in Programming Languages (20 points)
COMP316 Artificial Intelligence Techniques and Applications (20 points)
COMP317 Design and Analysis of Algorithms (20 points)
COMP340 Reasoning about Programs (20 points)

400 LEVEL (BCMS ONLY)
Recommended to take at least three of:
COMP421 Machine Learning Algorithms (15 points)
COMP423 Data Stream Mining (15 points)
COMP455 Bioinformatics (15 points)
COMP456 Metaheuristic Algorithms (15 points)
COMPUTER TECHNOLOGY

WHAT IS COMPUTER TECHNOLOGY?

Computer Technology is the study of the hardware and software that are the foundations of modern computer systems. Computers are now a fundamental part of everyday lives, controlling everything from toasters to nuclear power stations. The need to build and deploy effective computing infrastructure is crucial to business and other organisations.

Operating systems are computer programs that control computers – allowing us to store information and run application software. They must support new hardware with multiple processors, ever faster and larger memories and a myriad of accessories and add-ons. You’ll go beyond Microsoft Windows to learn about alternative operating systems, how operating systems work, and how to set up secure systems.

The demand for people who have the skills to build new and better networks is ever expanding; today’s applications require more speed, mobility, reliability and capacity than yesterday’s, and tomorrow’s networks will require even more. You’ll gain those skills – learning from networks lecturers who have significant industry experience themselves, and who can show you cutting-edge research and development in this field.

BSC FOCUS AREA Computer Technology 3 years 360 points

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<td>MATH102</td>
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BCMS Only

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* Chosen from MATH2**, ENEL213, COMP221.

** Chosen from COMP301, COMP311, COMP313, COMP317, ENEL317, ENEL321.

*** Three papers chosen from COMP401, COMP413, COMP414, COMP418.

For the honours programme, 40 points at 200 level have to be replaced by two 300 level papers, and Year 4 requirements are COMP520 Report of an Investigation (45 points) plus five COMP5XX papers (15 points each).
FOCUS AREAS IN
COMPUTER SCIENCE
Cont’d

DATA MINING
This focus area will enable you to understand and use data mining techniques. The term data mining refers to the process of extracting potentially useful information from complex data using computational methods. Data mining has its roots in artificial intelligence, databases, and statistics. You will learn how to prepare the data for mining, get to know data mining algorithms, and learn to understand and evaluate the models that summarize the extracted information.

Compulsory papers from degree planner on page 35 for BCMS and page 37 for BSc, plus:

100 LEVEL
MATH101 Introduction to Calculus (15 points)

200 LEVEL
Highly recommended paper:
COMP219 Database Practice and Experience (20 points)

Plus it is highly recommended to take at least one of:
STAT221 Statistical Data Analysis (20 points)
STAT226 Bayesian Statistics (20 points)

300 LEVEL
Highly recommended papers:
COMP321 Practical Data Mining (20 points)
COMP329 Database Systems (20 points)
COMP317 Design and Analysis of Algorithms (20 points)

Recommended additional paper:
COMP316 Artificial Intelligence Techniques and Applications (20 points)

400 LEVEL (BCMS ONLY)
At least two of the following four papers:
COMP421 Machine Learning Algorithms (15 points)
COMP423 Data Stream Mining (15 points)
COMP455 Bioinformatics (15 points)
COMP456 Metaheuristic Algorithms (15 points)

Recommended additional papers:
COMP432 Information Visualisation (15 points)
COMP453 Extremely Parallel Programming (15 points)
**GAMES AND MULTIMEDIA**

This focus area combines creative design with a computer science education and the papers emphasise art, design, and creativity, and provide a background in related areas such as video, film and music. Students taking this focus area will usually have taken art related papers at high school or shown interest in other creative and artistic fields.

Compulsory papers from degree planner on page 35 for BCMS and page 37 for BSc, plus:

**100 LEVEL**

Highly recommended to also take at least two of:
- COMP125 Visual Computing (15 points)
- COMP126 Computing Media (15 points)
- MUSI140 Music and Computers (leads into MUSI240) (15 points)
- SMST101 Digital Screens (15 points)
- SMST102 Media Cultures (15 points)
- SMST112 Video Production 1 (leads into SMST212) (15 points)

**200 LEVEL**

COMP224 Visual Design for Interactive Media (20 points)

Highly recommended to also take at least one of:
- COMP223 Information Discovery (20 points)
- MUSI240 Screen Music Composition (20 points)
- SMST210 Small Studio Production 1 (20 points)
- SMST212 Video Production 2 (20 points)

Recommended to also take at least 20 points from:
- MATH251 Multivariable Calculus (10 points)
- MATH253 Linear Algebra (10 points)
- MATH255 Differential Equations (10 points)
- STAT221 Statistical Data Analysis (20 points)
- STAT226 Bayesian Statistics (20 points)

**300 LEVEL**

COMP324 Interaction Design (20 points)
- COMP325 Human-Computer Interaction (20 points)
- COMP336 Graphics and Computer Games (20 points)

Plus at least one of:
- COMP314 Software Engineering Project (20 points)
- COMP317 Design and Analysis of Algorithms (20 points)
Recommended to also take some of:
SMST318 Animation Studies (20 points)
SMST319 Games Studies (20 points)
CGRD350 Intern Project (20 points)

400 LEVEL (BCMS ONLY)
COMP424 Topics in Interaction Design (15 points)
COMP436 Advanced Graphics and Computer Games (15 points)

Plus at least one of:
COMP432 Information Visualisation (15 points)
COMP448 Developing Mobile Applications (15 points)
COMP450 Location-Based Systems as Context-Aware Systems (15 points)
INFORMATION SYSTEMS
The focus area concentrates on building appropriate information systems for many different kinds of situations. Information systems design, software development, information systems technologies, and practical work are strongly emphasised. It is valuable to have a good understanding of the area for which you are building a system therefore we recommend taking optional papers in your choice of application area, including papers in management, accounting, finance, HRM, operations management, with other areas possible.

Compulsory papers from degree planner on page 35 for BCMS and page 37 for BSc, plus:

100 LEVEL
Recommended to also take at least two of:
STMG191 Introduction to Management (15 points)
ACCT101 Accounting for Management (15 points)
PHIL103 Critical Reasoning (15 points)

200 LEVEL
COMP219 Database Practice and Experience (20 points)
Recommended to also take at least one of:
HRMG241 Organisational Behaviour (20 points)
MCOM231 Interpersonal Communication at work (20 points)
MCOM292 Business Communication (20 points)
PHIL218 Ethics at Work (20 points)

300 LEVEL
COMP315 Information Systems Development (20 points)
COMP329 Database Systems (20 points)
COMP325 Human-Computer Interaction (20 points)
Recommended to also take some of:
COMP321 Practical Data Mining (20 points)
COMP333 Web Applications Development (20 points)
COMP313 Topics in Programming Languages (20 points)
COMP317 Design and Analysis of Algorithms (20 points)
MCOM331 Managing Conflict and Consensus (20 points)

400 LEVEL (BCMS ONLY)
COMP442 Web Search: Technical and Social Issues (15 points)
COMP443 Information Management (15 points)
Plus at least one of:
COMP432 Information Visualisation (15 points)
COMP450 Location-Based Systems as Context-Aware Systems (15 points)
INTERACTION DESIGN
Interaction design is a rapidly growing field of study with a particular focus on complementary skills needed for the design, development, and evaluation of digital products and services that we use in our everyday lives. Interaction design is inherently inter-disciplinary in nature, and combines strong technical design skills with other forms of creative design skills. Interaction design practitioners therefore require a sound knowledge of computer science as well as having practical skills in applied areas such as interface design, psychology, etc.

Compulsory papers from degree planner on page 35 for BCMS and page 37 for BSc, plus:

100 LEVEL
Highly recommended to also take at least two of:
COMP126 Computing Media (15 points)
COMP125 Visual Computing (15 points)
PSYC103 General and Experimental Psychology (15 points)
SMST112 Video Production 1 (15 points)

200 LEVEL
COMP224 Visual Design for Interactive Media (20 points)

Highly recommended to also take at least one of:
COMP233 Internet Applications (20 points)
PSYC226 The Psychology of Perception (10 points) and PSYC230 Cognitive Psychology (10 points)
SSRP202 The Practice of Social Science Research (20 points)
STAT221 Statistical Data Analysis (20 points)

300 LEVEL
COMP324 Interactive Multimedia Systems (20 points)
COMP325 Human-Computer Interaction (20 points)

Plus at least one of:
COMP314 Software Engineering Project (20 points)
COMP317 Design and Analysis of Algorithms (20 points)
CGRD350 Intern Project (20 points)

400 LEVEL (BCMS ONLY)
COMP424 Interaction Design (15 points)

Plus at least one of:
COMP432 Information Visualisation (15 points)
COMP448 Developing Mobile Applications (15 points)
COMP450 Location-Based Systems as Context-Aware Systems (15 points)
INTERNET APPLICATIONS

The Internet is now an accepted part of people’s lives. We expect to be able to communicate, shop and access information from the convenience of our homes, or via smartphones or tablets when we are travelling. This focus area will enable you to understand and use the software that makes it all possible; from building individual web pages, through client and server scripting to provide interactivity, to the methods of identifying people visiting a website and storing information that will enable you to construct web based information systems.

Compulsory papers from degree planner on page 35 for BCMS and page 37 for BSc, plus:

200 LEVEL
COMP233 Internet Applications (20 points)
COMP219 Database Practice and Experience (20 points)

300 LEVEL
COMP333 Web Applications Development (20 points)
COMP325 Human-Computer Interaction (20 points)

Recommended to also take:
COMP312 Computer Networks (20 points)

400 LEVEL (BCMS ONLY)
COMP413 Topics in Computer Networks (15 points)
COMP442 Web Search: Technical and Social Issues (15 points)

Recommended to also take:
COMP418 Cyber Security (15 points)
COMP448 Developing Mobile Applications (15 points)
COMP450 Location-Based Systems as Context-Aware Systems (15 points)
NETWORKS

Computer networks are a fundamental infrastructure in a modern society. The uses and importance of computer networks continues to increase. These networks include the internet and the many private networks, such as those operated by banks, government agencies and large retail organisations. While all computing graduates need a basic understanding of computer networks, the networks focus area prepares students to take a major role in this dynamic and growing area. Students will gain an understanding of how computers communicate at a physical and logical level, the strengths and weaknesses of different communications protocols, the technologies underlying the internet and the trends and future of computer networks. The focus area includes both practical and theoretical aspects of computer networks.

Compulsory papers from degree planner on page 35 for BCMS and page 35 for BSc, plus:

200 LEVEL
Recommended to also take:
ENEL212 Electronics for Digital Systems (10 points)

300 LEVEL
COMP301 Operating Systems (20 points)
COMP312 Computer Networks (20 points)
Recommended to also take:
COMP311 Computer Systems Architecture

400 LEVEL (BCMS ONLY)
COMP413 Topics in Computer Networks (15 points)
COMP414 Carrier and ISP Networks (15 points)
COMP418 Cyber Security (15 points)
SOFTWARE DEVELOPMENT

Software development is the specification, design, implementation, documentation and maintenance of computer programs. The Software Development focus area will help you to take a systematic approach to the development of quality software, have an understanding of the software life cycle, gain an appreciation of the role of formal methods in software development, be familiar with a variety of programming languages and tools, and be able to use a wide selection of algorithms and data structures in your programming.

Compulsory papers from degree planner on page 35 for BCMS and page 37 for BSc, plus:

100 LEVEL
Recommended to also take one of:
PHIL102 Introduction to Logic (15 points)
PHIL103 Critical Reasoning (15 points)

200 LEVEL
Recommended to also take:
PHIL218 Ethics at Work (20 points)

300 LEVEL
COMP314 Software Engineering Project (20 points)

Plus at least two of:
COMP301 Operating Systems (20 points)
COMP313 Topics in Programming Languages (20 points)
COMP317 Design and Analysis of Algorithms (20 points)
COMP340 Reasoning about Programs (20 points)

400 LEVEL (BCMS ONLY)
At least three of:
COMP413 Topics in Computer Networks (15 points)
COMP440 Software Engineering Methodologies
COMP448 Developing Mobile Applications (15 points)
COMP452 Model Checking (15 points)
COMP453 Extremely Parallel Programming (15 points)
COMP454 Specification Languages and Models (15 points)
BACHELOR OF ENGINEERING (HONOURS) (BE(HONS)) SOFTWARE ENGINEERING

The Faculty of Computing & Mathematical Science offers Software Engineering only. For other engineering programmes, please contact the Faculty of Science & Engineering.

WHAT IS SOFTWARE ENGINEERING?
Software Engineers design the software that we increasingly rely on. Industrial robots, mobile phones, cars, trains, planes, DVD players, washing machines, computer games, energy networks, security systems – all these are driven by software. And that software must be reliable and flexible, usable and cost-effective – after all, we now depend absolutely on these devices. Building that kind of software requires a software engineer! The world is changing rapidly, and software engineers are at the forefront of many of those changes. Companies in New Zealand and overseas are looking for software engineering graduates.

Our BE(Hons) in Software Engineering, which is accredited by the professional body IPENZ, is a four-year degree that starts with programming and basic engineering ideas in the first year, progresses through more advanced design and programming techniques in the second year, then branches out into a wide variety of design and implementation challenges in the third and fourth years. You’ll also study professional ethics, marketing and engineering management.

After your second and third years of study you will spend each summer in paid employment – working in an industry setting, perhaps developing new software.

In your fourth year, half your time will be spent on a major project which will exercise the knowledge and skills you will have built up in the previous years.

SOME REASONS FOR STUDYING SOFTWARE ENGINEERING

• Our work placement scheme means that you’ll leave university with 800 hours of paid work experience in software engineering.
• The BE(Hons) papers emphasise innovation and practical business skills, so you’ll have the background to be an entrepreneur as well as an inventor.
• You will gain a qualification in what is projected to be one of the fastest growing occupations over the next five years.
## BACHELOR OF ENGINEERING (HONOURS) (BE(HONS)) SOFTWARE ENGINEERING

### BE(HONS) DEGREE PLANNER  Software Engineering 4 years  480 points

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<td>ENMP102, ENGG180</td>
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* Choose two of: CHEM100, CHEM111, CHEM112, ENEL111, STAT111, STAT121, or PHYS103

** Recommended papers: COMP401, COMP413, COMP414, COMP424, COMP426, COMP439, COMP440, COMP448, COMP452, COMP453 and COMP454.

### ENTRY REQUIREMENTS FOR THE BE(HONS) (SOFTWARE ENGINEERING ONLY)

To be guaranteed a place in the Bachelor of Engineering (Honours) in Software Engineering you must achieve University Entrance including a minimum of 16 credits at NCEA Level 3 Calculus plus at least 14 credits in each of two other approved subjects for University Entrance. The Software Engineering programme does not require Physics.

If you do not meet these requirements but are eligible to be admitted into a BSc degree you may be able to take relevant papers to build up your skills. For further information please contact the Faculty of Computing & Mathematical Sciences.

For further information on Engineering at Waikato see the website [www.eng.waikato.ac.nz](http://www.eng.waikato.ac.nz)
Your selection of papers should be based on your own needs and interests, but you should also check the prerequisites for papers you may want to take in future years, and make sure you enrol in any you will need.

SUPPORTING PROGRAMMES
If you intend to take only two or three Computer Science papers as support for another major subject, you should enrol initially in COMP123 The Computing Experience. The Computing Experience provides an introduction to computers and their use and can lead to further general Computer Science study at 200 level. This should also be your choice if you wish to take only one paper in Computer Science and have no previous experience.

COMP103-16A (HAM) & 16B (HAM)
INTRODUCTION TO COMPUTER SCIENCE 1
15 points
This paper introduces computer programming in C# – the exciting challenge of creating software and designing artificial worlds within the computer. It also covers concepts such as the internals of the home computer, the history and future of computers, how computers are changing society, and current research and challenges in computing.

Assessment Internal assessment/Final examination ratio 2:1 or 1:2, whichever works in your favour. The practical programme must be completed to the satisfaction of the co-ordinator for the paper.

COMP104-16B (HAM) & 16S (HAM)
INTRODUCTION TO COMPUTER SCIENCE 2
15 points
This paper continues from COMP103, assuming a knowledge of basic programming techniques, which it expands on particularly in the areas of data organisation and algorithms. It also provides an introduction to: code contracts, computer architecture, Boolean algebra, assembly language, program analysis, and object-oriented programming.

Prerequisite Paper(s) COMP103 or relevant computing experience subject to Chairperson’s approval
Restricted Paper(s) COMP134
Assessment Internal assessment/Final examination ratio 2:1 or 1:2, whichever works in your favour. The practical programme must be completed to the satisfaction of the co-ordinator for the paper.
COMP123-16A (HAM) & 16B (HAM) & 16S (HAM)
THE COMPUTING EXPERIENCE
15 points
This paper provides an introduction to the wealth of computer tools available for application in the sciences, the arts, and other disciplines. It is based on an intensive laboratory programme to give an overview of the nature and use of computers. A wide range of practical exercises is provided. You tailor the paper to your own needs and interests by selecting an appropriate set of these exercises. There are introductory practical sessions catering to the needs of those who have not used a computer before. More advanced exercises extend and challenge those with previous computing experience. The paper is recommended to students from all disciplines as an important contribution to a modern education.

Assessment Internal assessment/Final examination ratio 1:0. The practical programme must be completed to the satisfaction of the co-ordinator for the paper

Note(s) This paper is not normally available to students majoring in Computer Science.

COMP125-16A (HAM)
VISUAL COMPUTING
15 points
In this paper students will create multimedia web content using appropriate software packages. Web design concepts will be introduced for the effective use of text, images and sounds. Students will be introduced to relevant computing concepts and provided with software tutorials and related exercises.

Assessment Internal assessment/Final examination ratio 1:0

COMP126-16B (HAM)
COMPUTING MEDIA
15 points
In this paper students will create multimedia web content using appropriate software packages. Web design concepts will be introduced for the effective use of text, images and sounds. Students will be introduced to relevant computing concepts and provided with software tutorials and related exercises.

Assessment Internal assessment/Final examination ratio 1:0
**ENEL111-16A (HAM)**

**INTRODUCTION TO ELECTRONICS**

*15 points*

This paper covers basic electronic concepts. Topics include circuit theory, Thevenin’s theorem, resistors, capacitors, inductors and power sources, diodes, amplifiers, feedback, logic circuits, analog-to-digital and digital-to-analog converters.

**Assessment** Internal assessment/Final examination ratio 1:1
COMP200-16A (HAM)  
COMPUTER SYSTEMS  
10 points

This paper provides an overview of the operation of computer systems, including their hardware and software. The central theme of the paper is the way in which the hardware and software of a computer system co-operate to allow the execution of programs written in a high-level language.

Topics covered include: Data Representation, Assembly Language Programming, Operating Systems.

Prerequisite Paper(s) COMP104 or COMP134 or (COMP103 and ENEL111)

Assessment Internal assessment/Final examination ratio 1:1

COMP202-16B (HAM)  
COMPUTER COMMUNICATIONS  
10 points

This paper provides an overview of the technologies and protocols and security issues involved in computer communications. It will introduce programming issues in communications, including error handling and concurrency. Practical work will look at the Internet Protocols TCP, and IP, and include programming exercises using socket interfaces.

Prerequisite Paper(s) COMP104 or COMP134

Assessment Internal assessment/Final examination ratio 1:1

COMP203-16A (HAM)  
PROGRAMMING WITH DATA STRUCTURES  
10 points

This paper introduces programming with data structures using Java. It assumes a familiarity with basic object-oriented programming concepts and techniques, as introduced in COMP103 and COMP104 using the C# programming language. Students will learn how to program in Java and become familiar with the design, analysis, and application of commonly-used data structures, including stacks, queues, lists, trees, and sets.

Prerequisite Paper(s) COMP104 or COMP134

Restricted Paper(s) COMP241, COMP258

Assessment Internal assessment/Final examination ratio 1:0
COMP204-16B (HAM)
OBJECT-ORIENTED PROGRAM DESIGN
10 points

This paper introduces Project Management, UML, Design Patterns, TDD, OOD and Android. The primary language is Java with others used where appropriate.

Prerequisite Paper(s) COMP203
Restricted Paper(s) COMP242
Assessment Internal assessment/Final examination ratio 1:0

COMP219-16A (HAM)
DATABASE PRACTICE AND EXPERIENCE
20 points

Databases are increasingly being used in both small and large businesses as the cornerstone of modern information management systems. Through advances in client/server computing it is now possible to support corporate database activity on a variety of personal computer platforms.

The objective of this paper is to provide students with the knowledge and experience of a modern corporate relational database system. The paper will emphasise practical skills learned from a series of laboratory exercises.

Topics covered in both the laboratory and lecture programme will include: Data, Databases and DBMS, Database Design, Data Definition (SQL), Data Retrieval (SQL) Data Modification (SQL), Views, Triggers and Integrity Constraints, Security.

Prerequisite Paper(s) COMP103
Assessment Internal assessment/Final examination ratio 1:0
COMP221-16A (HAM) & 16B (HAM) & 16S (HAM)

INTRODUCTION TO 3D MODELLING AND ANIMATION

10 points

Introduces 3D modelling concepts through self-paced laboratory exercises. Students will use polygons, nurbs, and texturing to develop simple scenes. Basic key framing, path animation, and the use of dynamics are explored, along with the effects of lighting and cameras for rendering.

Prerequisite Paper(s) COMP103 or COMP123
Assessment Internal assessment/Final examination ratio: 1:0
Restrictions Students enrolling in this paper and one of COMP223/COMP278 cannot include the 3D Modelling and Animation practicals in their COMP223/COMP278 module selections

COMP223-16A (HAM) & 16B (HAM) & 16S (HAM) & 16A (TGA)

INFORMATION DISCOVERY

20 points

This paper can be taken as a follow on to COMP123 The Computing Experience or directly by students with prior experience at using computers. The paper provides an opportunity to widen your experience of computer software. It is based on an intensive laboratory programme, where you are able to tailor the paper to your own needs and interests by selecting an appropriate set of modules.

Modules Include: Video editing, information presentation, exploitation of information sources, computer game construction, animation and 3D modelling. Please note that module availability may vary depending on resources.

Prerequisite Paper(s) No prerequisite papers but assumes prior experience at using computers
Assessment Internal assessment/Final examination ratio 1:0

COMP224-16A (HAM)

VISUAL DESIGN FOR INTERACTIVE MEDIA

20 points

This paper is a practical study of computer graphic design principles; covering topics such as graphic design techniques, typography, colour, digital images, designing for computer displays and the web.

Prerequisite Paper(s) One of CGRD141 or COMP126
Restricted Paper(s) CGRD241, CGRD224
Assessment Internal assessment/Final examination ratio 1:0
COMP233-16B (HAM)
INTERNET APPLICATIONS
20 points

This paper provides a broad overview of the principles and technologies used in Internet Applications, with practical experience of client-side and server-side programming. Client-side topics include HTML, CSS and Javascript to support the development of interactive web pages containing a variety of media. Server-side topics focus on the development of database-driven websites using PHP and MySQL to dynamically generate web page content.

Prerequisite Paper(s) COMP103
Assessment Internal assessment/Final examination ratio 2:1

COMP235-16B (HAM)
LOGIC AND COMPUTATION
20 points

Please see Page 89 for more information.

COMP241-16A (HAM)
SOFTWARE ENGINEERING DEVELOPMENT
10 points

This paper introduces programming with data structures using Java, and software engineering practices such as unit testing and pre/post specification. Students will learn how to program in Java and become familiar with the design, analysis, and application of commonly-used data structures, including stacks, queues, lists, trees, and sets.

Prerequisite Paper(s) COMP104 or COMP134
Restricted Paper(s) COMP203
Assessment Internal assessment/Final examination ratio 1:0

COMP242-16B (HAM)
SOFTWARE ENGINEERING PROCESS
10 points

This paper introduces Project Management, UML, Design Patterns, TDD, OOD and Android. The primary language is Java with others used where appropriate.

Prerequisite Paper(s) COMP241
Restricted Paper(s) COMP204
Assessment Internal assessment/Final examination ratio 1:0
COMP258-16A (HAM)
PROGRAMMING USABLE SYSTEMS
20 points

The paper develops the basic programming expertise gained in COMP103, and introduces issues of software usability. The paper is practically oriented, with laboratory sessions, problem-solving tutorials and small to medium-sized project work providing opportunity for application of newly-learned skills and techniques. Object-oriented software development techniques (including use-case analysis, object modelling and implementation) will be addressed, and aspects of designing usable software (including prototyping, design principles, component use, layout and feedback) will be introduced.

Prerequisite Paper(s) COMP103
Restricted Paper(s) COMP203, COMP241
Assessment Internal assessment/Final examination ratio 1:1

COMP278-16A (HAM) & 16B (HAM) & 16S (HAM)
INTERACTIVE COMPUTING
20 points

Students can select from a variety of themes, including 3D modelling and animation; video editing; information presentation; computer game construction; and human-computer interaction.

Prerequisite Paper(s) COMP103 or COMP123
Assessment Internal assessment/Final examination ratio: 1:0

ENEL212-16A (HAM)
ELECTRONICS FOR DIGITAL SYSTEMS
10 points

This paper covers the theory, design and applications of logic circuits and technology related to digital systems.

Prerequisite Paper(s) ENEL111 or COMP104
Restricted Paper(s) ENEL211
Assessment Internal assessment/Final examination ratio: 1:1
COMP301-16B (HAM)
OPERATING SYSTEMS
20 points
This paper focuses on operating systems design and implementation. Topics include operating system architecture, process management, inter-process communication, and deadlock memory management devices.

Prerequisite Paper(s) COMP200, and one of COMP203 or COMP241
Assessment Internal assessment/Final examination ratio 1:0. The practical programme must be completed to the satisfaction of the co-ordinator of the paper.

COMP311-16B (HAM)
COMPUTER SYSTEMS ARCHITECTURE
20 points
This paper explains the inner workings of CPUs. The paper covers the following topics in detail: CPU System Components and ALU Internals; Single Cycle, Multicycle and Pipelined ISA Architectures; Cache and Memory hierarchies; Multicore Data Synchronisation; Virtual Memories and TLBs and provides introductions to alternate architectures including SISD, MISD, SIMD and MIMD. Verilog is used for the related labs.

Prerequisite Paper(s) COMP200, and one of COMP203, COMP206 or COMP241
Assessment Internal assessment/Final examination ratio 1:0

COMP312-16A (HAM)
COMPUTER NETWORKS
20 points
A study of computer networks with a focus on internet protocols. The aim of this paper is to develop a practical understanding of the operation and programming of core internet protocols, application protocols and transmission technologies.

Topics covered include: Review of basic communications concepts, IPv4 and IPv6, TCP, Routing principles, Interior routing protocols including OSPF, External routing protocols (BGP), DNS, Network applications and application protocols, Ethernet, Other transmission technologies.

Prerequisite Paper(s) COMP202, and one of COMP203 or COMP241
Assessment Internal assessment/Final examination ratio 1:1
COMP313-16A (HAM)
TOPICS IN PROGRAMMING LANGUAGES
20 points

This paper deals with the design, implementation and use of a selection of programming languages. **Topics will be selected from:** The history and future of programming languages, Grammars and parsing techniques, Language implementation issues (interpreters, compilers, garbage collection), Practical language semantics, Language support for object-orientation, Declarative programming languages.

Prerequisite Paper(s) COMP200, and one of COMP203 or COMP241
Assessment Internal assessment/Final examination ratio 1:0

COMP314-16B (HAM)
SOFTWARE ENGINEERING PROJECT
20 points

Students will contribute to all aspects of building a medium-sized piece of software: developing requirements and specification; designing the system structure and user-interface; carrying out documentation, implementation and maintenance. This work is complemented by lectures which cover these items and also introduce other important software engineering ideas.

Prerequisite Paper(s) COMP204 or COMP242
Restricted Paper(s) COMP315
Assessment Internal assessment/Final examination ratio 1:0

COMP315-16B (HAM) & 16B (TGA)
INFORMATION SYSTEMS DEVELOPMENT
20 points

This project-based paper covers advanced topics in information systems development, while emphasising their application during an actual information systems development project.

The paper will be of interest to those majoring in computer science and information systems and also to students in other Faculties who wish to deepen their understanding of information systems design beyond that covered in COMP219 Database Practice and Experience, and to obtain hands-on experience with these systems in a real business environment.

Prerequisite Paper(s) COMP219
Restricted Paper(s) COMP314
Assessment Internal assessment/Final examination ratio 1:0
**COMP316-16A (HAM)**
**ARTIFICIAL INTELLIGENCE TECHNIQUES AND APPLICATIONS**
*20 points*

This paper gives an overview of artificial intelligence, including intelligent search, logic-based and probabilistic knowledge representation and reasoning, and machine learning.

**Prerequisite Paper(s)** COMP203 or COMP241  
**Assessment** Internal assessment/Final examination ratio 2:1 or 1:2, whichever works in your favour

**COMP317-16B (HAM)**
**DESIGN AND ANALYSIS OF ALGORITHMS**
*20 points*

This paper is concerned with fundamental data structures and their algorithms. It involves a study of classical and recently discovered methods, aimed at giving students an awareness of techniques for solving a diverse range of problems using a computer. Analysis of important performance characteristics, efficiency and scalability and discussion of issues pertaining to applicability, adaptation and design will also be addressed. This is an essential paper for students interested in the art and science of computer programming.

**Prerequisite Paper(s)** COMP203 or COMP241  
**Assessment** Internal assessment/Final examination ratio 2:1

**COMP321-16B (HAM) & 16B (TGA)**
**PRACTICAL DATA MINING**
*20 points*

This paper is a practical introduction to data mining. Students will gain hands-on experience using the WEKA open-source data mining software developed by the Computer Science Department and used by companies and universities both in New Zealand and overseas.

**Prerequisite Paper(s)** COMP103 and 20 points at 200 level in Computer Science  
**Assessment** Internal assessment/Final examination ratio 2:1
COMP324-16A (HAM)
INTERACTION DESIGN
20 points

This paper introduces interactive multimedia systems, covering topics such as design, development and evaluation of multimedia applications. Students will acquire a theoretical and practical understanding of interactive multimedia systems and will be able to design, develop and evaluate such systems.

Prerequisite Paper(s) CGRD224, CGRD242 or COMP224
Assessment Internal assessment/Final examination ratio 2:1

COMP325-16B (HAM) & 16B (TGA)
HUMAN–COMPUTER INTERACTION
20 points

This paper provides an introduction to the field of human-computer interaction (HCI), to enable students to gain a sound understanding of, and appreciation for, the importance of the HCI, to develop skills and techniques for the design and implementation of modern computer interfaces, to understand the role of interface design in the system life-cycle, and to gain experience in the study of software usability.

Prerequisite Paper(s) One of COMP203, COMP241, COMP233, COMP258, CGRD224, CGRD242, or COMP224
Assessment Internal assessment/Final examination ratio 2:1

COMP329-16A (HAM)
DATABASE SYSTEMS
20 points

This paper provides an introduction to the advanced features of database management systems. Students will have hands-on practice in using these features to administer a large database. The specific attributes that successful students will acquire are:

• An understanding of the role of the database administrator in managing large complex databases
• Skill at database design for large, complex data sets
• The ability to effectively use advanced database administrator functions of a database management system.

Prerequisite Paper(s) COMP219 and one of COMP203, COMP204, COMP241, COMP242, COMP258
Assessment Internal assessment/Final examination ratio 2:1 or 1:2, whichever works in your favour
COMP333-16A (HAM) & 16A (TGA)
WEB APPLICATIONS DEVELOPMENT
20 points

This paper covers a range of topics relating to the development of software applications delivered via the web. These include: the latest developments in HTML, CSS and JavaScript; asynchronous client-server communication using AJAX; security issues; Object Oriented Javascript; JSON; Javascript libraries; consuming and creating RESTful web services; XML.

Prerequisite Paper(s) COMP233
Assessment Internal assessment/Final examination ratio 1:0

COMP336-16B (HAM)
GRAPHICS AND COMPUTER GAMES
20 points

This paper introduces interactive computer graphics, 3D modelling, real-time rendering, and animation; as applied to computer games. Topics covered include: vector graphics, 3D modelling and animation, and real time rendering with an introduction to shaders. Practical work will involve programming computer game scene presentation and interaction, including camera motion, navigation, collision detection and character animation.

Prerequisite Paper(s) COMP258 or COMP204
Assessment Internal assessment/Final examination ratio 2:1

COMP340-16A (HAM)
REASONING ABOUT PROGRAMS
20 points

This paper introduces predicate logic as it is used in various areas of software development and artificial intelligence, as well as Hoare logic and its use for program verification. Methods of reasoning in logic and automated theorem proving are discussed. In the laboratories, students learn to practice software verification using modern proof tools.

Prerequisite Paper(s) COMP103 and (COMP235 or MATH258) and (COMP203 or COMP241 or 40 points at 200 level in Mathematics)
Assessment Internal assessment/Final examination ratio 1:1
COMP390-16A (HAM) & 16B (HAM) & 16C (HAM) & 16C (TGA)
DIRECTED STUDY
20 points
A directed study paper involving the design, implementation and testing of the solution to a hardware and/or software engineering problem; and production of a formal report.

Assessment Internal assessment/Final examination ratio 1:0

PLACEMENT PAPERS
This section contains placement papers offered for BSc(Tech) students only

COMP371-16C (HAM)
COMPUTER SCIENCE PLACEMENT 1
20 points
This paper is only available to BSc(Tech) students.

COMP372-16C (HAM)
COMPUTER SCIENCE PLACEMENT 2
20 points
This paper is only available to BSc(Tech) students.

COMP373-16C (HAM)
COMPUTER SCIENCE PLACEMENT 3
20 points
This paper is only available to BSc(Tech) students.
COMP401/501-16A (HAM)
TOPICS IN OPERATING SYSTEMS
15 points
One or more topics in operating systems implementation at an advanced level.

Prerequisite Paper(s) Three 300 level Computer Science papers, including COMP301
Restricted Paper(s) COMP412 and COMP512
Assessment Internal assessment/Final examination ratio 1:0

COMP402/502-16B (HAM)
CRYPTOGRAPHY
15 points
An introduction to cryptographic methods.

Prerequisite Paper(s) COMP235 or MATH258
Restricted Paper(s) MATH320
Assessment Internal assessment/Final examination ratio 1:0

COMP413/513-16A (HAM)
TOPICS IN COMPUTER NETWORKS
15 points
One or more special topics in computer networks, at an advanced level.

Prerequisite Paper(s) (COMP202 and 60 points at 300 level in Computer Science) or COMP414/514 or COMP418/518
Assessment Internal assessment/Final examination ratio 1:0

COMP414/514-16B (HAM)
CARRIER AND ISP NETWORKS
15 points
This paper studies large scale networks as used for public internet infrastructure. It covers the technologies used to implement such networks in a practical manner.

Prerequisite Paper(s) (COMP312 and a further 40 points at 300 level in Computer Science) or COMP413/513 or COMP418/518
Assessment Internal assessment/Final examination ratio 1:0
**COMP418/518-16B (HAM)**

**CYBER SECURITY**

*15 points*

This paper introduces the key topics in the important field of cyber security. It will cover a range of topics relating to defensive security (e.g., malware analysis, social engineering, intrusion detection and prevention), offensive security (e.g., pen testing, Web app security) and preventative security (e.g., cryptography, applied cryptography, access control, risk and governance).

**Prerequisite Paper(s)** (COMP202 and 60 points at 300 level in Computer Science) or COMP413/513 or COMP414/514

**Assessment** Internal assessment/Final examination ratio 1:0

**COMP421/521-16A (HAM)**

**MACHINE LEARNING ALGORITHMS**

*15 points*

This paper covers machine learning algorithms such as the ones implemented in the WEKA machine learning workbench at a more advanced level, including techniques that deliver state-of-the-art predictive performance.

**Prerequisite Paper(s)** Three 300 level Computer Science papers, including COMP321 or COMP316

**Assessment** Internal assessment/Final examination ratio 1:0

**COMP423/523-16B (HAM)**

**DATA STREAM MINING**

*15 points*

Data streams are everywhere, from F1 racing over electricity networks to news feeds. Data stream mining relies on and develops new incremental algorithms that process streams under strict resource limitations. This paper focuses on, as well as extends the methods implemented in MOA, an open source stream mining software suite currently being developed by the Machine Learning group.

**Prerequisite Paper(s)** Three 300 level Computer Science papers, including COMP321 or COMP316

**Assessment** Internal assessment/Final examination ratio 1:0
COMP424/524-16B (HAM)
TOPICS IN INTERACTION DESIGN
15 points

This paper offers advanced topics in interaction design. It takes a practical approach to interaction design for better user experience.

Prerequisite Paper(s) COMP324 or COMP325
Restricted Paper(s) CGRD524, COMP438, COMP538
Assessment Internal assessment/Final examination ratio 1:0

COMP426/526-16A (HAM)
ENGINEERING INTERACTIVE SYSTEMS
15 points

This paper introduces the topic of engineering methods for interactive systems. It provides both the background theory and practical methods for modelling and testing interactive systems.

Prerequisite Paper(s) COMP340
Assessment Internal assessment/Final examination ratio 1:0

COMP427/527-16B (HAM)
CLOUD COMPUTING TECHNOLOGIES AND SECURITY
15 points

This paper explores cloud computing’s underlying enabling technologies (eg virtualisation) and business models. It also covers key research topics in cloud computing security, trust and data privacy.

Prerequisite Paper(s) COMP312, COMP301
Assessment Internal assessment/Final examination ratio 1:0
COMP432/532-16B (HAM)
INFORMATION VISUALISATION
15 points

Information visualisation is concerned with the design and implementation of presentations of often complex information in such a way that users are able to efficiently and effectively extract the relevant features in and for their given context, and are able to gain insight about the information which might not otherwise have been possible. This paper aims to provide an awareness of the potential offered by visualisation techniques, a familiarity with the underlying concepts, and an understanding and ability to effectively design and apply information visualisations in a given context.

Prerequisite Paper(s) Three 300 level Computer Science or Computer Graphic Design papers
Restricted Paper(s) CGRD532
Assessment Internal assessment/Final examination ratio 1:0

COMP436/536-16A (HAM)
ADVANCED GRAPHICS AND COMPUTER GAMES
15 points

A lecture and laboratory based paper on the use of 3D immersive computer game engines. Topics will include 3D modelling, texturing, lighting effects, use of pixel shaders, game physics, scripting of game play, and use of games engines for non game program development.

Prerequisite Paper(s) COMP336 and a further 40 points at 300 level in Computer Science
Assessment Internal assessment/Final examination ratio 1:0

COMP439/539-16B (HAM)
USABILITY ENGINEERING
15 points

This paper covers the design and evaluation of interactive computer systems with a focus on user studies. Topics covered include: designing and performing user studies ethnography, automated usability evaluation, and ethical issues involved in studying human-computer interaction.

Prerequisite Paper(s) Three 300 level Computer Science papers, including COMP325
Restricted Paper(s) COMP425 and COMP525
Assessment Internal assessment/Final examination ratio 1:0
COMP440/540-16B (HAM)
SOFTWARE ENGINEERING METHODOLOGIES
15 points

This paper focuses on modern software design and development methodologies, with emphasis on the ‘lightweight’ methods. The paper will also examine safety-critical aspects of software engineering, in particular how safety analysis fits into the software life cycle.

Prerequisite Paper(s) Three 300 level Computer Science papers, including COMP314 or COMP315
Assessment Internal assessment/Final examination ratio 1:0

COMP442/542-16A (HAM)
WEB SEARCH: TECHNICAL AND SOCIAL ISSUES
15 points

This paper covers the operation of web search engines, the development of web spam and techniques for combatting it, and social issues raised by centralised search engines.

Prerequisite Paper(s) Three 300 level Computer Science papers, and either COMP204 or COMP242
Assessment Internal assessment/Final examination ratio 1:0

COMP443/543-16B (HAM)
INFORMATION MANAGEMENT
15 points

One or more special topics in Information Management, at an advanced level.

Prerequisite Paper(s) 60 points at 300 level in Computer Science, Philosophy, Management Communication or Management Systems
Assessment Internal assessment/Final examination ratio 1:0
**COMP448/548-16B (HAM)**
**DEVELOPING MOBILE APPLICATIONS**

*15 points*

This paper will consider the design and implementation of applications for mobile devices covering topics such as: mobile application software architectures; development platform options; design and evaluation of small-screen touch-based user interfaces; leveraging technologies such as global positioning, near-field communication and orientation/environmental sensing; mobile web applications and publishing to application stores. Practical work will use the Android platform and so the paper is best-suited to students with experience of Java programming.

**Prerequisite Paper(s)** 60 points at 300 level in Computer Science

**Assessment** Internal assessment/Final examination ratio 1:0

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**COMP450/550-16A (HAM)**
**LOCATION-BASED SYSTEMS AS CONTEXT-AWARE SYSTEMS**

*15 points*

This paper will introduce techniques of location-based and context-aware systems (such as GPS and personalisation). Participants will develop a location-based system and evaluate its qualities as an information system. The lecturer has extensive experience with research in location-based systems – course participants will get hands-on experience with currently ongoing research systems.

**Prerequisite Paper(s)** COMP329

**Assessment** Internal assessment/Final examination ratio 1:0

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**COMP452/552-16A (HAM)**
**MODEL CHECKING**

*15 points*

This paper shows how reactive systems can be modelled and analysed using finite-state machines and temporal logic, and how model checking tools can be used to verify crucial properties of safety-critical systems. The paper also provides an introduction into the algorithms and data structures used to model check very large finite-state systems.

**Prerequisite Paper(s)** COMP235 and 60 points at 300 level in Computer Science

**Assessment** Internal assessment/Final examination ratio 1:0
COMP453/553-16A (HAM)
EXTREMELY PARALLEL PROGRAMMING
15 points

This paper covers advanced parallel programming for large-scale parallelism. A variety of programming techniques will be covered, with application to cluster computers, GPU computing, many-core computing. This paper will be taught using a mixture of classroom and online delivery modes.

Prerequisite Paper(s) COMP203 or COMP241 and COMP204 or COMP242, or equivalent Java and JUnit experience
Assessment Internal assessment/Final examination ratio: 1:0

COMP454/554-16B (HAM)
SPECIFICATION LANGUAGES AND MODELS
15 points

This paper deals with various aspects of modelling systems using advanced good practice methods from the software engineering field. It will introduce at least one of the main software modelling languages, Z, including its semantics, logic and associated tools.

Prerequisite Paper(s) COMP235, COMP340 and a further 40 points at 300 level in Computer Science
Assessment Internal assessment/Final examination ratio: 1:0

COMP455/555-16A (HAM)
BIOINFORMATICS
15 points

An introduction to bioinformatics, open to students majoring in computer science or biology. It includes an overview of molecular biology, genomics, script language programming, algorithms for biological data, an introduction to machine learning and data mining.

Prerequisite Paper(s) 60 points at 300 level in Computer Science and/or Biology, including either COMP317 or BIOL310 plus STAT111 or STAT121
Assessment Internal assessment/Final examination ratio 1:0
This paper explores common metaheuristic algorithms such as stimulated annealing and genetic algorithms, and their application in areas such as finance, engineering and science.

Prerequisite Paper(s) Either COMP316 or COMP321 and a further 40 points at 300 level in Computer Science
Assessment Internal assessment/Final examination ratio 1:0

One or more special topics in computer science, at an advanced level.

Prerequisite Paper(s) Three 300 level Computer Science papers
Assessment Internal assessment/Final examination ratio 1:0

Note(s) Admission to this paper is at the discretion of the Chairperson of Department.

A directed study investigation and report on an approved project or study topic under the supervision of a lecturer. Students should obtain the lecturer’s approval and signature on a directed study enrolment sheet (available from the Computer Science department office).

Prerequisite Paper(s) Students must qualify for entry according to the criteria determined by the Dean
Assessment Internal assessment/Final examination ratio 1:0

Note(s) This paper is available only to students undertaking a non-honours degree programme for the BCMS by permission of the Dean.
COMP520-16C (HAM) & 16D (HAM)
REPORT OF AN INVESTIGATION
45 points
A directed study investigation and report on an approved project or study topic under the supervision of a lecturer. Students should obtain the lecturer’s approval and signature on a directed study enrolment sheet (available from the Computer Science department office).

Prerequisite Paper(s) Students must qualify for entry according to the criteria determined by the Dean
Restricted Paper(s) COMP420 and MATH520
Assessment Internal assessment/Final examination ratio 1:0

ENGG501-16A (HAM)
CONTROL THEORY AND IMAGE PROCESSING
30 points
This paper deals with PID feedback control of linear systems using classical as well as state space methods. It is highly computer and project based.

Prerequisite Paper(s) ENEL317 or ENME352
Restricted Paper(s) ENGG401
Assessment Internal assessment/Final examination ratio 1:0

ENEL417/517-16A (HAM)
MECHATRONICS
20 points/30 points
This paper covers an advanced treatment of the control of electromechanical systems, especially robotics.

Prerequisite Paper(s) ENEL317
Assessment Internal assessment/Final examination ratio 1:0

LAWS526-16A (HAM)
LEGAL ASPECTS OF CYBER SECURITY
30 points
This paper explores the legal aspects of cyber security and cyber crime, by analysing selected legislation and case law relevant to the area of cyber security. The paper covers the ethical and legal boundaries of rights and liability of security professionals.

Assessment Internal assessment/Final examination ratio 1:0.
COMP107
TOPICS IN COMPUTER SCIENCE

COMP124
HE TOMOKANGA KI TE AO ROROHIKO

COMP205
INTERNSHIP PAPER 1

COMP305
INTERNSHIP PAPER 2

COMP505
INTERNSHIP PAPER 3

COMP422/522
RELATIONAL DATA MINING

COMP428/528
MIXED INTEGER PROGRAMMING

COMP435/535
IMAGE PROCESSING

COMP437/537
USER INTERFACES FOR INFORMATION RETRIEVAL

COMP438/538
TOPICS IN HUMAN-COMPUTER INTERACTION

COMP589
PROGRAMMING FOR RESEARCH

COMP590
RESEARCH IN COMPUTER SCIENCE
MATHEMATICS
INTRODUCTION

A graduate with a mathematics degree, or even with a strong mathematical component to his/her degree, is a valuable person in today’s world.

WHY STUDY MATHEMATICS?

Studying mathematics in combination with another area means you can work on problems in other fields such as chemistry, biology, earth sciences, medicine, computing, economics, finance, engineering, physics, electronics, banking and meteorology, to name just a few. A solid mathematics background also makes it easy to have a career in teaching. In fact, mathematics is used in almost every type of business, large and small.

GRADUATES HAVE STARTED THEIR CAREERS IN JOBS SUCH AS:

- Strategic management consultant
- System implementation analyst
- Consents engineer
- Data analysts
- Payments analyst
- Policy analyst
- Technical associate
- Model analyst
- Market analyst
- Risk management analyst for the Reserve Bank
- Financial data analyst.

TESS BENSEMAN
BCMS MATHEMATICS AND ANTHROPOLOGY
CHAIRPERSON
TBC

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Combinatorics: latin squares; defining sets; graph decompositions; graph labellings.

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HONORARY FELLOWS
Alfred Sneyd
BA, BSc, MSc Auck PhD Camb

John Turner
MSc Leeds DPhil Waik
With a good mathematics degree you will be attractive to employers in a wide range of occupations, not just those directly using Mathematics. This is because your degree is a demonstration that you have problem-solving skills and clear analytical thinking.

BCMS(HONS) DEGREE PLANNER  Mathematics 4 years 480 points

<table>
<thead>
<tr>
<th>Level</th>
<th>Courses</th>
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| 100 level | MATH102  
COMP104*  
STAT111  
COMP103*   |
| 200 level | MATH251 AND MATH252  
MATH253 AND MATH255  
20pt MATH OR COMP235  
200 level*  
200 level or above |
| 300 level | MATH311  
MATH3XX OR COMP340  
300 level  
300 level |
| 500 level | MATH520  45 points  
MATH5XX  15 points  
500 level  30 points  
500 level  30 points |

* BCMS(Hons) regulation 10 requires 50 points from subjects in the field other than the major including at least 20 points above 100 level. COMP103, COMP104 and STAT111/121 will help satisfy these requirements and are strongly recommended in their own right. These papers also help students keep their options open for changing to another major with the Faculty if desired.

Candidates must also include 50 points from a Faculty or School of studies other than the Faculty of Computing & Mathematical Sciences, with at least 20 points above 100 level.
BACHELOR OF SCIENCE (BSC)

If you wish to do a three-year degree which provides a solid grounding in mathematics, then you may consider doing a BSc degree majoring in Mathematics. Doing mathematics helps you to develop analytical skills and logical thinking that are valuable outside mathematics itself. Such skills are attractive to a wide range of employers. Besides mathematics papers, majoring students usually include some papers in Computer Science and in Statistics. If you are also interested in economics and finance, you may choose to do a double major.

BSC DEGREE PLANNER Mathematics 3 years 360 points

100 level
- MATH101
- MATH102
- STAT121* OR STAT111
- COMP103*
- COMP104*

200 level
- MATH251 AND MATH252
- MATH253 AND MATH255
- 20pt MATH OR COMP235
- 200 level
- 200 level or above

300 level
- MATH311
- MATH3XX
- MATH3XX OR COMP340
- 300 level

BACHELOR OF SCIENCE (HONOURS) (BSC(HONS))

BSC(HONS) DEGREE PLANNER Mathematics 1 year 120 points

500 level
- MATH591 30 points
- MATH5XX 15 points
- MATH5XX 15 points
- 500 level 30 points
- 500 level 30 points

ADMISSION TO HONOURS PROGRAMME

Candidates will require a major in Mathematics in the BSc degree with an average grade of B in 80 points in 300 level Mathematics. BSc(Hons) students complete 120 points at 500 level including a 30 point dissertation (MATH591). In rare circumstances, students may be permitted to enrol in a larger dissertation.
DOUBLE MAJORS

Able students may wish to consider doing a BSc/BCMS(Hons) double major with one major in Mathematics and the other major in another subject, for example in either Computer Science, Economics or Finance. For further details about a double major, contact the Faculty Reception (cms@waikato.ac.nz).

For a BSc double major, students must complete:
• 120 points at 100 level
• 120 points at 200 level – 60 points in each major
• 120 points at 300 level – 60 points in each major

Double majors in Computer Science and Mathematics
Flexible double major programmes in Computer Science and Mathematics are available. Students with this qualification should be very attractive to employers, but it is also ideal for students interested in areas such as artificial intelligence, formal methods, the theory of algorithms, and data mining.

Students doing the BCMS(Hons) will need to complete 60 points in each subject at 500 level. In the Honours year, exactly one of the Honours project papers COMP520 and MATH520 will need to be selected. Students who opt for COMP520 (45 points) are usually permitted to take up to two 15-point COMP papers rather than just one, and vice versa for those opting to take MATH520. Sometimes Honours projects with supervision from both subjects are possible, which can add further flexibility to the choice of papers.

BSC DOUBLE MAJOR DEGREE PLANNER Mathematics and Economics 3 years 360 points

*Science Papers should be recognised papers offered by the Faculty of Science & Engineering or the Faculty of Computing & Mathematical Sciences (except MATH168) and PHIL102, PSYC102 and PSYC103. These papers must be taken across four science subjects.

Note(s) COMP235 Logic and Computation and COMP340 Reasoning about Programs can count towards the Mathematics major. No more than 40 points of FINA coded papers may be included in an Economics major.
### BSC DOUBLE MAJOR DEGREE PLANNER  
**Mathematics and Finance 3 years 360 points**

#### 100 level

- **MATH101**
- **MATH102**
- **STAT160**
- **100 level***
  - **Compulsory paper**
- **100 level***
- **100 level***
- **100 level**
  - **Science paper**

#### 200 level

- **MATH251**
  - **AND**
- **MATH252**
  - **MATH253**
  - **AND**
- **MATH255**
  - **20pt MATH or COMP235**
  - **FINA201**
  - **Elective Paper**
- **ECON204**
- **FINA3XX**

#### 300 level

- **MATH311**
- **MATH3XX**
- **MATH3XX**
  - **OR**
- **COMP340**
  - **FINA311**
- **FINA312**
- **FINA3XX**

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*Science Papers should be recognised papers offered by the Faculty of Science & Engineering or the Faculty of Computing & Mathematical Sciences (except MATH168) and PHIL102, PSYC102 and PSYC103. These papers must be taken across four science subjects.*

*No more than 40 points of ECON coded papers may be included in an Finance major.*
100 LEVEL PAPERS

Introduction to Calculus and Introduction to Algebra are each offered in both Semester A and Semester B. Both are essential for Mathematics majors, for students who might wish to have the option of going on to 200 level Mathematics papers, and for students who require a good mathematics foundation for their other university studies.

Students admitted to a Bachelor of Engineering degree (BE(Hons)) must take MATH101 Introduction to Calculus and MATH102 Introduction to Algebra.

Admission to the paper MATH101 Introduction to Calculus and MATH102 Introduction to Algebra is guaranteed for students who meet the entry criteria (please see page 86).

For students who do not meet the entry requirement for the two main papers, there are two closely related introductory mathematics papers: MATH165 General Mathematics and MATH166 Management Mathematics. A sufficient entry requirement for both is 18 credits at NCEA Level 2 Mathematics or 10 credits from NCEA Level 3 Calculus or 14 credits from NCEA Level 3 Mathematics. Again, those not meeting these requirements will be considered on a case-by-case basis. These two papers are offered in both Semester A and Semester B. They provide a broad introduction to algebra and calculus, and a pass in either enables progression into one or both of the two main 100 level papers.

The paper MATH168 Preparatory Mathematics is targeted at students who do not meet the requirements for General Mathematics or Management Mathematics. This is a good paper for either a second chance or a mature returning student, or a person who wishes to embark on a new direction at university. A pass with a B- or better in Preparatory Mathematics will enable entry to General Mathematics or Management Mathematics.
MATH101-16A (HAM) & 16B (HAM) & 16S (HAM)
INTRODUCTION TO CALCULUS
15 points

This paper is fundamental to the study of mathematics at university, whether you wish to advance in mathematics or use the theories and techniques in the study of other subjects.

Paper Content Functions, limits and continuity, the derivative and its geometric meaning, rules for differentiation, the chain rule and higher derivatives, the mean value theorem, and Taylor series. Applications of the derivative including curve sketching, maxima and minima, related rates. The integral as an area, fundamental theorem of calculus, techniques of integration, including substitution and integration by parts. Applications of the integral including the calculation of volumes. The logarithm, exponential and hyperbolic functions, inverse functions. Elementary differential equations and their applications.

Prerequisite Paper(s) MATH165, MATH166, MATH102, at least a B grade in CAFS004; or 16 credits of NCEA Level 3 Calculus including at least 11 credits from AS91577, AS91578 and AS91579; or equivalent (eg the Cambridge examinations). Those not meeting these criteria will be considered on a case-by-case basis.

Assessment Internal assessment/Final examination ratio 1:1

MATH102-16A (HAM) & 16B (HAM)
INTRODUCTION TO ALGEBRA
15 points

This paper gives an introduction to the algebra needed in all areas of mathematics and subjects which use mathematical methods.

Paper Content Vector algebra with three-dimensional geometry; complex numbers – basic operations, polar representation and de Moivre’s theorem; systems of linear equations; matrix operations, inverses, and determinants; introduction to eigenvalues and linear transformations.

Prerequisite Paper(s) MATH165, MATH166, at least a B grade in CAFS004; or 16 credits at Level 3 in NCEA Calculus; or equivalent

Assessment Internal assessment/Final examination ratio 1:1
MATH165-16A (HAM) & 16B (HAM)
GENERAL MATHEMATICS
15 points

This paper is provided for students who have not attained the entry standard for MATH101 or MATH102. A pass in this paper can be used to gain entry to MATH101 and MATH102, but it has no direct sequel at 200 level.


Equivalent Paper(s) MATH166
Prerequisite Paper(s) 18 credits from NCEA Level 2 Mathematics, 10 credits from NCEA Level 3 Calculus, 14 credits from NCEA Level 3 Mathematics or at least a B- in MATH168
Assessment Internal assessment/Final examination ratio 1:1

Note(s) This paper may not be taken concurrently with or subsequent to obtaining a pass in MATH101 Introduction to Calculus, or MATH102 Introduction to Algebra.

MATH166-16A (HAM) & 16B (HAM)
MANAGEMENT MATHEMATICS
15 points

An introduction to algebra and calculus for students in Management or Social Sciences. Students who meet the prerequisites of MATH101 and/or MATH102 may wish to take these paper(s) instead.

Equivalent Paper(s) MATH165
Prerequisite Paper(s) 18 credits from NCEA Level 2 Mathematics, 10 credits from NCEA Level 3 Calculus, 14 credits from NCEA Level 3 Mathematics or at least a B- in MATH168
Assessment Internal assessment/Final examination ratio 1:1

Note(s) This paper may not be taken concurrently with or subsequent to obtaining a pass in MATH101 Introduction to Calculus, or MATH102 Introduction to Algebra.
MATH168-16A (HAM) & 16B (HAM)
PREPARATORY MATHEMATICS
15 points

This is an intensive catch-up paper in basic algebraic concepts, with a brief introduction to statistics and calculus. It is intended for those who wish to improve their basic mathematical skills. It provides the general mathematical background needed for many other subjects such as MATH165, MATH166, STAT121 and STAT160. If you are using MATH168 as preparation for any mathematics or statistics paper, you should aim for a B- grade or better.

Assessment Internal assessment/Final examination ratio 1:1.

Note(s) This paper may not be taken with, or after a pass, in any 100 level Mathematics or Statistics paper. Permission for a second attempt will only be granted to students who have completed all of the assessments and made a good effort to pass on their first attempt. This paper may not be counted towards the required number of papers for a supporting subject in Mathematics.
Students concentrating on applied mathematics should include the papers MATH257 Computational Mathematics and MATH259 Mathematical Modelling. Students interested in pure mathematics should consider taking COMP235 Logic and Computation, or at least MATH258 Introduction to Discrete Mathematics.

For Science students, the papers MATH251 Multivariable Calculus, MATH253 Linear Algebra, MATH255 Differential Equations and MATH259 Mathematical Modelling are the most suitable.

The most appropriate papers for students in economics, finance, and management systems are MATH251 Multivariable Calculus and MATH253 Linear Algebra.

**COMP235-16B (HAM)**

**LOGIC AND COMPUTATION**

*20 points*

This paper introduces computer science and mathematics students to the formal theory of computation, as well as some important ideas in discrete mathematics of relevance to computer science and IT.

In the discrete mathematics half of the paper, a formal approach to logic is introduced: the basic connectives, well-formed formulas, truth tables, laws of equivalence, testing validity of logical arguments, plus an introduction to predicates and quantifiers. Also covered are modular arithmetic and its applications (to coding and cryptography for example) as well as an introduction to binary relations and directed graphs (connectivity and Warshall’s algorithm).

The other half of the paper deals with the theory of computation. Topics include: finite state automata and regular languages, Kleene’s theorem, Turing machines and the Halting problem, formal grammars and the Chomsky hierarchy. There is laboratory work in which students design Turing Machines.

**Prerequisite Paper(s)** MATH102

**Restricted Paper(s)** MATH258

**Assessment** Internal assessment/Final examination ratio 1:1

**Note(s)** This paper is compulsory for a major in Computer Science, except for the Applied Computing specialisation.
MATH251-16A (HAM)
MULTIVARIABLE CALCULUS
10 points

This paper continues the technical development of calculus begun in MATH101 Introduction to Calculus, extending it to functions of several real variables.

**Paper Content** Differentiation of functions of n variables and vector functions; applications including linearisation and optimisation; integration in n dimensions; applications including curve length, surface areas and volumes.

Further topics will be selected from: centre of mass co-ordinates and moments of inertia; the gradient, divergence and curl operators; curvilinear co-ordinate systems; the integral theorems of Green, Gauss and Stokes; Taylor’s Theorem in n dimensions.

**Prerequisite Paper(s)** MATH101 and MATH102
**Restricted Paper(s)** ENGG285
**Assessment** Internal assessment/Final examination ratio 1:1

MATH252-16B (HAM)
ELEMENTS OF ANALYSIS
10 points

This paper is an essential introduction to the theory and methods of real analysis. Topics in the first half are the absolute value, least upper bound and greatest lower bound, monotone sequences, convergence of sequences, sums, products and quotients of limits, tests for convergence of series, limits of real functions, and the intermediate value theorem.

For the second half, topics are the boundedness of continuous functions, differentiation, Rolle’s, Mean Value and Taylor’s theorems, optimisation, and power series for elementary functions. Additional topics may include an introduction to the Riemann integral, Landau’s “O,o” notations, and the implicit function theorem.

**Prerequisite Paper(s)** MATH101 and MATH102
**Assessment** Internal assessment/Final examination ratio 1:1
MATH253-16A (HAM)
LINEAR ALGEBRA
10 points

This paper deals with the complete theory of linear relationships between quantities, (unlike calculus which examines more complicated relationships). It is particularly useful if you are majoring in computer science, statistics, operations research, chemistry or physics.

The paper develops the basic themes of linear algebra introduced in MATH102 Introduction to Algebra. Topics will be selected from the following: the basis and dimension of a vector space, the geometric effect of a matrix transformation, the determinant, subspaces of vector spaces, linear independence, change of basis, range and kernel, eigenvectors and eigenvalues, diagonalisation of matrices, the inner product, orthonormal bases, the Gram-Schmidt process, orthogonal diagonalisation of symmetric matrices, the complex inner product, unitary, Hermitian and normal matrices and their diagonalisation properties.

Prerequisite Paper(s) MATH102
Restricted Paper(s) ENGG283
Assessment Internal assessment/Final examination ratio 1:1

MATH255-16B (HAM)
DIFFERENTIAL EQUATIONS
10 points

This paper deals with ordinary and partial differential equations in both theory and practice. Such equations arise in a diverse range of areas including biology, economics and physics. It begins with first-order equations and then discusses higher-order equations and systems of equations. Phase-plane diagrams and geometrical methods are introduced. Problems involving partial differential equations (wave equation, heat diffusion equation, Laplace’s equation) are solved via separation of variables and Fourier series techniques.

Prerequisite Paper(s) MATH101 and MATH102
Restricted Paper(s) ENGG284
Assessment Internal assessment/Final examination ratio 1:1
MATH257-16A (HAM)  
COMPUTATIONAL MATHEMATICS  
10 points

Numerical methods for mathematicians, engineers, scientists, computer scientists and economists.


Prerequisite Paper(s)  MATH101 and MATH102
Assessment  Internal assessment/Final examination ratio 1:1

Note(s) Experience with programming (such as COMP103) is recommended.

MATH258-16B (HAM)  
INTRODUCTION TO DISCRETE MATHEMATICS  
10 points

Introduction to discrete mathematics and its applications. Topics include: propositional logic, binary relations, directed graphs and modular arithmetic with applications to cryptography.

Prerequisite Paper(s)  MATH102
Restricted Paper(s)  COMP140, COMP235
Assessment  Internal assessment/Final examination ratio 1:1

MATH259-16B (HAM)  
MATHEMATICAL MODELLING  
10 points

An introduction to the uses of applied mathematics in science and engineering, with a focus on how differential equations are used to formulate mathematical models and obtain concrete results. The syllabus includes: solution techniques for first and second-order differential equations, equilibrium solutions and linearised stability analysis, phase-plane methods and qualitative solutions, dimensional analysis and scaling.

Prerequisite Paper(s)  MATH101. MATH102 is recommended
Assessment  Internal assessment/Final examination ratio 1:1
COMP340 can be counted towards a mathematics major. Well prepared students may also, with the approval of the Chairperson of the Department of Mathematics, enrol in appropriate papers at 500 level for credit towards an undergraduate degree.

**COMP340-16A (HAM)**
**REASONING ABOUT PROGRAMS**
*20 points*

Please see page 65 for further information.

**MATH310-16A (HAM)**
**MODERN ALGEBRA**
*20 points*

This paper is a first course in abstract algebra. It begins with the notion of a group, a structure appearing in geometry, physics and number theory, and indeed anywhere symmetry is important. Basic concepts such as normal subgroups, factor groups and homomorphisms are studied, and powerful counting techniques are presented.

The work on groups leads naturally into the study of rings and fields, which are generalised number systems. The theory of ideals and factor rings is developed mainly for commutative rings. Possible application areas include: impossibility of geometric constructions, counting methods based on generating functions, and construction of Latin squares.

An important objective of this paper is learning how to construct proofs.

**Prerequisite Paper(s)** MATH253 or COMP235 or MATH258.
**Assessment** Internal assessment/Final examination ratio 1:1 or 0:1, whichever is more favourable for the student.
MATH311-16A (HAM)
ADVANCED CALCULUS
20 points

Topics for real calculus: line, surface and volume integrals, vector calculus (div, grad, curl), the integral theorems of Gauss and Stokes, improper integrals, Gamma and Beta functions, and Fourier series.

Topics for complex calculus: the complex plane, holomorphic functions, the Cauchy-Riemann equations, Cauchy’s integral theorems, the fundamental theorem of algebra, singularities, power and Laurent series, the residue theorem, and contour integration.

Prerequisite Paper(s) ENGG285 or MATH251 and ENGG283 or MATH253
Recommended Paper MATH252
Assessment Internal assessment/Final examination ratio 1:1 or 0:1, whichever is more favourable for the student

MATH320-16B (HAM)
DISCRETE MATHEMATICS AND NUMBER THEORY
20 points

The discrete mathematics half of this paper is concerned with graph theory. Graphs can be used to model the synapses between neurons, transportation networks, and many other phenomena. Well-known problems include the four-colour theorem, recently proved with the aid of a computer. Topics covered in the paper include admissible degree sequences, connectivity, Eulerian graphs, Hamiltonian graphs, planarity, graph colourings and graph decompositions.

The other half of the paper concerns number theory. The oldest subject in mathematics, number theory is now as relevant as ever because it provides the basis of cryptography and computer security. Famous problems include Fermat’s Last Theorem, the Riemann Hypothesis and the Goldbach Conjecture. Topics covered in the paper include such gems as the distribution of primes, Gauss’s theory of quadratic equations modulo p, and the mysteries of the zeta-function.

Prerequisite Paper(s) MATH258 or COMP235
Restricted Paper(s) MATH319
Assessment Internal assessment/Final examination ratio 1:1 or 0:1, whichever is more favourable for the student
MATH329-16A (HAM)
TOPICS IN APPLIED MATHEMATICS
20 points

This paper provides an introduction to more advanced topics in applied mathematics, especially as it applies to physical problems, to supplement the methods-oriented approach of MATH331. It will also provide background for more advanced work at graduate level in areas such as fluid mechanics, classical and quantum mechanics, and relativity. Students will acquire an understanding of several topics in applied mathematics and its uses in modelling the physical world.

Corequisite Paper(s) MATH311. MATH331 is recommended
Prerequisite Paper(s) MATH251 and MATH253
Assessment Internal assessment/Final examination ratio 1:1 or 0:1, whichever is more favourable for the student

MATH331-16B (HAM)
METHODS OF APPLIED MATHEMATICS
20 points

This paper introduces the three most widely used methods for solving partial differential equations – separation of variables, integral transforms, and complex variable methods. The syllabus includes: introduction to continuum mechanics, Sturm-Liouville theory and eigenfunction expansions; Bessel functions and Legendre polynomials; Green’s functions for ordinary and partial differential equations; Laplace’s equation, the wave equation, the diffusion equation, Laplace and Fourier transforms, application to ordinary and partial differential equations; complex variable methods, including conformal transformations, the Bromwich contour, and the method of characteristics. The choice of topics may vary from year to year.

Prerequisite Paper(s) MATH251, MATH253 and MATH255
Restricted Paper(s) ENGG383
Assessment Internal assessment/Final examination ratio 1:1 or 0:1, whichever is more favourable for the student
MATH334-16Y (HAM)  
CLASSICAL AND QUANTUM MECHANICS  
20 points

The theory of classical mechanics from a variational point of view. Topics include fundamentals of quantum mechanics and the quantisation of elementary systems.

**Corequisite Paper(s)** MATH311  
**Prerequisite Paper(s)** Admission to this paper is through the permission of the Chairperson of the Department of Mathematics  
**Restricted Paper(s)** MATH534  
**Assessment** Internal assessment/Final examination ratio 1:0

MATH380-16A (HAM) & 16B (HAM)  
TOPIC IN MATHEMATICS  
10 points

A topic in mathematics taught as either a reading or short lecture course. In rare circumstances a student may need only 10 points to complete their degree. This paper allows the Department to offer such a student a specialised course of study to meet that requirement. The content of this paper may vary and is determined at the time of enrolment.

**Prerequisite Paper(s)** Admission to this paper is through the permission of the Chairperson of the Department of Mathematics  
**Assessment** Internal Assessment/Final Examination ratio 1:0
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td>MATH319</td>
<td>TOPICS IN PURE MATHEMATICS</td>
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<tr>
<td>MATH333</td>
<td>CLASSICAL FIELD THEORY</td>
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<td>MATH342</td>
<td>NUMERICAL MATHEMATICS</td>
</tr>
<tr>
<td>MATH505</td>
<td>TOPICS IN ANALYSIS AND TOPOLOGY</td>
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<td>MATH506</td>
<td>COMBINATORICS</td>
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<tr>
<td>MATH511</td>
<td>SEMIGROUPS AND UNIVERSAL ALGEBRA</td>
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<td>MATH512</td>
<td>CONTINUOUS GROUPS</td>
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<tr>
<td>MATH515</td>
<td>ANALYTIC NUMBER THEORY</td>
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<tr>
<td>MATH518</td>
<td>RINGS AND MODULES</td>
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<tr>
<td>MATH543</td>
<td>NONLINEAR DYNAMICS AND CHAOS</td>
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<tr>
<td>MATH554</td>
<td>ASTROPHYSICAL FLUIDS</td>
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<td>MATH564</td>
<td>SPECIAL RELATIVITY</td>
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<tr>
<td>MATH565</td>
<td>GENERAL RELATIVITY</td>
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</tbody>
</table>
STATISTICS
INTRODUCTION

Without data we have to resort to gut feeling or hunches, neither of which can be relied on. Statistics tells us how to deal with variability, and how to collect and use data so that we can make good decisions.

WHAT IS STATISTICS?

The word statistics conjures up images of tables of numbers or graphs. However, the subject statistics is much more than that – it is the science of collecting data and extracting information from that data. Statistical analysis is used to make informed decisions in most areas of human endeavour, such as agriculture, industry and commerce, law, medicine, forestry, psychology, insurance and economics. More than that, an understanding of statistics is essential to critical thinking: it is a skill that is useful in everyday life. Studying statistics makes you more aware of how data can be used and misused to persuade you to vote for a political party, to purchase consumer goods, to form opinions on social issues, and many other everyday decisions.

Statistics at Waikato can be studied by itself or in conjunction with other subjects from science and social science. If you take a major in statistics you have the opportunity of choosing support subjects: from computer science, mathematics, psychology, biology, earth sciences or many other areas, for statistical analysis is vital to the understanding of almost all facets of life. In particular, if you have an interest in economics, we offer the Economics specialisation in the BSc. When you study statistics you will become familiar with the use of powerful statistical software packages, which aid the collection and analysis of data. People with the skills from an education in statistics are highly sought after both in government and industry.

Smart organisations know that smart decisions come from using statistical methods.
Throughout your career you will have a large variety of tasks even if you work in the same area for the whole of your career. One exciting aspect of working as a statistician is working with people from other areas (chemists, biologists, managers and production workers) and continually learning about their disciplines, their work and the problems they face.

You may need to undertake further graduate study for some careers in statistics. For example, the Crown Research Institutes tend to recruit students who have at least a masters degree.

**CAREER OPPORTUNITIES**

Career prospects in Statistics are excellent, with opportunities in many areas:

- Agriculture and horticulture
- Industry
- Finance and insurance
- Market research
- Government
- Medicine
CHAIRPERSON
TBC

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HONORARY FELLOWS

Ray Littler
MSc Auck PhD Monash

William Bolstad
BA Missouri MSc Stan DPhil Waik

Murray Jorgensen
BSc(Hons) Cant MA PhD Br Col

HONORARY LECTURERS

Harold Henderson harold.henderson@agresearch.co.nz
BSc(Hons) Massey PhD C’nell
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Hans Hockey hans@biometricsmatters.com
BSc MSc Waik
Agricultural statistics; medical statistics, statistical consulting.
If you wish to do a three-year degree which provides a solid grounding in statistics, then you may consider doing a BSc degree majoring in statistics. Doing statistics helps you to master a wide range of statistical techniques used for the collection and analysis of data. Such skills are attractive to a wide range of employers. Besides statistics papers, majoring students usually include some papers in Computer Science and in Mathematics. If you have an interest in economics then you may choose to do a double major.

### BSC DEGREE PLANNER
**Statistics 3 years 360 points**

<table>
<thead>
<tr>
<th>Level</th>
<th>Papers</th>
</tr>
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<tbody>
<tr>
<td>100</td>
<td>STAT121 OR STAT111, MATH101*, MATH102*, COMP103*, COMP104*</td>
</tr>
<tr>
<td>200</td>
<td>STAT221, STAT226, MATH251 AND MATH253 OR STAT3XX</td>
</tr>
<tr>
<td>300</td>
<td>STAT3XX, STAT3XX, STAT3XX OR ECON304</td>
</tr>
</tbody>
</table>

*Science Papers should be recognised papers offered by the Faculty of Science & Engineering or the Faculty of Computing & Mathematical Sciences (except MATH168) and PHIL102, PSYC102 and PSYC103. These papers must be taken across four science subjects. MATH101, MATH102, COMP103 and COMP104 will help satisfy these requirements and are strongly recommended in their own right. These papers also help students keep their options open for changing to another major with the Faculty if desired. BSc regulation 9 requires 40 points above 100 level in a subject or subjects other than the major.

### BACHELOR OF SCIENCE (HONOURS)
**(BSC(HONS))**

**BSC(HONS) DEGREE PLANNER** **Statistics 1 year 120 points**

<table>
<thead>
<tr>
<th>Level</th>
<th>Papers</th>
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<tr>
<td>500</td>
<td>STAT591 30 points, STAT5XX 15 points, STAT5XX 15 points, 500 level 30 points</td>
</tr>
</tbody>
</table>

**ADMISSION TO HONOURS PROGRAMME**

Candidates will require B+ grades or better in at least 60 points in 300 level Statistics in the BSc and must have passed the prerequisites for the 500 level papers they wish to enrol in.
DOUBLE MAJOR

For a BSc double major, students must complete:
• 120 points at 100 level
• 120 points at 200 level – 60 points in each major
• 120 points at 300 level – 60 points in each major.

DOUBLE MAJOR IN STATISTICS AND ECONOMICS
The purpose of this double major is to provide students with the skills and techniques needed for economic and statistical analysis. Statistical skills and a thorough understanding of economics are important in the analysis of economic data. People with both these skills are highly sought after by a wide range of private and public sector organisations. This programme integrates the strengths of the two departments of statistics and economics to produce graduates with a high level of skills in economics and statistical analysis.

BSC DOUBLE MAJOR DEGREE PLANNER Statistics and Economics 3 years 360 points

100 level

<table>
<thead>
<tr>
<th>STAT160</th>
<th>MATH101</th>
<th>MATH102</th>
<th>ECON100</th>
<th>Compulsory paper</th>
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<tr>
<td>COMP103*</td>
<td>COMP104*</td>
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200 level

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<th>STAT226</th>
<th>MATH251 AND MATH253</th>
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<td>ECON204</td>
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300 level

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*Science Papers should be recognised papers offered by the Faculty of Science & Engineering or the Faculty of Computing & Mathematical Sciences (except MATH168) and PHIL102, PSYC102 and PSYC103. These papers must be taken across four science subjects. COMP103 and COMP104 will help satisfy these requirements and are strongly recommended in their own right. These papers also help students keep their options open for changing to another major with the Faculty if desired.

No more than 40 points of FINA coded papers may be included in an Economics major.
**STAT111-16B (HAM) & 16B (SEC)**

**STATISTICS FOR SCIENCE**

*15 points*

This paper provides a first course in Statistics for students in the Faculty of Science & Engineering. Microsoft Excel is used throughout. Topics include the presentation of data, elementary probability calculations, principles of experimental design, estimation, hypothesis testing and regression.

**Prerequisite Paper(s)** Admission to the BSc, MATH168, 18 credits at Level 2 NCEA Mathematics, or 14 credits at Level 3 in NCEA Statistics, Calculus or Mathematics

**Restricted Paper(s)** STAT121 and STAT160

**Assessment** Internal assessment/Final examination ratio 1:1

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**STAT121-16A (HAM) & 16S (HAM)**

**INTRODUCTION TO STATISTICAL METHODS**

*15 points*

This paper is designed to provide an introduction to statistical data collection and analysis for students in statistics, science and technology, computer science and the social sciences. It covers a selection of the statistical tools necessary for the effective use and analysis of data in research and practice. It is a practical course that uses relevant examples to illustrate the use of statistical methods. This paper is an essential paper for anyone planning to do research or experiments in their studies or future careers. Topics covered include general principles for statistical problem-solving; sampling and experimental design; techniques for extracting information from data; some practical examples of statistical inference; and the study of relationships between variables using regression analysis. The statistical computer software package, Minitab, is used for most of the statistical computations and graphical displays.

**Prerequisite Paper(s)** MATH168, 18 credits at Level 2 NCEA Mathematics, or 14 credits at Level 3 in NCEA Statistics, Calculus or Mathematics

**Restricted Paper(s)** STAT111 and STAT160

**Assessment** Internal assessment/Final examination ratio 1:1
STATISTICS PAPERS
100 LEVEL
Cont’d

STAT160-16A (HAM) & 16B (HAM) & 16T (HAM)
MANAGEMENT STATISTICS
15 points

This paper is an introduction to statistical thinking and concepts for managers and satisfies the core statistics requirement for the BMS degree.

All business activities are subject to variability. As a consequence managing a business effectively requires the ability to think statistically about how to deal with the resulting uncertainty and its effect on decision-making in management and commerce. This paper combines practical statistical methods along with the core theory underlying these approaches, with a focus on statistical thinking and its application to management. The paper’s scenario based interactive format and the use of Excel facilitate and reinforce the learning experience.

The topics covered include understanding variability, problem-solving methods, need for and use of data, analysing attribute or qualitative data, sampling, estimation and margins of error, simple linear regression, multiple regression, forecasting, decision theory and statistical quality control.

Restricted Paper(s) STAT111 and STAT121
Assessment Internal assessment/Final examination ratio 1:1
Assessment (16T (HAM) Occurrence only): Internal assessment/Final examination ratio 1:0

Note(s) This paper is normally available to students enrolled in the BBA(Fin) and BMS degrees, or certain related programmes of study, such as BSocSc Economics majors. Students with 18 credits at Level 2 in NCEA Mathematics or better may choose STAT121 in place of STAT160.
STATISTICS
PAPERS
200 LEVEL

STAT221-16A (HAM)
STATISTICAL DATA ANALYSIS
20 points

Statistical Data Analysis is an essential paper for anyone planning to do research or experiments in their future studies or careers. The methodology given and applied in the paper is used in many areas of scientific research, for example in medicine, business analysis, sociological and policy research, engineering, and science. This is a practical paper with an emphasis on real data and real problems. Extensive use is made of computing through statistical software.

The topics covered include data collection and organisation, graphical methods, analysis of variance, regression and multivariate statistics. Students will need to take this paper in order to study further papers in statistics at 300 level.

Prerequisite Paper(s) STAT111, STAT121 or STAT160

Restricted Paper(s) ECON204

Assessment Internal assessment/Final examination ratio 1:1

STAT226-16B (HAM)
BAYESIAN STATISTICS
20 points

This paper introduces statistical methods from a Bayesian perspective, which gives a coherent approach to the problem of revising beliefs given relevant data. It is a paper that is suitable for students with a mathematical background and is particularly relevant for statistics, mathematics and computer science students.

Prerequisite Paper(s) At least one of MATH101, MATH102, STAT111, or STAT121

Assessment Internal assessment/Final examination ratio 1:1
**STATISTICS PAPERS 300 LEVEL**

**STAT321-16B (HAM)**  
**ADVANCED DATA ANALYSIS**  
*20 points*

The purpose of this paper is to develop skills in the use of statistical packages for data analysis and modelling. The emphasis is on observational rather than experimental data. The topics covered are regression modelling and its generalisations; cluster analysis; principal components analysis and discriminant analysis.

**Prerequisite Paper(s)** STAT221  
**Assessment** Internal assessment/Final examination ratio 1:1

**STAT323-16A (HAM)**  
**DESIGN AND ANALYSIS OF EXPERIMENTS AND SURVEYS**  
*20 points*

This paper outlines the principles and practicalities of designing and analysing experiments and surveys, with emphasis on the design.

**Prerequisite Paper(s)** MATH102 and STAT221  
**Assessment** Internal assessment/Final examination ratio 1:1

**STAT326-16B (HAM)**  
**COMPUTATIONAL BAYESIAN STATISTICS**  
*20 points*

Computational Bayesian statistics introduces the big idea that Bayesian inference can be performed on random samples drawn from the posterior distribution. Methods are developed for drawing these samples, even when the posterior is only known in the proportional form. Either random draws from an easily sampled candidate distribution are reshaped into a sample from the posterior by only accepting some draws, or a Markov Chain is set up that has the posterior as its long-run distribution. A draw from the chain after it has been running a long time is a random draw from the posterior. This is known as Markov Chain Monte Carlo (MCMC) sampling. In this paper the emphasis is on the computer implementation of these methods.

**Prerequisite Paper(s)** STAT221 or STAT226  
**Assessment** Internal assessment/Final examination ratio 1:1
STAT352-16A (HAM)
STATISTICS FOR QUALITY IMPROVEMENT
20 points

This paper aims to equip students with the statistical skills needed to contribute to the important activity of continuous quality improvement. It covers the fundamentals of quality from a statistical point of view, statistical process control and capability, process design and improvement, and includes the design of industrial experiments. Students taking this paper will be preparing themselves for a career as an industrial statistician. As well as students in statistics this paper would be of particular interest to students studying management and management information systems.

Prerequisite Paper(s) STAT221
Restricted Paper(s) ENGG381
Assessment Internal assessment/Final examination ratio 1:1

STAT390-16A (HAM) & 16B (HAM) & 16Y (HAM)
DIRECTED STUDY
20 points

With the special permission of the lecturer and the Chairperson of Department

Assessment Internal assessment/Final examination ratio 1:0

ENGG381-16A (HAM)
ENGINEERING STATISTICS
20 points

This paper is aimed specifically at engineering students. It covers statistical models, experimentation for quality design and control, process measurement and improvement, statistical process control and capability, and reliability.

Prerequisite Paper(s) MATH101 and MATH102
Restricted Paper(s) STAT352
Assessment Internal assessment/Final examination ratio 1:1
STATISTICS

PAPERS NOT OFFERED IN 2016

**STAT389**
DIRECTED STUDY

**STAT524**
STATISTICAL CONSULTING
GRADUATE STUDY
CONTACT DETAILS FOR GRADUATE AND POSTGRADUATE STUDY

COMPUTER SCIENCE/COMPUTER GRAPHIC DESIGN
Department of Computer Science, The University of Waikato,
Private Bag 3105, Hamilton 3240, New Zealand
Phone +64 7 838 4021
Fax +64 7 858 5095
Email cms@waikato.ac.nz
Web www.cs.waikato.ac.nz

MATHEMATICS
Department of Mathematics, The University of Waikato,
Private Bag 3105, Hamilton 3240, New Zealand
Phone +64 7 838 4713
Fax +64 7 838 4155
Email cms@waikato.ac.nz
Web www.math.waikato.ac.nz

STATISTICS
Department of Statistics, The University of Waikato,
Private Bag 3105, Hamilton 3240, New Zealand
Phone +64 7 838 4038
Fax +64 7 838 4155
Email cms@waikato.ac.nz
Web www.stats.waikato.ac.nz

THE FACULTY OF COMPUTING & MATHEMATICAL SCIENCES
Faculty of Computing & Mathematical Sciences,
The University of Waikato, Private Bag 3105,
Hamilton 3240, New Zealand
Phone +64 7 838 4322
Fax +64 7 838 4155
Email cms@waikato.ac.nz
Web www.cms.waikato.ac.nz
GRADUATE AND POSTGRADUATE QUALIFICATIONS

The Faculty of Computing & Mathematical Sciences offers the following graduate and postgraduate qualifications:

- Bachelor of Computer Graphic Design with Honours (BCGD(Hons))
- Bachelor of Science with Honours (BSc(Hons))
- Graduate Certificate (GradCert)
- Graduate Diploma (GradDip)
- Postgraduate Certificate (PGCert)
- Postgraduate Certificate in Information Technology (PGCertInfoTech)*
- Postgraduate Diploma (PGDip)
- Master of Computer Graphic Design (MCGD)
- Master of Cyber Security (MCS)
- Master of Information Technology (MInfoTech)*
- Master of Science (Research) (MSc(Research))
- Master of Science (MSc)
- Master of Philosophy (MPhil)
- Doctor of Philosophy (PhD)

*Subject to Universities NZ CUAP approval

Most graduate programmes require candidates to have completed a bachelor's degree with a major in the relevant subject (Computer Science, Computer Graphic Design, Software Engineering, Mathematics, or Statistics).

ENGLISH LANGUAGE REQUIREMENTS FOR GRADUATE AND POSTGRADUATE STUDY

You are required to meet the English language requirements for admission into Graduate and Postgraduate qualifications. You are required to achieve an IELTS (academic stream) overall score of 6.5 with at least 6.0 in the writing band OR successfully complete the University of Waikato Pathways College English Language level 8 with a B grade or higher.

What follows is a brief description of each qualification. Precise details of the regulations can be found in the 2016 University of Waikato Calendar.
GRADUATE FEES

University fees are reviewed annually and information on current fees is available on the website
www.waikato.ac.nz/sasd/enrolment/fees.shtml

For overseas students, in addition to tuition fees, you will also need sufficient funds to cover your living expenses in New Zealand for the duration of your programme.

New international PhD students are eligible for domestic fees for their PhD studies. Conditions apply.

For more information see the Postgraduate Studies Office website
www.waikato.ac.nz/sasd/postgraduate

NEW ZEALAND CITIZENS AND PEOPLE WITH PERMANENT RESIDENCE

For New Zealand citizens and people with permanent residence, the following sources of funding may be available:

UNIVERSITY OF WAIKATO MASTERS RESEARCH SCHOLARSHIPS

These awards provide one year of funding for students commencing the second or final year of a full-time masters degree at the University of Waikato. The awards are made on academic merit and the minimum average grade required for application is an B+ (75%).

Application forms are available from the Scholarships website
www.waikato.ac.nz/scholarships

UNIVERSITY OF WAIKATO DOCTORAL SCHOLARSHIPS

These awards provide three years of funding for students undertaking a full-time Doctoral degree at the University of Waikato. Awards are made on academic merit and the minimum average grade required for application is an B+ (75%).

Application forms are available from the Scholarships website
www.waikato.ac.nz/scholarships

INTERNATIONAL STUDENTS

International (non-New Zealand resident) students can apply for a “New Zealand Scholarship” funded by the New Zealand Government or for scholarships funded by their own country. A very limited number of Computer Science Department Scholarships may also be available.

To apply for a Computer Science Department scholarship send your CV and the research area you wish to work in to cs@waikato.ac.nz

Note(s) Computer Science Department scholarships will normally only be awarded to top students working in already established Computer Science Department research areas.
UOW INTERNATIONAL DOCTORAL SCHOLARSHIPS
These awards provide three years of funding for students undertaking a full-time Doctoral degree at the University of Waikato. Awards are made on academic merit and the minimum average grade required for application is an A- (75%). Application forms are available from the Scholarships website www.waikato.ac.nz/scholarships

To apply for a New Zealand scholarship visit www.newzealandeducated.com/scholarships/homepage.html

COMMONWEALTH SCHOLARSHIPS
If you live in one of the 60 member countries involved in the Commonwealth Scholarship and Fellowship Plan, you may apply in your own country for a Commonwealth Scholarship to be taken up at the University of Waikato. If you do have a scholarship, or other funds, that will allow you to cover the cost of your education, then we encourage you to apply to enter our graduate programme.

COMPUTER SCIENCE DEPARTMENT SCHOLARSHIPS
The Computer Science Department awards graduate student funding packages to selected students. These are allocated on a competitive basis and the number of scholarships varies from year to year depending on available funding.

COMPUTER SCIENCE DEPARTMENT GRADUATE ASSISTANTSHIPS
Selected students may receive Graduate Assistantships. Again, these are allocated on a competitive basis. A graduate assistant receives $7,125 per year for a total of 256 hours work.

SCHOLARSHIPS OFFICE
The Scholarships Office is located in the Student Centre and provides advice and administration services and information about available scholarships.

The University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand

Phone +64 7 838 4489
Fax +64 7 838 4600
Email scholarships@waikato.ac.nz
Web www.waikato.ac.nz/scholarships
BACHELOR OF SCIENCE WITH HONOURS (BSC(HONS))

The BSc(Hons) is a one-year graduate qualification available to students who have completed a BSc at the University of Waikato, and who have reached a high standard in their major subject.

Intending candidates for the degree should discuss these requirements with the Graduate Adviser of the relevant department. See page 114 for department contact details.

STRUCTURE

The programme of study consists of 120 points at 500 level, including a dissertation equivalent to 30 points. The degree will be awarded with First Class Honours, Second Class Honours (first division), Second Class Honours (second division) or Third Class Honours. It will not be awarded without Honours – a failure to reach the required level for Honours means that the degree as a whole is failed.

BSC(HONS) ENTRY REQUIREMENTS

Each subject has its own entry and programme requirements for the degree. For 2016 these are:

Computer Science: Candidates will require an average grade of A- in at least 80 points at 300 level in Computer Science.

Mathematics: Candidates will require a major in Mathematics in the BSc degree with an average grade of B in 80 points in 300 level Mathematics. There are no special paper requirements other than those implied by the BSc(Hons) degree regulations.

Statistics: Candidates will require B+ grades or better in at least 60 points in 300 level Statistics in the BSc and must have passed the prerequisites for the 500 level papers they wish to enrol in.

GRADUATE CERTIFICATES

The Graduate Certificate (GradCert) is a qualification for graduates with at least a bachelors degree in any subject. The normal minimal time for completion of the GradCert is one semester. You will need to pass 60 points at 100 level or above, including at least 40 points at 300 level or above. At least 40 points must be in your subject area, Computer Science, Computer Graphic Design, Mathematics, or Statistics.

GRADCERT PLANNER 6 months 60 points

| 100 level or above 20 points | 300 level 20 points | 300 level 20 points |
GRADUATE DIPLOMAS
The Graduate Diploma (GradDip) is a qualification for graduates with at least a bachelor's degree in any related subject. The normal minimal time for completion of the GradDip is one year. You will need to pass 120 points at 100 level or above, including at least 80 points at 300 level or above. At least 80 points must be in your subject area.

GRADDIP PLANNER 1 year 120 points

POSTGRADUATE CERTIFICATES
The Postgraduate Certificate (PGCert) is a qualification for graduates with at least a bachelor's degree in a related subject, Computer Science, Mathematics, or Statistics. The normal minimal time for completion of the PGCert is one semester. You will need to pass 60 points at 500 level in your subject area, Computer Science, Mathematics, or Statistics.

PGCERT PLANNER 6 months 60 points

POSTGRADUATE DIPLOMAS
The Postgraduate Diploma (PGDip) is a qualification for graduates with at least a bachelor's degree in a related subject, Computer Science, Computer Graphic Design, Mathematics, or Statistics. It normally takes one year of full-time study, but can also be taken part-time over an extended period. You will need to pass 120 points at 500 level with at least 90 points in your subject area, Computer Science, Computer Graphic Design, Mathematics, or Statistics.

You should design your programme in consultation with one of the Postgraduate Certificate/Diploma Advisers in the relevant department.

PGDIP PLANNER 1 year 120 points

GRADUATE AND POSTGRADUATE QUALIFICATIONS
Con’t
MASTERS QUALIFICATIONS
You will need to discuss the choice of your actual programme of study – that is, the papers you are going to take and the area in which you plan to write a thesis – with the Adviser from the relevant department. We will go over your entire proposed graduate programme with you, not just the papers you plan to take in the first year. The outcome of the discussion will be recorded on a programme form, which is different from the University enrolment form. If you cannot come to the University in person, we can discuss your proposed programme by email or on the phone.

MASTER OF COMPUTER GRAPHIC DESIGN (MCGD)
The MCGD is either taken as a one and a half year (180 point*) degree or a one year (120 point) degree that stresses graphic design theory and original research. The MCGD is an opportunity to plan, develop and carry out a large scale design thesis realisation based on original research, collaboration with peers, members of the professional design industry and academic communities, in order to advance the body of design knowledge.

MCGD research is represented by both a written dissertation or thesis and an exhibited design realisation. The written dissertation/thesis and realisation are two expressions of the same research and are thus assessed as a single unit. This arrangement reflects the symbiotic link between theory and practice in this discipline.

There is no option to take a written only or a realisation only MCGD. There is an option to take approved taught papers alongside your research. This is particularly the case if taking a 180 point* MCGD degree.

*Subject to Universities New Zealand CUAP approval.

MCGD DEGREE PLANNER (Research and taught) 1 year 120 points

To enrol in the MCGD you must have completed the Bachelor of Computer Graphic Design* or a Bachelor of Computer Graphic Design (Honours) or equivalent. Enrolment in the MCGD can be completed online at www.waikato.ac.nz
MASTER OF CYBER SECURITY (MCS)

The MCS introduces students to the frontiers of knowledge and trains them in the relevant techniques of cyber security. Students will gain an advanced understanding and knowledge of cyber security from the point of view of preventative security, detection of security breaches, and offensive security (such as computer system penetration testing). At the same time, students will gain an advanced understanding and knowledge of cloud computing technologies, computer infrastructure, legal aspects of cyber security and a capacity to think innovatively and be able to use research-led knowledge to advance professional practice.

The MCS is normally an 18-month postgraduate degree building on the computer science major at undergraduate level. Very able students and those who already have an honours degree or a postgraduate diploma may be able to complete it in 12 months, subject to the Dean’s approval. For admission to the MCS, students will need to have completed a relevant bachelors degree or postgraduate diploma, normally in Computer Science or in Computer Engineering. They will need an average of at least a B+ in their 300 level or higher Computer Science papers (or equivalent subject).

If you are entering with a three-year bachelors degree, the MCS consists of 180 points of 500 level papers made up of 120 points of 500 level taught papers and a 60-point dissertation. If you have an honours degree or a postgraduate diploma and have done study equivalent to 15 points of the compulsory papers, you will require a total of 120 points for the qualification including a 60-point dissertation. Dissertations may be co-supervised with relevant IT or security institutions in New Zealand. For the MCS, very capable students may opt for a research-intensive 90-point thesis as an alternative to the 60-point dissertation, subject to the Dean’s approval.

MCS DEGREE PLANNER 1.5 years 180 points

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP501</td>
<td>15</td>
</tr>
<tr>
<td>COMP513 OR COMP514</td>
<td>45 points at 500 level</td>
</tr>
<tr>
<td>COMP518</td>
<td>15</td>
</tr>
<tr>
<td>COMP527</td>
<td>15</td>
</tr>
<tr>
<td>LAWS526</td>
<td>30</td>
</tr>
<tr>
<td>COMP592</td>
<td>60</td>
</tr>
</tbody>
</table>

To enrol for a MCS degree, you can apply online by going to www.waikato.ac.nz
POSTGRADUATE CERTIFICATE IN INFORMATION TECHNOLOGY (PGCERTINFOTECH)

*Subject to Universities New Zealand CUAP approval.

The PGCertInfoTech* has been designed to allow students with undergraduate qualifications in areas other than IT (Information Technology) to gain the necessary knowledge and understanding of IT in order to progress to the Master of Information Technology. This qualification is jointly awarded with the University of Auckland.

PGCERTINFOTECH PLANNER 6 months 60 points

500 level 15 points 500 level 15 points 500 level 15 points 500 level 15 points

MASTER OF INFORMATION TECHNOLOGY (MINFOTECH)

*Subject to Universities New Zealand CUAP approval.

The MInfoTech* is a new degree (jointly awarded with the University of Auckland) which is designed to help students become “industry ready”. It will provide them with advanced skills in a specialist area, an increased understanding of workplace norms, and an enabling experience of the development and commercialisation of technology products and services.

A key feature of the MInfoTech is a directed research internship paper, linking all specialisations, and ensuring students gain industry specific skills and experience.

Students with a BSc in Computer Science or equivalent can enrol directly into the 180pt MInfoTech programme. A combination of papers will be offered that focus on improving IT skills, as well as communication and critical thinking skills.

Students who have gained the equivalent of an Honours degree in Computer Science are able to complete the 120pt MInfoTech programme. This will focus on developing business enterprise skills and knowledge for industry.

MINFOTECH DEGREE PLANNER 1 – 1.5 years 180 points

500 level 15 points 500 level 15 points 500 level 15 points 500 level 15 points

Internship 60 points
MASTER OF SCIENCE (MSC)
To enrol in an MSc you must have completed (or almost completed) a bachelors degree with a major in the relevant subject (software engineering, computer science, mathematics, or statistics) and attained good enough grades for advanced study. If you have a bachelors degree in a non relevant subject, and then complete an appropriate Graduate Diploma, you may be accepted into an MSc. The degree may be awarded with or without honours.

If you have a BCMS(Hons), BSc(Hons) or PGDip you may be eligible to enter directly into the second year of the MSc.

The degree normally requires 180 points and is completed over an 18 month period. The degree consists of taught papers and a research component which could include research methods papers and/or a dissertation.

MSC DEGREE PLANNER 1.5 years 180 points

| Research – at least 60 points | Taught papers |

To enrol for an MSc degree, you can enrol online by going to www.waikato.ac.nz
MASTER OF SCIENCE (RESEARCH) (MSC(RESEARCH))

To enrol in an MSc(Research) you must have completed (or almost completed) a bachelors degree with a major in the relevant subject (software engineering, computer science, mathematics, or statistics) and attained good enough grades for advanced study. If you have a bachelors degree in a non relevant subject, and then complete an appropriate Graduate Diploma, you may be accepted into an MSc(Research).

The MSc(Research) is a two-year degree, consisting of 240 points at 500 level. The normal pattern is to gain 120 points in the first year, then complete a 120 point thesis in the second. The thesis must comprise a satisfactory record of research undertaken by the candidate, or a satisfactory critical survey of knowledge in the approved field of study. It must show competence in the appropriate method of research and/or an adequate knowledge of the field of study; exhibit independence of approach or presentation; be satisfactory in literary presentation; and include full reference to the literature.

The degree may be awarded with or without honours. To be eligible for honours, you must complete the requirements of the degree and submit your thesis in no more than two years of full-time study (or the equivalent for part-time enrolment).

If you have a BCMS(Hons), BSc(Hons) or PGDip you may be eligible to enter a one year MSc(Research) requiring 120 points. In Computer Science, the normal route to enrol in an MSc(Research) is to substitute a Postgraduate Diploma (PGDip) for the first year of MSc(Research) study.

MSC(RESEARCH) DEGREE PLANNER 2 years 240 points

A thesis worth at least 90 points

Taught papers

To enrol for an MSc(Research) degree, you can enrol online by going to www.waikato.ac.nz
DOCTOR OF PHILOSOPHY (PHD)

To enrol for a PhD you normally need an honours degree with first or second-class honours (first division).

A PhD involves advanced study and research under the direction of a supervisor for at least three years (full-time). You write a thesis on an original investigation relating to some branch of your chosen subject (computer science, mathematics or statistics).

Although the PhD does not normally involve coursework, you may be required to take up to two preliminary papers. More details on the PhD regulations and general guidelines can be found in the Higher Degrees Handbook which can be obtained from the Postgraduate Studies Office, or online in PDF format from the website.

Enrolment of all new candidates for the PhD approved by the Postgraduate Studies Committee is conditional for an initial period of six months. Confirmation of enrolment by the Postgraduate Studies Committee after the initial period of six months is subject to the submission by the candidate of:

- An acceptable research plan, and
- A formal presentation to a Confirmed Enrolment Panel, and
- A report by the supervisors recommending confirmation of enrolment, and
- Evidence of ethical approval or a statement confirming that it is not required, in accordance with the Ethical Conduct in Human Research and Related Activities Regulations 2008.

Visit [www.waikato.ac.nz/sasd/postgraduate](http://www.waikato.ac.nz/sasd/postgraduate)

MASTER OF PHILOSOPHY (MPhil)

To enrol for a MPhil you normally need an honours degree with first or second-class (first division) honours in a relevant subject (software engineering, computer science, mathematics or statistics). Like the PhD, this is a research degree, but of more limited scope, and the aim is to complete in one year (full-time). As with the PhD, you first choose a supervisor, topic, write a proposal and apply to the Postgraduate Studies Committee (PSC). You may be required to take up to two preliminary papers.

It is sometimes possible to transfer from a MPhil to a PhD, usually after one year, provided you have made good progress. An application and expanded research proposal must be submitted to the PSC.
ENROLLING IN A PHD OR MPHIL

To enrol for a PhD or MPhil degree programme, you should begin by discussing your application with the Adviser from the relevant subject department. If you live outside Hamilton this initial discussion can be by phone or email. You will be referred to members of staff who are potential supervisors in the area in which you wish to work. You can help in this process by examining the research interests of members of the Department and looking for ideas about likely supervisors.

The next step is discussion with potential supervisors about project areas. You can contact them by phone or email. It is always a good idea to consult widely at first, with more than one potential supervisor, and to consider a variety of possible research topics, though eventually you must settle on a particular supervisor and project area. More information about research interests and likely supervisors is contained in the Computer Science, Mathematics and Statistics sections of this handbook, and online.

Research students are normally supervised by a panel of two or three supervisors, one of whom – the one with whom you have set up the research topic – is designated “chief supervisor”. This scheme provides breadth of coverage and some insurance against a supervisor’s absence or illness. Your chief supervisor will arrange the other member(s) for your supervisory panel, and will discuss the choice with you.

The next step is to fill out an application form for the PhD/MPhil degree. This is an application to the Postgraduate Studies Committee for registration. It will include a synopsis of the research project you intend to tackle. Your chief supervisor will help you to come up with a suitable description of the proposed research. Once the Postgraduate Studies Committee has approved your admission to the programme, you must then fill in a standard University of Waikato enrolment form so that the Academic Services Division can record the necessary information. For more information about the formal side of the registration process, please contact the Postgraduate Studies Office.

POSTGRADUATE STUDIES ADMINISTRATOR
Postgraduate Studies Office, the University of Waikato,
Private Bag 3105, Hamilton 3240, New Zealand

Phone  +64 7 838 4466 Extn: 6337
Fax      +64 7 838 4130
Email   postgrad@waikato.ac.nz
Web     www.waikato.ac.nz/sasd/postgraduate
COMPUTER GRAPHIC DESIGN
Graphic design is everywhere in our world today, on almost every surface, material or digital – that we touch and see; conveying messages from commerce, education, government and society; entertaining us, interacting with us. In the midst of emerging media, liquid culture and accelerating technology, graphic design makes coherent communication possible.

Graphic design at a graduate level applies theory and practice to communication aesthetics. Computer graphic design at the University of Waikato is unique in New Zealand as a specialist graphic design qualification that offers both visual design and computer science.

Graduate level study in computer graphic design is an opportunity to plan, develop and carry out a large-scale design project supported by original research. Topics are tailored to suit the aspirations of the individual student and therefore provide an opportunity for honing a particular aspect of graphic design further.

We currently offer a Bachelor of Computer Graphic Design with Honours (BCGD(Hons)) and a Master of Computer Graphic Design (MCGD).

BCGD graduates wanting parity with an international four-year BFA can take the BCGD(Hons).

Graduate students have a dedicated lab space and access to all of our undergraduate facilities. This includes high-end Apple computers running the latest industry standard software. Staff supervisors are friendly and very accessible. We welcome both New Zealand and international students.

**REQUIREMENTS FOR THE GRADDIPCGD, PGDIPCGD, AND MCGD**

Students seeking entry to graduate qualifications should have a bachelors degree and/or relevant experience in a related discipline. Applicants for the Master of Computer Graphic Design should have the BCGD(Hons) or equivalent, or (subject to Universities New Zealand CUAP approval) a BCGD Degree.

Applicants who have not completed another graphic design qualification at the University of Waikato must submit a portfolio of creative work with their applications. The portfolio of creative work (10-20 items) should include finished pieces and pieces still under development, to help us understand your creative-thinking process.

You can submit your portfolio as printed copies of work, as digital files or a combination of both. Please do not submit originals. Original pieces can be photographed and submitted by email, with individual works clearly labelled. Each of the 10-20 pieces should be accompanied by a title and a short (100 word max.) description of the work and its purpose and process of production.

Graduate programmes are highly tailored to the needs of the student. Acceptance to graduate programmes requires an agreed upon programme of study and, in the case of the honours and masters, a supervisor.

Please email cms@waikato.ac.nz to discuss study options.
BCGD(HONS) PAPERS

CGRD524-16B
TOPICS IN INTERACTION DESIGN
15 points

This paper offers advanced topics in Interaction Design. It takes a practical approach to interaction design for better user experience.

Prerequisite Paper(s) COMP324 or COMP325
Restricted Paper(s) COMP424/524
Assessment Internal assessment/final examination ratio: 1:0

CGRD532-16B (HAM)
INFORMATION VISUALISATION
15 points

Information visualisation concerns the design and implementation of presentations of often complex information in such a way that users are able to efficiently and effectively extract the relevant features in and for their given context, and are able to gain insight about the information which might not otherwise have been possible. This paper aims to provide an awareness of the potential offered by visualisation techniques, a familiarity with the underlying concepts, and an understanding and ability to effectively design and apply information visualisations in a given context.

Prerequisite Paper(s) Three 300 level Computer Science or Computer Graphic Design papers
Restricted Paper(s) COMP432/532
Assessment Internal assessment/Final examination ratio 1:0

CGRD551-16A (HAM)
STUDIO MANAGEMENT
15 points

This paper is intended for people looking for a future senior position in a design studio, or those managing freelance teams. Students will apply the theory they earned in lectures to the management of a client-driven project by supervising a project team.

Prerequisite Paper(s) CGRD350 or equivalent
Assessment Internal assessment/Final examination ratio 1:0

Note(s) Enrolment is limited to 10 students.
**CGRD581-16A (HAM) & 16B (HAM) & 16S (HAM)**

**REPORT OF AN INVESTIGATION**

30 points

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**CGRD591-16Y (HAM)**

**DISSERTATION AND EXHIBITION**

30 points

Restricted Paper(s) CGRD592

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**CGRD592-16Y (HAM)**

**DISSERTATION AND EXHIBITION**

60 points

Restricted Paper(s) CGRD591

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**PGDIPCGD PAPERS**

Students enrol in 120 points at 500 level. Appropriate papers will be decided in consultation with a Graduate Adviser.

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**MCGD PAPERS**

Students work closely with a supervisor to select a research topic and many students choose to enrol in the 120 point CGRD594 Computer Graphic Design Thesis and Realisation to complete a full research-led MCGD. The 90 point CGRD593 Computer Graphic Design Thesis and Realisation is an alternative choice for a research-led MCGD.

Students taking 180* points for the MCGD are required to include CGRD581 Report of an Investigation (30 points). Students not wishing to complete a research-led MCGD degree could take CGRD591 Dissertation and Exhibition (30 points) if CGRD581 is in their programme of study or could take CGRD592 Dissertation and Exhibition (60 points).

The remaining papers should be chosen from appropriate 500 level taught papers listed for the BCGD (Hons) degree or as approved by the Convener of Computer Graphic Design.

*180 point MCGD subject to Universities NZ CUAP approval.

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**CGRD581-16A (HAM) & 16B (HAM) & 16S (HAM)**

**REPORT OF AN INVESTIGATION**

30 points
COMPUTER SCIENCE PAPERS

COMP575-16A (HAM) & 16B (HAM)  
PROGRAMMING FOR RESEARCH 1  
15 points

Please see page 138 for the paper description.

COMP576-16A (HAM) & 16B (HAM)  
PROGRAMMING FOR RESEARCH 2  
15 points

Please see page 138 for the paper description.

COMPUTER GRAPHIC DESIGN RESEARCH  
Tomás García Ferrari, Simon Laing, Keith Soo, Claire Timpany, Emmanuel Turner, Nicholas Vanderschantz

Research in computer graphic design is focused on visual communication and interactivity. The research encompasses historical studies in Aotearoa/New Zealand design, examining the meaning of form in character design, user interfaces for large information stores, typography for education and advanced media experimentation.

Further publications can be obtained from the group’s website at cgd.waikato.ac.nz/research/cgd_research_group
OLIVIA PARIS
(Bachelor of Computer Graphic Design Graduate)

"I finished my BCGD studies with an FCMS summer scholarship nomination, tasked with the redesign of the Faculty handbook. The scholarship project gave me valuable experience in designing large scale publications and working with a client.

During my summer scholarship I was also offered a full-time job working with the Waikato Students’ Union. My main responsibility is the design and production of the University of Waikato’s weekly student magazine, Nexus. I also create promotional material for events or services the WSU offers, and help with the design, development and upkeep of our websites. I was lucky to intern with Nexus magazine during my last year of study as a part of the BCGD internship paper. This gave me an advantage in applying for the job and allowed me to transition easily into the role with my previous experience in the production of the magazine. My position with the WSU and Nexus is perfect for a first job and it allows me to utilise my love of print and publication design, formatting and layout, and typography.

The combination of graphic design and computer science that the BCGD programme offers allowed me to gain experience and knowledge in a range of software and programming languages, and has taught me the fundamentals of graphic design elements and principles. The BCGD has set me up with the skills I need to work in various different areas of design. The possibilities for the future are wide open and I’m excited to see where this career will lead me."
COMPUTER SCIENCE
INTRODUCTION

Computer Science is the body of knowledge dealing with the design, analysis, implementation, efficiency and application of processes that transform information. The fundamental question underlying all of computer science is: “What can be automated?” Out of this question many new professions have arisen and our graduate programmes in computer science prepare you for them as a leader, an innovator, a practitioner at the cutting edge of technology.

The Department of Computer Science is involved in a wide range of exciting and innovative research that transcends the boundary between theory and practice. Individual staff members and their students undertake many research projects. There are some large group projects that deserve special mention. One is looking broadly at machine learning, from theoretical foundations through practical tools, to applications in New Zealand’s industries. Another is analysing computer networks. A third is concerned with collaborative information gathering and the application of large interactive display surfaces. A fourth is looking at research issues in digital libraries and novel interfaces for retrieving and browsing information, offering a widely used international digital library service. The fifth is developing languages and tools for modelling automated systems and reasoning about the models. As well as these group research projects, there are a host of other research activities within the department. The Computer Science Department is youthful and enthusiastic, and has a distinctly international flavour with many academic staff boasting experience from North America and Europe. The research laboratories are well equipped with high-end modern workstations of all types, as well as grunty computation servers and file servers.

At Waikato, research is fun – fun we take seriously. Come and join in.

For more information on our activities, visit www.cs.waikato.ac.nz
COMPUTER SCIENCE PAPERS
500 LEVEL

COMP501-16A (HAM)
TOPICS IN OPERATING SYSTEMS
15 points
Please see page 67 for the paper description.

COMP502-16B (HAM)
CRYPTOGRAPHY
15 points
Please see page 67 for the paper description.

COMP513-16A (HAM)
TOPICS IN COMPUTER NETWORKS
15 points
Please see page 67 for the paper description.

COMP514-16B (HAM)
CARRIER AND ISP NETWORKS
15 points
Please see page 67 for the paper description.

COMP518-16B (HAM)
CYBER SECURITY
15 points
Please see page 68 for the paper description.

COMP520-16C (HAM) & 16D (HAM)
REPORT OF AN INVESTIGATION
45 points
Please see page 75 for the paper description.

COMP521-16A (HAM)
MACHINE LEARNING ALGORITHMS
15 points
Please see page 68 for the paper description.

COMP523-16B (HAM)
DATA STREAM MINING
15 points
Please see page 68 for the paper description.
COMP524-16A (HAM)
TOPICS IN INTERACTION DESIGN
15 points
Please see page 69 for the paper description.

COMP526-16A (HAM)
ENGINEERING INTERACTIVE SYSTEMS
15 points
Please see page 69 for the paper description.

COMP527-16B (HAM)
CLOUD COMPUTING TECHNOLOGIES AND SECURITY
15 points
Please see page 69 for the paper description.

COMP532-16B (HAM)
INFORMATION VISUALISATION
15 points
Please see page 70 for the paper description.

COMP536-16A (HAM)
ADVANCED GRAPHICS AND COMPUTER GAMES
15 points
Please see page 70 for the paper description.

COMP539-16B (HAM)
USABILITY ENGINEERING
15 points
Please see page 70 for the paper description.

COMP540-16B (HAM)
SOFTWARE ENGINEERING METHODOLOGIES
15 points
Please see page 71 for the paper description.
COMP542-16A (HAM)
WEB SEARCH: TECHNICAL AND SOCIAL ISSUES
15 points
Please see page 71 for the paper description.

COMP543-16B (HAM)
INFORMATION MANAGEMENT
15 points
Please see page 71 for the paper description.

COMP548-16B (HAM)
DEVELOPING MOBILE APPLICATIONS
15 points
Please see page 72 for the paper description.

COMP550-16A (HAM)
LOCATION-BASED SYSTEMS AS CONTEXT-AWARE SYSTEMS
15 points
Please see page 72 for the paper description.

COMP552-16A (HAM)
MODEL CHECKING
15 points
Please see page 72 for the paper description.

COMP553-16A (HAM)
EXTREMELY PARALLEL PROGRAMMING
15 points
Please see page 73 for the paper description.

COMP554-16B (HAM)
SPECIFICATION LANGUAGES AND MODELS
15 points
Please see page 73 for the paper description.
COMP555-16A (HAM)
BIOINFORMATICS
15 points

Please see page 73 for the paper description.

COMP556-16A (HAM)
METAHEURISTIC ALGORITHMS
15 points

Please see page 74 for the paper description.

COMP560-16A (HAM) & 16C (HAM)
TURING TOPICS IN COMPUTER SCIENCE
15 points

Please see page 74 for the paper description.

COMP575-16A (HAM) & 16B (HAM)
PROGRAMMING FOR RESEARCH 1
15 points

A paper in programming techniques applicable to a range of research applications in Computer Science.

Prerequisite Paper(s) Admission to the Postgraduate Certificate (PGCert), Postgraduate Diploma (PGDip) or Masters programme in Computer Science (MSc or MSc(Research)) or Computer Graphic Design (MCGD)
Restricted Paper(s) COMP589
Assessment Internal assessment/Final examination ratio 1:0

COMP576-16A (HAM) & 16B (HAM)
PROGRAMMING FOR RESEARCH 2
15 points

A paper where research programming techniques are applied to a specific (elective) field in Computer Science.

Corequisite Paper(s) COMP586
Restricted Paper(s) COMP589
Assessment Internal assessment/Final examination ratio 1:0
COMPS585-16A (HAM) & 16B (HAM)
RESEARCH IN COMPUTER SCIENCE 1
15 points
A paper about how to plan, conduct and report research in the field of computer science, in which students gain skills in and understanding of reading and critiquing research materials, planning research projects and developing research proposals, carrying out literature surveys, and writing research papers.

Restricted Paper(s) COMP590
Assessment Internal assessment/Final examination ratio 1:0

COMPS586-16A (HAM) & 16B (HAM)
RESEARCH IN COMPUTER SCIENCE 2
15 points
A paper that puts into practice core research skills to plan, conduct and report research in a specific (elective) field of computer science.

Prerequisite Paper(s) COMP585
Corequisite Paper(s) COMP576
Restricted Paper(s) COMP590
Assessment Internal assessment/Final examination ratio 1:0

COMPS591-16C (HAM) & 16D (HAM)
DISSERTATION
30 points

COMPS592-16C (HAM)
DISSERTATION
60 points

COMPS593-16C (HAM)
COMPUTER SCIENCE THESIS
90 points

COMPS594-16C (HAM)
COMPUTER SCIENCE THESIS
120 points
“With the goal of becoming a cyber-security technician for the Government Communications Security Bureau, I am making a conscious effort to make the most of my time at university. Following schooling at Trident High School in Whakatane, I began a degree at the University of Waikato due to the excellent reputation of the Computer Science department. I’ve been able to apply the technical knowledge gained from study at my part-time job at Gallagher Group and was recently awarded the Sir William Gallagher Cyber Security Scholarship. The scholarship has allowed me to further my study towards a Master of Cyber Security this year, which has proven to be an interesting programme and had a positive impact on my working career.”
RESEARCH DIRECTIONS

Research activities in the Department take place in seven research groups. Although many staff participate in projects across different groups we have arranged the descriptions below into the seven areas. In practice there is considerable overlap between the activities in the various groups.

CYBER SECURITY GROUP
Ryan Ko, Geoff Holmes, Tony McGregor, Richard Nelson

The Cyber Security Researchers of Waikato (CROW) aims to return control of data to data owners, by focusing on research addressing data security from a user-centric perspective. With the emergence of cloud computing technologies and prevalent mobile device usage, we are witnessing the diminishing effectiveness of traditional cyber security approaches such as perimeter defence, intrusion detection and infrastructure hardening.

A major focus of the Cyber Security Laboratory is developing fundamental algorithms and innovative solutions which will enable users to know their data provenance, or “what has happened to their data”. Data provenance empowers data stakeholders to understand the evolution and derivation history of their data, and empowers other important technologies such as data leakage prevention, malicious insiders in cloud computing environments or behaviour-based detection of malware. After the successful acquisition or recording of provenance information, effective ways to visualise these multi-dimensional data sets in userintuitive techniques are tantamount. The group has a large-scale cloud computing test bed for the realistic testing and verification of our tools. Another major focus is on preserving both the privacy and utility of data. If encrypted data can be processed in servers without the need to be decrypted, the privacy of data in foreign environments will be addressed effectively. The lab is currently working on practical and efficient techniques addressing this.

Together with New Zealand industry partners, multi-national companies and international consortia such as the Cloud Security Alliance, the lab also works on discovering and disclosing vulnerabilities that exposes user data to dangers in both systems and network. The Lab also aims to invent techniques that effectively eradicate the effects of new-generation malicious software.

Further details on the group can be obtained from the group’s website at: https://crow.org.nz/
DIGITAL LIBRARY GROUP
Mark Apperley, David Bainbridge, Sally Jo Cunningham, Annika Hinze, Steve Jones, Te Taka Keegan, David Nichols, Ian Witten

The migration of information from paper to electronic media promises to change the whole nature of research and, in particular, the methods by which people locate information. The goal of the New Zealand Digital Library project (www.nzdl.org) is to explore the potential of internet based digital libraries. Our vision is to develop systems that automatically impose structure on fundamentally anarchic, uncatalogued, distributed repositories of information, thereby providing information consumers with effective tools to locate what they need and peruse it conveniently and comfortably.

We have developed an open source digital library system called Greenstone (www.greenstone.org) which is widely used in many countries all over the world and has also been adopted to deliver humanitarian information in developing countries. The software makes it easy to produce collections on CD-ROM, which is a practical format for areas with little internet access. The same collections are also available in precisely the same form over the web.

The user interacts through any standard web browser and the software incorporates a web server so that if the system happens to be connected to an intranet (eg in a hospital or school) the information is automatically served to other machines on the network. Many Greenstone CD-ROMs have been produced from various organisations, including NGOs and several UN agencies. UNESCO has adopted Greenstone and works with us to distribute it widely throughout the developing world. We collaborate with the UN FAO on the dissemination of agricultural information; the Humanities Library Project in Belgium on creating new information collections; and the Koha Foundation, USA, on equipping people in developing countries with the ability to create and distribute their own information collections.

Our present research is aimed at re-engineering Greenstone to take account of emerging XML-based standards; extending it into a full content management system; looking at novel interfaces for retrieval and browsing that cater to a wide spectrum of users; monitoring usage to study library users’ needs; and developing methods for inferring bibliographic information from document files and using this information to enhance presentation and for bibliometric research.

Further details on the group can be obtained from the group’s website at: www.nzdl.org
ENERGY INFORMATICS GROUP
Mark Apperley, Masood Masoodian, Bill Rogers

Energy Informatics concerns the application of information technologies to improve the efficiency and effectiveness of energy utilization, from source, through distribution, to consumption. The research of the Energy Informatics group includes (i) maximising the utilisation of energy when and where it is available, (ii) energy conservation – that is ensuring that energy is not used wastefully or unnecessarily, and (iii) end-use efficiency – ensuring that the energy we do use is used effectively. At present the focus of this research is on: electricity demand-side load management and storage mechanisms, which provide a means of improving the integration of renewable energy sources such as wind and tide; smart homes, which involves the integration of these technologies in the home; electric vehicles as an alternative to fossil fuel usage, and as a potential means of providing storage on the electricity grid; and mitigation of energy expended on personal transport.

This research is aligned with New Zealand’s energy strategy, to achieve a level of 90% of electricity generated from renewables by 2025. This goal requires better utilization of existing and new renewable generation sources, particularly wind, solar and tidal/wave, all of which are highly variable in their output, as well as improved efficiency and load management at the consumption end in the face of increasing quality of life expectations and population growth. A further factor influencing the work of this group is New Zealand’s goal to reduce greenhouse gas emissions to 80% of 1990 levels by 2020. Electricity generation produces about 19% of the country’s greenhouse gases, emphasizing the need for more effective utilization of renewable electricity sources, but transport accounts for 44%, providing another research focus on the impact and integration of electric vehicles on the transport fleet, as well as improved video conference and virtual presence systems to counter the ever-growing trends of personal travel.

Further details on the group can be obtained from the group’s website at www.cs.waikato.ac.nz/research/ei/
FORMAL METHODS GROUP

Judy Bowen, Robi Malik, Steve Reeves

Established in 1998, this is the first Formal Methods laboratory in New Zealand. The work that goes on in this lab is based on the view that programming is at the heart of computer science. It is also based on the view that, as engineers and scientists, we should use the machinery of mathematics to model and reason about the systems that we build before we build them. This is in contrast with the view that programs should be written by trial and error (usually at great expense and with a high likelihood of failure, judged by current experience) with our users ironing out our mistakes for us at their expense. To this end, we are developing languages and tools for modelling systems, for reasoning about those models and for transforming them into code in a way that is guaranteed to preserve meaning and correctness. We do not want to build software that usually works – we want software that always works, and in the way intended by the requirements.

One particular project is aimed at producing methods that will allow the development of user-interfaces to the same level of dependability as the functional part of a system. We are also developing tools for generating test suites from specifications, to improve the cost-effectiveness of testing. We are investigating languages and logics for dealing with refinement at a general level, and techniques for developing discrete event systems.

Driving the work of the lab are problems that we have been presented with by various parts of the New Zealand (and beyond) software development industry. This means that we can be sure our work is going to be useful for solving problems that are important to people outside the research environment.

Further details on the group can be obtained from the group’s website at www.cs.waikato.ac.nz/research/fm/
HUMAN-COMPUTER INTERACTION GROUP
Mark Apperley, Judy Bowen, Sally Jo Cunningham, Annika Hinze, Lyn Hunt, Steve Jones, Te Taka Keegan, Simon Laing, Masood Masoodian, David Nichols, Bill Rogers, Nicholas Vanderschantz, Ian Witten

HCI is the noble face of computer science. The discipline is concerned with designing, implementing and evaluating human-computer interface technologies over an ever-expanding range of applications and environments, as computer technology becomes increasingly pervasive. It involves understanding how computer technology can better fit user needs, and provides theories and tools to assist developers in making useful and usable systems. The work of this research group at Waikato covers many aspects of HCI, including:

- Mobile Devices, Interaction and Applications
- Interaction Design
- Interfaces for Information Retrieval
- Information Visualisation
- Computer-Supported Collaborative Work
- Open Source Usability
- Indigenous Language Interfaces
- User Centred Design (including Formal Methods)
- Knowledge-Based Interfaces
- Smart Environments and Pervasive Computing.

The team is actively engaged in these research areas across a wide range of applications, including meeting support, energy management, realistic virtual books, digital libraries, children’s on-screen reading, virtual travel, environments for knowledge workers, second language learning and location awareness. There are extensive connections with the international research community through publication in key journals and conferences, and reflected in visits from leading HCI researchers.

The group has a range of apparatus and infrastructure available for research students including a usability laboratory, large interactive displays, table-top displays, PDAs, GPS units, mobile audio devices, multi-layered display units, vision tracking systems and sketching interaction tools.

Further details on the group can be obtained from the group’s website at www.cs.waikato.ac.nz/hci/
Most of the computer applications you encounter today are in fact Information Systems, that means, systems that manage, store and deliver information to users. Examples are search engines like Google, ticket booking systems, or online stores. Exciting new kinds of applications that we look at in the ISDB group are mobile tourist information systems, memory-aid systems and systems that notify you about changes, eg, in web pages or online shops. Our latest projects are context-aware systems that deliver information to their users depending on a user’s location, time of the day, task, or mood.

Inside these systems, the data is often stored in a database or another complex storage system. The Information Systems and Databases Group (ISDB) is interested in both – the underlying technical and the application aspects of computer systems. We are working on different types of information systems, addressing a wide range of challenges.

A list of our projects includes:

• A mobile tourist information system (TIP) that provides travellers with up-to-date information about sights and recommends upcoming interesting events and locations to visitors. One aspect of TIP that we recently incorporated is a link to an interactive map service and a digital library. We also support a kind of mobile wikipedia for travellers and a personalised mobile gallery. For this project we co-operate with the HCI and the DL group as well as with the formal methods group. We also work with the Waikato Museum and investigate how to capture ways of different cultures, Māori and Pākehā, to approach the notion of place and history.

• An electronic parrot – a personalised extension of your memory that will make it easier to remember people, events, and data. This project was started just recently. We are concerned with questions like: How can we describe, store and access the data? What would a useful interface look like?

We also look at aspects of events and change management in the semantic web, in digital libraries, and in health care. In addition, we focus on the more technical side of information systems by analysing distributed event notification.

We are the youngest group in the department. That also means that a lot of our projects are done with close co-operation and support by our students in the department.

Further details on the group can be obtained from Annika Hinze. Email: hinze@waikato.ac.nz
MACHINE LEARNING GROUP
Eibe Frank, Geoff Holmes, Michael Mayo, Bernhard Pfahringer, Tony Smith, Ian Witten

Machine learning is concerned with the task of automatically extracting useful information from data. The aim is to identify patterns that can be used to understand the domain from which the data was collected and to make predictions. Consider the task of constructing a spam filter for email messages. Instead of laboriously creating a handcrafted set of filtering rules, we can use machine learning to extract patterns that differentiate spam from ham, based solely on a collection of messages that have been labelled as spam and ham respectively, and then use those patterns in the filter. Consider the task of understanding customer preferences by mining for interesting patterns in supermarket checkout data. There are efficient algorithms that can automatically extract those patterns in the form of simple if-then rules. Given the availability of vast amounts of raw data in electronic form, there is a plethora of applications for machine learning techniques.

Our team works on new, more efficient, algorithms for machine learning and data mining as well as new applications. We are well known for a software “workbench” called the Waikato Environment for Knowledge Analysis (WEKA), which contains a large number of machine learning techniques. WEKA is widely used for research, teaching, and commercial applications of machine learning. It has been used to help determine what information dairy farmers use in deciding which cows to keep in their herds, been applied to bioinformatics problems such as gene interaction discovery, and been used for many other applications such as mining supermarket transaction data for high profit product associations, predicting the levels of chemicals like nitrogen and carbon in soils to aid farmers’ fertilizer decisions, and processing natural language to extract keywords from documents.

Further details on the group can be obtained from the group’s website at: www.cs.waikato.ac.nz/research/ml/
Computer networks, including the internet, are having an ever-increasing impact on everyday life. Computer networks come in many shapes and sizes. The internet is the largest man-made structure, while bluetooth networks may cover just a desktop. The WAND group is the department’s computer networks research group.

One major focus of the WAND group is developing high performance networks. This work starts with designing and building measurement tools and techniques to study real networks. The data obtained from measurement can be used directly for management or used to build simulation models and perform detailed analysis of a range of possible scenarios perhaps including networks that can not currently be built. The WAND group is also developing visualisation software to display network traffic and aid in understanding the behaviour of measured networks and simulations. The group has a large test bed network for emulating real networks. This is used for development of tools and protocols, verification of our simulations and for testing new network devices.

Another major focus of the group is long distance wireless networks. The main project in this area is looking at connecting rural communities using low cost wireless technologies. Aspects of this work include developing network management systems, developing new routing algorithms and designing hardware including wireless NIC cards. As a part of this work the group has built wireless networks connecting rural schools and communities in the Waikato and Te Urewera National Park areas. Networks have also been built in the Pacific Islands and rural South Africa. The group is also embarking on a rapid deploy project looking at how wireless networks can be deployed in a matter of hours using minimal levels of expertise for disaster recovery and also for special events.

Further details on the group can be obtained from the group’s website at www.cs.waikato.ac.nz/research/wand/
MATHEMATICS
Mathematics today has a multitude of applications: car, aircraft, and ship design, cryptography, error-correcting codes, climate modelling and weather forecasting, improving the efficiency of industrial processes, power scheduling and energy modelling, financial and market prediction, and astrophysics, to name just a few. But mathematics also has interest for its own sake, because of the depth and beauty of the problems. High-profile pure mathematics problems solved in recent years include the Four Colour Problem, Fermat’s Last Theorem, and the Poincaré Conjecture.

Staff in the Department of Mathematics at the University of Waikato carry out research on a wide variety of topics in pure and applied mathematics, work that calls on mathematical knowledge from many fields such as algebra, analysis, number theory, differential equations and numerical analysis. A typical graduate programme includes papers from several of these areas.

These pages give information about the people who teach and supervise graduate work. Programmes may involve one, two or three years of study beyond a first degree. We welcome both New Zealand and international students. We have a friendly active group of experienced researchers in pure, applied and computational mathematics. Students can expect frequent informal contact with staff (often in the tearoom).

The Department provides good computing facilities. Our senior laboratory has a network of computers running Linux and Windows. Software includes: Maple, Mathematica, Matlab, Fortran 90, and Java. Internet services are provided.

You can find out more about the Mathematics Department on our website www.math.waikato.ac.nz
If you intend to take these papers you must consult one of the Graduate Advisers of the Department of Mathematics. The Mathematics Department does not offer any 400 Level papers.

**MATH501-16B (HAM)**
**METRIC SPACES**
**15 points**

Axioms of a metric space, open and closed sets, cluster points etc. Completeness, continuity, connectedness and compactness in metric spaces. Fixed-point theorems. Generalisation to topological spaces.

**Prerequisite Paper(s)** MATH311

**Assessment** Internal assessment/final examination ratio 1:0

**MATH509-16A (HAM)**
**NUMBER THEORY**
**15 points**


**Prerequisite Paper(s)** COMP235 or MATH258 or MATH320

**Assessment** Internal assessment/Final examination ratio 1:0

**MATH513-16B (HAM)**
**FINITE GROUPS**
**15 points**

A continuation of the group theory begun in MATH310.

**Topics include:** Sylow’s Theorem and applications, composition series, Jordan-Holder Theorem, normal series, central series, chief series, nilpotent and solvable groups, and an introduction to representation and character theory.

**Prerequisite Paper(s)** MATH310 or equivalent

**Assessment** Internal assessment/Final examination ratio 1:0.
MATH516-16A (HAM)
TOPICS IN DISCRETE MATHEMATICS
15 points
Graph theory and combinatorics, including network optimisation algorithms.
Prerequisite Paper(s) MATH320
Restricted Paper(s) MATH416
Assessment Internal assessment/Final examination ratio 1:0

MATH520-16C (HAM)
REPORT OF AN INVESTIGATION
45 points
A directed investigation and report on an approved project or study topic.
Prerequisite Paper(s) Students must qualify for entry according to the criteria determined by the Dean
Restricted Paper(s) COMP520
Assessment Internal assessment/Final examination ratio 1:0
Note(s) This paper is available only to students undertaking a BCMS(Hons) degree programme by permission of the Dean.

MATH541-16B (HAM)
CLASSICAL PARTIAL DIFFERENTIAL EQUATIONS
15 points
Topics chosen from: first-order equations; the method of characteristics; second-order equations; wave, diffusion, and potential; separation of variables, initial and boundary value problems; applications; heat and mass transfer, fluid dynamics, finance.
Prerequisite Paper(s) MATH311 and MATH331
Assessment Internal assessment/Final examination ratio 1:0
MATH542-16A (HAM)
ADVANCED PARTIAL DIFFERENTIAL EQUATIONS
15 points

A selection from the following topics: hyperbolic, elliptic and parabolic partial differential equations, solitons, integrability conditions and exactly solvable evolution equations.

Prerequisite Paper(s) MATH311
Assessment Internal assessment/Final examination ratio 1:0

MATH553-16B (HAM)
FLUID DYNAMICS
15 points

Basic principles of fluid dynamics. A review of thermodynamics and hydrostatic equilibrium. Derivation of the continuity, momentum, and energy equations, Navier-Stokes equations. Ideal and viscous flows, effects of compressibility. Selected applications of these principles to topics including surface water waves, boundary layers, shocks and jets, instabilities and convection, turbulence, the solar wind, and the dynamics of Earth’s atmosphere.

Prerequisite Paper(s) MATH329 and MATH331
Assessment Internal assessment/Final examination ratio 1:0

MATH555-16A (HAM)
ADVANCED CLASSICAL MECHANICS
15 points

Classical mechanics from a variational point of view including the central force problem, rigid body kinematics, Hamilton’s equations of motion, canonical transformations, Hamilton-Jacobi theory and the Lagrange formulation for continuous systems and fields.

Prerequisite Paper(s) MATH311
Restricted Paper(s) MATH334
Assessment Internal assessment/Final examination ratio 1:0

NOTES
MATH556-16B (HAM)
QUANTUM MECHANICS
15 points
The fundamentals of quantum mechanics and quantisation for elementary systems including: vector representations of states, spin, observables having continuous spectra, time variation of states, angular momentum, perturbation methods, Dirac's relativistic equation for the electron.

Prerequisite Paper(s) MATH311
Restricted Paper(s) MATH334
Assessment Internal assessment/Final examination ratio 1:0

MATH581-16A (HAM) & 16B (HAM)
SPECIAL TOPIC IN MATHEMATICS 1
15 points

MATH582-16A (HAM) & 16B (HAM)
SPECIAL TOPIC IN MATHEMATICS 2
15 points

MATH591-16C (HAM)
DISSERTATION
30 points

MATH592-16C (HAM)
DISSERTATION
60 points

MATH593-16C (HAM)
MATHEMATICS THESIS
90 points

MATH594-16C (HAM)
MATHEMATICS THESIS
120 points
"Choosing mathematics is definitely one of the craziest decisions I had ever made. (The other one is getting married.) And that changes my whole life. Learning mathematics is not just solving equations. More importantly, it helps you to think logically, improves the ability of problem solving and changes the view of the world. A good mathematics background might lead a successful career in science, engineering, computer science or finance. In Mathematics, we call the changes "variables", say "X"; and the things does not change "constant", say "C". Now, we can form the life as the following linear equation: Life = aX + C. That means that life is simply a couple of changes plus the faith in your mind. As I said, my "X" is studying mathematics in the top math department of the country. How about my "C"? Since I was a kid, I was dreaming to be a mathematician. I did not even know what mathematicians did at that time. But later, math did become my best friend. Math scares people sometimes, but for me, solving math problems is more like playing puzzle games. Everyone loves puzzle games. It is not just the challenge of problem solving, but also the satisfaction upon arriving at the correct answer. In my Honours year, I did a project with Dr. Daniel Delbourgo about finding zeroes of p-adic L-function in cubic field. The goal is to calculate all of the 5-adic and 7-adic λ-invariants attached to cubic extensions K/Q with cyclic Galois group (up to field discriminant < 10^7), and also tabulate the class number of K(e^{2\pi i/p}) for p = 5 and p = 7. If the λ-invariant is greater than 0, we then determine all the zeroes for the corresponding branch of the p-adic L-function. I started my PhD in number theory this year. What I am doing now is trying to use the techniques from representation theory, group theory and K-theory to solve some rank problems"
RESEARCH DIRECTIONS

The list to the right indicates general areas in which staff would be willing to supervise graduate projects and theses. The list is not exhaustive and most staff would consider other topics not listed here, which they would happily discuss with you. They will of course be receptive to your own ideas for projects.

For a PhD or MPhil, which involve original research, supervisors will only consider topics closely related to their own research. Otherwise there is a risk of repeating work already published, or which is of little interest. The other graduate degrees allow greater flexibility, and a review of published work on a mathematical topic in which you are particularly interested can often be a suitable project. Other projects may also be possible provided a suitable supervisor can be arranged. In some cases, this might involve a team which includes staff outside of the Department of Mathematics.

PROFESSOR KEVIN BROUGHAN
ELEMENTARY NUMBER THEORY

The proof of Fermat’s Last Theorem, together with a growing need for encryption within e-commerce, has rekindled interest in the techniques and outstanding problems of number theory. For example, smart cards sometimes include elliptic curve encryption algorithms. The use of the computer has also improved our ability to test conjectures and devise hypotheses based on real numerical data. In this project a problem from prime, algebraic or applied number theory will be considered: reading the background history and theories, looking at related results, carrying out computer experiments, testing some plausible conjectures etc will all lead up to the main goal – an attack on the outstanding problem or application itself.

SIEVE THEORY

The twin primes conjecture has long been regarded as a suitable problem which could be resolved using sieve theory, but so far the approach has failed. There are problems which have been solved. This project includes a study of the work of Henrich Iwaniec on sieves and might include an extension of his recent theorem “p=x²+y⁴ for an infinite number of primes p”.

ZETA FUNCTIONS

Modern analytic number theory includes the study and application of zeta and L-functions in a variety of settings, including number fields, groups and graphs. This is an active area of research and the aim of the project is to bring the student to a level (through a study of the works of Peter Sarnak, Dorian Goldfield and others) where one of the many unsolved problems might be attacked. The Waikato work has a strong computational flavour.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/kab
DR NICK CAVENAGH
COMBINATORICS
My research interests are chiefly in combinatorics, which is a branch of discrete mathematics, which in turn is a branch of pure mathematics.

Within combinatorics, I do a lot of work on latin squares, latin trades or bitrades and graph decompositions. Latin trades connect with many branches of pure mathematics including geometry (eg partitioning an integer-sided triangle into smaller, integer-sided triangles), finite field theory (in particular Weil’s theorem has been useful), group theory (some latin trades may be defined in terms of a group with specified properties) and linear algebra.

A latin square of order n is an nxn array of symbols 1,2,....,n such that each symbol occurs exactly once in each row and once in each column. Note that a completed Sudoku puzzle is a type of latin square of order 9. Problems in combinatorics are often easy to state but sometimes hard to solve. Those with an aptitude and disposition for finding patterns and solving puzzles often enjoy research in combinatorics.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/nickc

PROFESSOR IAN CRAIG
ASTROPHYSICS
The containment of hot plasmas by strong cosmic fields is not well understood. Research topics include the structure and stability of magnetic fields in the solar corona.

MAGNETIC FIELD LINE RECONNECTION
A problem of great interest in astrophysics is magnetic reconnection. The central idea is to release magnetic energy bound up in the topology of solar and stellar plasmas. Although it is known that reconnection is the only mechanism which allows topological change in the magnetised plasma, the real challenge for astrophysicists is to demonstrate a mechanism that can explain the explosive release of a solar or stellar flare.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/i.craig
**DR DANIEL DELBOURGO**

Number theory is as relevant today as it was 2,500 years ago, with the advent of high-powered computing and cryptography. My research interests lie in the area of arithmetic geometry, which uses tools from geometry and cohomology to study rational solutions to equations. As a famous example, Fermat’s Last Theorem asserted that there are no (non-trivial) integer solutions to the equation $x^n+y^n=z^n$ when $n>2$, yet its eventual proof by Andrew Wiles was found only after a mere 350 years of concentrated effort by numerous great mathematicians!

My work in this area applies ideas from classical Iwasawa theory and Galois representations, to study the arithmetic behaviour of invariants arising from these objects. I’m also interested in the special values of these L-functions, and there is a rich vein of conjectures connecting these values with elements in K-groups. Some of my recent efforts involve extending what we know over abelian extensions of the rationals, to some brand new non-abelian examples.

*Further details on sample publications can be obtained from [www.cms.waikato.ac.nz/people/delbourg](http://www.cms.waikato.ac.nz/people/delbourg)*

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**DR IAN HAWTHORN**

**GENERALISED SYLOW THEOREMS**

Sylow’s theorem is one of the most useful tools in a group theorist’s toolkit. It has now been generalised in a multitude of ways. The problem today is one of classifying the different generalisations and seeking a better understanding of the underlying principles that give rise to various categories of generalised Sylow theorems.

**SOLVABLE GROUP THEORY**

The composition series structure within a solvable group equips the group with a kind of a ‘scaffold’. This allows us to employ inductive arguments. Hence solvable group theory has quite a distinct flavour from the more difficult theory of finite groups in general. I have particular interest in the area of Fitting classes of solvable groups where there are a number of unsolved problems of current interest.

**OTHER TOPICS**

I also have interests in group theory in general. In particular I am interested in symmetry groups, Coxeter groups and Lie groups of relevance to theoretical physics. Research projects at a less advanced level are possible in these areas.

*Further details on sample publications can be obtained from [www.cms.waikato.ac.nz/people/hawthorn](http://www.cms.waikato.ac.nz/people/hawthorn)*
ASSOCIATE PROFESSOR STEPHEN JOE

LATTICE RULES

Lattice rules are used for the numerical integration of multiple integrals in hundreds or even thousands of variables. There has been much recent work on lattice rules and one of the main results is that the generating vectors for these lattice rules may be constructed by using a component-by-component algorithm.

There is now a need to do numerical testing of these lattice rules to see how they perform. Besides standard test problems, these lattice rules could be tested out on integrals arising from practical situations such as those from financial models.

Lattice rules are usually constructed for integrands over the unit cube. However, there are some applications in which one wants to approximate integrals where the integration region is all of Euclidean space. A question that arises is whether to use lattice rules for the unit cube and then do some mapping to Euclidean space or whether to use lattice rules designed for Euclidean space in the first place.

Of course, there are many other unanswered questions on lattice rules (such as those to do with their structure) and these are worthy of exploration as well.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/stephenj
PROFESSOR ERNIE KALNINS
PERTURBATIONS AND STABILITY IN GENERAL RELATIVITY
I am interested in the theory of perturbations in the vicinity of compact astrophysical objects such as black holes, and the stability of such structures with respect to such perturbations. In addition to these studies the solution of Einstein’s equations for bounded rotating masses is being actively pursued. In particular, the gravitational field in the vicinity of such configurations both classically and relativistically is under study. Affiliated to these ideas is the study of atoms in high magnetic fields and the relation to quantum chaos. These are important quantum mechanical problems to be solved here in an astrophysical sense.

QUANTUM GROUPS AND SPECIAL FUNCTIONS
Another interest is the study of quantum groups and quadratic algebras. This study is of actual quantum mechanical and classical mechanical systems which admit explicit solution and have definite algebraic properties. Also associated with this study are the properties of the special functions that arise in the solution of these problems and the consequences for the corresponding algebra. Of particular interest are generalisations of ellipsoidal harmonics in the case of quantum algebras.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/e.kalnins
DR WOEI CHET LIM
INHOMOGENEOUS COSMOLOGICAL MODELS

I am interested in the evolution of inhomogeneous cosmological models according to general relativity. The goal is to build an inhomogeneous model of the universe consistent with observational data, and to find any new relativistic phenomena.

I am currently studying the spike solution (in vacuum, with matter, or with an electromagnetic field), and the void model. The vacuum spike solution describes recurring inhomogeneous sheet-like gravitational distortions that occur during the chaotic BKL (Belinski-Khalatnikov-Lifshitz) phase shortly after the Big Bang; the void model describes the evolution of a relatively empty vast space. Sheets or bubbles of spikes are conjectured to intersect and interact with each other in filaments and points, and cause matter to gravitate towards these sheets, filaments and points to form large scale structures, leaving behind relatively empty regions that become voids. The inhomogeneous paradigm conjectures that the accelerated cosmic expansion, presently attributed to hypothetical dark energy in the homogeneous standard model, is an apparent effect of averaging the different expansion rates of the voids and the large scale structures.

The Einstein field equations of general relativity are a set of hyperbolic partial differential equations. I generally solve them numerically using finite difference methods. In special cases such as the spikes, I find the exact solution using solution-generating transformations. I also use analytical approximations and qualitative dynamical systems methods to study the evolution of the models.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/wclim

DR YURI LITVINENKO
ASTROPHYSICS

I am interested in developing theoretical models for a wide range of astrophysical processes – from energy release in flares on the Sun to the acceleration of galactic cosmic rays. The work is motivated by observations that put strong constraints on the theories, so developing models and making quantitative predictions is usually an interesting but challenging job.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/yuril
ASSOCIATE PROFESSOR SEAN OUGHTON

My current research interests centre on understanding the behaviour of turbulent flows. Physically we all have a good understanding of what a turbulent flow is. For example, white water rapids are clearly turbulent, whereas a (stationary) jar of honey is not. In fact, on the earth most flows, at most times, are turbulent. Mathematically, one might say that a turbulent flow is characterised by motions which occur over a broad range of length (and time) scales and that these motions interact nonlinearly. It is this nonlinear nature of the problem that makes it simultaneously so rich and so challenging.

A particular interest is magnetofluid turbulence, where the fluid is electrically conducting so that one must consider not just the behaviour of the fluid’s velocity, but also that of its magnetic field. Examples of magnetofluids include liquid metals (eg mercury) and plasmas (eg the sun, the solar wind, the working fluid in nuclear fusion devices). Most of the matter in the universe is thought to be in the plasma state, that is, the atoms have been ionised. One way to study conducting fluids is using magnetohydrodynamics (MHD). This is the marriage of the equations of fluid dynamics with those of electrodynamics, and provides a good approximation to the behaviour of various parts of the solar system (or heliosphere). Important dynamical features of MHD include waves, turbulence, plasma heating, and particle acceleration. The work involves a mixture of theory (including statistical mechanics and modelling) and computer simulations of the governing equations. I am happy to supervise PhD and masters topics on fluids and MHD, particularly solar wind/solar corona/turbulence.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/seano
DR TIMOTHY STOKES

ALGEBRA OF PARTIAL MAPS

An important topic in algebra is to abstractly represent certain concrete kinds of structure. For example, a well-known fact from group theory is that every group can be represented as a group of permutations of a set, and conversely, every collection of permutations closed under composition and inverse is a group. One of my main research interests is to generalise this correspondence to other situations. There are connections with the theory of relation algebras, of importance in Computer Science.

RADICAL THEORY

The Jacobson radical of ring theory is the key to unlocking much information about the structure of rings (algebraic objects generating the familiar number systems, which include polynomials and matrices as examples). I am interested in the generalisation of these ideas to other kinds of algebraic systems.

FREE SURFACE PROBLEMS

A very basic problem in the theory of ideal fluids is the behaviour of a free surface in response to the withdrawal of fluid through a submerged sink. The steady state case has received much attention in past decades, although recently a lot of work has been done in the unsteady case with the flow initiated from a quiescent situation. I am interested in this problem in two and three dimensions, for both finite and infinite depth situations.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/people/stokes
STATISTICS
Almost every facet of modern life relies on some application of statistics. For example:

- Discoveries in medical science owe much to the statistical analysis of clinical trials
- In agriculture, productivity increases have been achieved through the design and analysis of well planned experiments
- The quality of manufactured products has been improved using simple statistical process control methods;
- Good economic forecasts rely on the analysis of sound economic and financial data
- Government planning and the provision of services are based on information collected using statistical methods of sampling.

We offer a variety of qualifications, for both graduate and postgraduate students, which reflect this need for statistics in the community. They range from one-year postgraduate diplomas to three-year research degrees. Staff in the Department of Statistics at the University of Waikato have considerable experience in teaching a wide range of applied and theoretical statistics papers, and are actively involved in research on a variety of statistical topics; see the section on Research Directions.

The Department provides good computing facilities. Our senior computing laboratory has a network of PCs running Linux and Windows. Software available includes Minitab, R, Mathematica, Matlab, C++, and Fortran 90. The internet and email are also available. We welcome both New Zealand and international students.

You can find out more about the Statistics Department on our website: www.stats.waikato.ac.nz
GRADUATE PAPERS

Papers at the graduate level may include lectures, practical work, special readings, assignments, presentation of seminars and a dissertation (30 or 60 points) or thesis (90 or 120 points). Further topics may be available through directed study by arrangement with the Chairperson. Normally students enrolled in the MSc (Research) programme take four taught papers over two years, and begin a four-paper (120 points) thesis during the first year of study. Entry to all graduate papers is by way of permission of the Chairperson of Statistics.

STAT521-16A (HAM)
COMPUTATIONAL STATISTICS
30 points

Maximum likelihood estimation, advanced regression including nonlinear, generalised additive and tree-based models. Further topics selected from mixture models, temporal and spatial data, random coefficient models and data mining.

Prerequisite Paper(s) STAT321 or three other 300 level statistics papers

Assessment Internal assessment/Final examination ratio 1:0

STAT522-16B (HAM)
STATISTICAL INFERENCE
30 points

Statistical inference will be considered from both the classical and Bayesian perspectives. It covers maximum likelihood estimation, the properties of estimators, confidence intervals, and hypothesis tests. Bayes’ theorem is used to revise beliefs about the parameters given the data.

Assessment Internal assessment/Final examination ratio 1:0

STAT525-16A (HAM)
TOPICS IN STATISTICS
30 points

Assessment Internal assessment/Final examination ratio 1:0

STAT531-16B (HAM)
MULTIVARIATE ANALYSIS
30 points

Assessment Internal assessment/Final examination ratio 1:0

STAT533-16A (HAM)
STUDY DESIGN AND STATISTICAL INFERENCE
30 points

Assessment Internal assessment/Final examination ratio 1:0
STAT536-16B
BAYESIAN INFERENCE
30 points

This paper extends material taught in STAT326 and studies advanced topics in Bayesian methods, including advanced MCMC methods, sequential MC methods, non-MCMC methods, and theoretical foundations of Bayesian inference.

Restricted Paper(s) STAT326
Assessment Internal assessment/Final examination ratio 2:1

STAT590-16C (HAM)
DIRECTED STUDY
30 points

STAT591-16C (HAM)
DISSERTATION
30 points

STAT592-16C (HAM)
DISSERTATION
60 points

STAT593-16C (HAM)
STATISTICS THESIS
90 points

STAT594-16C (HAM)
STATISTICS THESIS
120 points
RESEARCH DIRECTIONS

The following pages will give prospective research students an indication of the research interests of the staff of the Department of Statistics. If you are considering a research-based degree, you are invited to discuss your interests with the Chairperson of the Department of Statistics, or directly with one of the staff members.

ROBERT DURRANT
HIGH DIMENSIONAL PROBLEMS

The enormous power of modern computers has made possible the statistical modelling of multivariate data with dimensionality that would have made this task inconceivable only decades ago. However, experience in such modelling has brought awareness of many issues associated with working in high-dimensional domains, collectively known as ‘the curse of dimensionality’, which can confound our desires to build good models from such data. When the dimensionality is very large, low-dimensional methods and geometric intuition both break down in these high-dimensional spaces.

I am interested in developing theory which reveals when and why popular current approaches can be expected to perform well (or badly), since this is often not well understood, and also in developing new and efficient approaches for high dimensional settings with theoretical performance guarantees.

APPLICATIONS OF MEASURE CONCENTRATION

Various flavours of the law of large numbers (LLN) say that the normalised sum of many independent random variables will typically be close to its expectation. However, what is so special about sums of independent random variables that leads to this ‘concentration’ about the mean? It turns out that the important thing about summation is that it is a Lipschitz-continuous function, and that for independent random variables we still get such concentration if we replace summation with any other Lipschitz function. What about independence though? Concentration of measure is an active field of research that aims, amongst other things, to quantify the extent to which we can relax independence and still obtain such LLN-type effects. Results of this type potentially have a wide range of practical and theoretical applications, within statistics and elsewhere, and I am interested in both developing and applying them.

Further details on sample publications can be obtained from www.stats.waikato.ac.nz/~bobd/
LYN HUNT

MIXTURE MODELS

One approach that can be used to discover underlying structure in data is to assume that the data comes from a finite mixture of distributions. This is a model based approach to ‘cluster analysis’. Murray Jorgensen and I are keen to continue the development of software using this approach.

MISSING DATA

Often data are collected in which not all values are observed for some observations. The subsequent problem that occurs is how to select an appropriate method for coping with missing values when you have to analyse data that does not have all values observed. A method has been implemented for data that comes from a finite mixture of distributions. We are continuing to develop this approach.

THREE-WAY DATA

I am also interested in detecting the structure in multivariate data where various measurements have been made on, for example, different species of plants grown in different conditions. A finite mixture model approach can also be used in this situation.

Further details on sample publications can be obtained from www.stats.waikato.ac.nz/people/la
RESEARCH AREAS

Computational Bayesian Inference, Bayesian Modelling and Statistical Modelling.

COMPUTATIONAL BAYESIAN INFERENCE AND BAYESIAN MODELLING

I am primarily interested in modelling complex real-life processes using statistical methods. Mostly, I choose Bayesian methods for their flexibility and versatility. Such modelling often leads to interesting research problems in statistical methods. To this end, I am interested in developing computationally efficient methods for Bayesian inference. Presently I am working on improving the computational efficiency of non-MCMC based methods by using the low discrepancy sequences.

STATISTICAL MODELLING

I have also been working on problems related to modelling species distribution. We have developed a novel mathematical framework called ‘Traitspace’ which incorporates the various processes/factors which govern the assembly of ecological communities and predicts the community assembly by using the observed trait values.

Recently I also finished supervising a project aimed at predicting the hospital re-admission data.

From 2003 until 2007, I worked as a statistician for a number of leading corporations in the pharmaceutical and market research area.

Further details on sample publications can be obtained from www.cms.waikato.ac.nz/~cjoshi/
YOONSUH JUNG

MODELLING HIGH THROUGHPUT GENETIC DATA

Alternative splicing is known to be a critical factor in cancer formation and progression, and splicing can be detected using Affymetrix exon tiling arrays. A typical exon tiling array experiment involves two (or more) groups—often cancer patients and disease-free subjects. An interesting observation is that alternative splicing events may show different degrees among or occur only among particular subgroups of cancer patients. We develop a statistical model and corresponding sequential tests to detect such cancer subgroup structure, and we find that this improves the detection of alternative splicing.

In genome-wide association studies, the primary task is to detect biomarkers in the form of Single Nucleotide Polymorphisms (SNPs) that have nontrivial association with a disease phenotype and some other important clinical/environmental factors. However, the extremely large number of SNPs compared to the sample size inhibits application of the existing classical methods, for example, multiple logistic regression for case-control studies. I am interested in modelling the genotypes of the SNPs simultaneously via a likelihood approach.

ROBUST MODELLING

Highly outlying observations are often removed to reduce the undesirable impact of the observation with the resulting sacrifice of degrees of freedom. To downsize the effect of outlying observations, a robust loss function such as Huber’s loss is also frequently used. With the aid of penalization, we add an indicator for each case in the data set and attach a penalty term for these case-specific indicators to produce a robust model. The proper choice of penalty can lead to a desired effect.

MODEL SELECTION UNDER HIGH DIMENSIONAL DATA

Traditional model selection method such as AIC, BIC, and cross-validation have dealt with the case where number of variables is fixed and smaller than the sample size. The consistent (or, oracle) properties of the mentioned model selection methods are no more applied under the high dimensional data where the number of variables is far larger than the number of sample. One of the key research interest is to develop model selection under the high dimensional data where the number of variables may diverge.

Further details on sample publications can be obtained from www.stats.waikato.ac.nz/~yoonsuh/
STEVEN MILLER

ECOLOGICAL STATISTICS
The interface between ecology and statistics is a fertile ground for the development of novel statistical methods and applications. This area of research is of particular importance in New Zealand, due to the number of native species threatened by the introduction of exotic competitors and predators, and vulnerable to changes in habitat and climate.

POPULATION GENETICS
Technology in the field of genetics is advancing rapidly, and novel statistical methods are required to cope with the ever-increasing amounts of data. The amount, quality and types of genetic data now available allow for the fine-scale resolution of parameters governing the growth and spread of populations. This enables population histories to be reconstructed far back into the past, even when there is access to solely modern data.

STOCHASTIC DYNAMICS
The mechanisms underlying many natural processes are so complex that traditional means of analysis are thwarted. Due to advances in computing power, such problems can now be addressed via computationally intensive techniques such as numerical approximation and simulation. There is scope to enhance the efficiency of many of these computational algorithms, and to escape restrictive assumptions lingering from earlier methods of analysis.

Further details on sample publications can be obtained from www.stats.waikato.ac.nz/people/smiller
FURTHER INFORMATION
SCHOLARSHIPS

The Faculty of Computing & Mathematical Sciences offers a number of undergraduate scholarships.

**COMPUTER SCIENCE UNDERGRADUATE SCHOLARSHIP**

Each year the Computer Science Department offers up to 10 tuition fees scholarships for first year undergraduate students. The scholarships will have a value of up to $5,000 and will be credited to the tuition fees account of the successful applicants. It will not be refundable to recipients who withdraw from their degree (BSc, BE(Hons) or BCMS, or BCGD), and can be held concurrently with other scholarships. It will be the responsibility of the student to pay the balance of their fees.

The scholarship examination is open to all Year 12 and Year 13 students at the New Zealand Secondary School.

The Scholarships are awarded on the basis of examination results of each applicant in the Waikato University Computer Science Scholarship Examinations, held each year in high schools. The examination is made up of two parts: a two-hour written examination and a six-hour practical examination and is roughly the equivalent to the practical programming tasks and final exam of the first year paper Introduction to Computer Science 1 (COMP103) at the University of Waikato, which gives students a basic level of competence in computer programming and computing concepts.

Information on the Waikato University Computer Science Scholarship Examinations are sent each year to schools around New Zealand. Please enquire with your school for further information or contact the Computer Science Department.

**COMPUTER GRAPHIC DESIGN FEES SCHOLARSHIP**

$5,000

The Computer Graphic Design Fees Scholarship is open to applicants who are enrolling in the first year of study towards an undergraduate degree with a specified programme in Computer Graphic Design at the University of Waikato. All students wishing to be considered for the Computer Graphic Design Fees Scholarships must apply on the official Scholarship application form and submit this with their portfolio.
MATHMATICS FEES SCHOLARSHIP
$5,000
The Mathematics Fees Scholarship is open to students enrolling in the first year of study towards an undergraduate degree with a major in Mathematics. Successful applicants will usually be intending to enrol in the Faculty of Computing & Mathematical Sciences, although in exceptional circumstances the Selection Panel may consider applicants who are enrolling in a Mathematics major through another School or Faculty. The scholarship to be awarded will be based on the results of a competitive examination.

STATISTICS FEES SCHOLARSHIP
$2,500
The Statistics Fees Scholarship is open to applicants who are enrolling in the second or third year of study towards an undergraduate degree with a major in Statistics at the University of Waikato. Successful applicants will usually be enrolled in the Faculty of Computing & Mathematical Sciences, although in exceptional circumstances the selection panel may consider applicants who are enrolled in a Statistics major through another Faculty or School. Up to two Scholarships may be awarded each year.

CMS INTERNATIONAL EXCHANGE SCHOLARSHIP
$1500-$2500
The CMS International Exchange Scholarships are awarded twice a year for exchanges commencing in A and B Semester and are offered on the basis of:

- Academic performance
- Goals and aspirations as outlined in a cover letter, including perceived benefits of the exchange programme for the applicant.
- To be eligible to apply for a CMS International Exchange Scholarship candidates must meet the following conditions:
  - Have completed at least one year of study as a student enrolled in the Faculty of Computing & Mathematical Sciences.
  - Have applied for a University of Waikato exchange programme
  - Be a full-time student enrolled in the Faculty of Computing & Mathematical Sciences.

Preference will be given to students who have achieved a minimum of B+ grade average in the previous two semesters of study. The offer of a scholarship will be conditional on the recipient being accepted onto a University of Waikato exchange programme.
DEAN’S AWARD FOR EXCELLENCE
The awards will be presented to the best 10 students, in each level, enrolled in an undergraduate degree in the Faculty of Computing & Mathematical Sciences, as recommended by the Faculty Board of Examiners.

For the closing date and further information about these scholarships please contact the Scholarships Office.

ALAN TURING PRIZE
$300
The Alan Turing Prize is awarded annually to the student who has performed best in a third-year programme of studies which includes at least two 300 level papers in Computer Science and at least two 300 level papers in Mathematics.

THE A ZULAUF TRUST SCHOLARSHIP
$5000
Candidates will, in the year of application, be enrolled or enrolling full-time to undertake the research portion of their masters degree. It is expected that the bulk of that research will take place in the year of application.

EMMY NOETHER PRIZE IN MATHEMATICS
$500
The Waikato Branch NZFGW Emmy Noether Prize in Mathematics is awarded annually to the most outstanding woman student in her first year of study in Mathematics.

EULER PRIZE IN MATHEMATICS
$250
This prize will be awarded to the student who has completed two full years of study at the University of Waikato who is majoring or enrolled in a programme which the Department of Mathematics is responsible, and who in the opinion of the Chairperson is the most outstanding second year mathematics student and worthy of the award.

GORDON HARRIS BACHELOR OF COMPUTER GRAPHIC DESIGN PRIZE
$250
The Gordon Harris Bachelor of Computer Graphic Design Prize is awarded every second year, to the top second-year student of the BCGD.
HILBERT PRIZE IN MATHEMATICS
The Hilbert Prize in Mathematics is awarded annually to the best student who has completed at least four papers at 300 Level in Mathematics in the year of the award.

JOHN CLEARY PRIZE
$250
The John Cleary prize will be awarded to the top student in the paper COMP317-Design and Analysis of Algorithms.

JOHN TURNER PRIZE
$200
The John Turner Prize is awarded to the student who achieves the highest mark for the 520 research project and report for the BCMS (Honours) paper COMP520 Report of an Investigation.

KEITH HOPPER PRIZE IN COMPUTER SCIENCE
$250
This prize will be awarded annually to the top student taking second-year Computer Science Systems papers at the University of Waikato in the year of award.

LEIBNIZ PRIZE IN MATHEMATICS
$250
This prize will be awarded to an undergraduate student who has completed at least 60 points of papers above 100 level in mathematics, and who in the opinion of the Chairperson of the Department is an outstanding student and worthy of the award.

MARGARET JEFFRIES PRIZE IN COMPUTER SCIENCE
$250
The Margaret Jeffries Prize in Computer Science is awarded annually to the top female student taking second-year Computer Science papers at the University of Waikato in the year of award.
**MILLENIUM PRIZE IN MATHEMATICS**
The Millennium Prize in Mathematics is awarded annually to the most outstanding student who has completed two full-time years of study at the University of Waikato, and who is majoring in Mathematics (or enrolled in a specified programme sponsored by the Department of Mathematics).

**RAMANUJAN CENTENARY PRIZE**
$200
The Ramanujan Centenary Prize is awarded annually to the student who has completed the degree of Bachelor of Computing and Mathematical Sciences with the best overall performance.

**VON NEUMANN PRIZE IN MATHEMATICS**
The Von Neumann Prize in Mathematics is awarded annually to a student in their first year of study at the University of Waikato, who is enrolled in at least one paper offered by the Department of Mathematics and who is, in the opinion of the Chairperson of the Department, the most outstanding first-year student and worthy of the award.

**WILLIAM AND SYLVIE BOLSTAD BAYESIAN STATISTICS PRIZE**
$200
The William and Sylvie Bolstad Bayesian Statistics Prize is awarded annually to the top undergraduate student who has undertaken a Bayesian Statistics paper at the University of Waikato in the year of award.
SIR EDMUND HILLARY SCHOLARSHIP PROGRAMME – FULL FEES
The Sir Edmund Hillary Scholarship Programme provides support for students studying at Waikato who have an established record of excellence in sport, or in performing or creative arts, exhibit leadership qualities, have University Entrance, and have achieved a specified number of credits at Level 3 NCEA in a specified number of approved subjects.

Recipients of this award receive a full-fees Hillary Scholarship for the duration of their studies, academic support, leading coaches/tutors, free gym membership and a leadership and personal development plan.

THE VICE-CHANCELLOR’S ACADEMIC EXCELLENCE SCHOOL LEAVER SCHOLARSHIP
$5,000 towards fees or accommodation, awarded to students in their first year of study who gain NCEA level 3 Certificate with an Excellence endorsement*, University Entrance and meet the criteria for entry to their programme and in their first year are enrolled in a full-time programme.

THE UNIVERSITY OF WAIKATO ACADEMIC MERIT SCHOOL LEAVER SCHOLARSHIP
$3,000 towards fees or accommodation, awarded to students in their first year of study who gain NCEA level 3 Certificate with an Merit endorsement*, University Entrance and meet the criteria for entry to their programme and in their first year are enrolled in a full-time programme.

Your eligibility for the school leaver scholarship will be assessed when the University receives the NCEA results. (*or equivalent in CIE or IB).

The Scholarships Office is responsible for all administration associated with scholarships and prizes awarded by the University and outside sponsors. These include University of Waikato Scholarships, Universities New Zealand Scholarships.

For the closing date and further information about these scholarships please contact the Scholarships Office.

SCHOLARSHIPS OFFICE
The University of Waikato, Private Bag 3105, Hamilton 3240

Phone +64 7 838 4489
Fax +64 7 838 4600
Email scholarships@waikato.ac.nz
Office Hours 8.30am to 5pm
The Library is located in the Student Centre/Te Manawa. The Library provides students with access to:

**BUILDING RESOURCES**
- Computers, laptops, photocopiers, scanners
- Group study rooms
- Quiet study spaces
- Comfortable social spaces.

**STUDY AND RESEARCH RESOURCES**
- Books/Journal articles/Proceedings/Technical reports – print and online
- Other resources (DVDs, maps, microfilms etc).

**STAFF ASSISTANCE**
- Library tours
- Tutorials (how to find, reference and present your information; computing skills)
- General queries and information (information desks, online chat, Virtual Reference Desk, Facebook)
- 1:1 consultations with your Subject Librarian
- Interlibrary loans (loaning resources from other libraries).

You can find out more about the Library on our website: www.waikato.ac.nz/library

**COMPUTING & MATHEMATICAL SCIENCES LIBRARIAN – CLIVE WILKINSON**
The Library, the University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand

Phone +64 7 838 4749
Email cwilkins@waikato.ac.nz
By using our computing facilities, you agree to abide by the Computer Regulations as listed in the 2016 University of Waikato Calendar as well as the following additional conditions and requests.

- Do not use another person’s account, even with their explicit permission.
- Do not do anything in the name of another user, including sending email messages.
- Do not deliberately disrupt or adversely affect the use of the facilities by other students.
- Do not unplug lab computers.
- Do not attempt to gain access to any system within, or external to, the University to which you are not entitled.
- Do not copy or interfere with software on the computers.
- Do not install or attempt to use any unlicensed software.
- Do not attempt to “break” any software or hardware protection.
- Do not act in a manner likely to cause damage to equipment – this includes the chairs.
- Ensure that your computer is properly logged off after use. Any costs incurred while the computer is logged in under your name will be charged to your account, even if you were not using that computer at the time. Please change your password immediately if you suspect that others know it.
- Do not use the computer systems to access, download or store any material that might be deemed inappropriate or be in violation of copyright law.
- You must provide your username to Computer Support staff if they request it in the course of their duties.
- Please report any theft or vandalism that you may observe.
- Technical and teaching staff may access your account as part of their duties.
- A computer account belongs to the University and is provided to you for the purposes of academic work.

calendar.waikato.ac.nz/policies/computersystems.html
A LITTLE CONSIDERATION GOES A LONG WAY

- During busy periods in the labs, please give priority to students doing course-related work.
- Please leave a room in a timely fashion when asked to by staff, for example, when a lab has been booked for a class.
- Respect other users when using your mobile phone. If your phone rings, answer it, but please leave the lab and take the call in a corridor or outdoors.
- If listening to music or watching videos, please use headphones.

Non-compliance with the above conditions and requests can result in a range of penalties including but not limited to – the suspension of your account, referral to the University Student Discipline Committee, referral to the Police.

FOOD AND DRINK

Food and non-alcoholic beverages are allowed in the labs under the following conditions:

- Beverages are in containers with spill resistant lids. (eg travel mugs, closed drink bottles, cans, etc)
- Food is cold and produces minimal mess and smell. (eg vegetables, cheese, raisins, chocolate bars, etc)
- All spills, crumbs, smears, etc, must be cleaned up by the consumer
- All garbage and waste materials are disposed of in the rubbish bins.

Although you can consume food and drink in the labs, please respect those around you and try to consume food and drink in the spaces provided outside of the labs where possible.