Established in 1964 as a result of the demands of a local community, the University of Waikato offers a comprehensive range of programmes and attracts outstanding students from the Waikato and Bay of Plenty Regions, from the rest of New Zealand, and from around the world. The University is a vibrant multicultural community providing a high quality student experience in a beautiful park-like campus environment.

Research is the driving force that distinguishes universities from other tertiary institutions, and the researchers and postgraduate students at the University of Waikato are providing unique perspectives on issues of importance to contemporary society and answers to some of the key problems being faced by industries, governments and nations around the world. We have seven research institutes, including a new NZ Institute for Security and Crime Science, which enable our academic staff and postgraduate students to contribute to regional, national and global research.

Our graduates are committed to making a real difference for their employers. The newly implemented Curriculum Design Framework will see the University delivering a more future-focused curriculum that is responsive to changing student, employer and societal needs. This includes a focus on cultural competency and work-integrated learning opportunities, helping to create work-ready graduates with the skills employers need.

Data from Universities New Zealand and the Graduate Longitudinal Survey continue to demonstrate the value of a university degree. A typical university graduate earns about $1.6 million more over their working life than a non-graduate. Two years after graduation, 80% of graduates said that getting a degree was well worth the time and cost, and graduates expressed high levels of satisfaction with their lives following university.

Whatever your aspirations may be, the University of Waikato provides an outstanding learning environment and we look forward to seeing you on campus.

Professor Neil Quigley
VICE-CHANCELLOR
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, data analytics, mathematics, or 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
# CONTENTS

## UNDERGRADUATE STUDY

- 2018 teaching and assessment periods  
- Faculty contacts  
- Faculty Office and Department contacts  
- Overview of qualifications  
- Example degree structure  
- University terminology  
- Double Majors and Minors  
- Certificates and Diplomas  
- General entry requirements (bachelors degree)  
- General information for international students (bachelors degree)  

## DESIGN

- Introduction  
- Staff  
- Communication Design  
- Interface Design  
- Media Design  
- Papers  

## COMPUTER SCIENCE

- Introduction  
- Staff  
- Applied Computing  
- Study in Tauranga  
- What is Computer Science?  
- Bachelor of Computing and Mathematical Sciences with Honours (BCMS(Hons)) degree planner  
- Bachelor of Science (BSc) degree planner  
- Bachelor of Science Technology (BSc(Tech)) degree planner  
- Science papers  
- Focus areas in Computer Science  
  - Artificial Intelligence  
  - Data Mining  
  - Games and Multimedia  
  - Information Systems  
  - Interaction Design  
  - Internet Applications  
  - Networks  
  - Software Development  
- Bachelor of Engineering with Honours (BE(Hons))  
- Software Engineering  
- Papers  

## MATHEMATICS

- Introduction  
- Staff  
- Bachelor of Computing and Mathematical Sciences with Honours (BCMS(Hons)) degree planner  
- Bachelor of Science (BSc) degree planner  
- Papers
The information contained in this handbook is correct at the time of printing (September 2017). 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 2018 University of Waikato Calendar.
# 2018 Teaching and Assessment Periods

<table>
<thead>
<tr>
<th>Week</th>
<th>Starting</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Holidays and Other Important Dates</th>
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<tbody>
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<td>1</td>
<td>1-Jan-18</td>
<td>NYD</td>
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<td></td>
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<td>1-2 January, New Year’s Day (Observed)</td>
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<td>Term 1 starts 5</td>
<td>29-Jan-18</td>
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<td></td>
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<td>29 January, Auckland Anniversary Day</td>
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<td>6</td>
<td>5-Feb-18</td>
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<td>6 February, Waitangi Day</td>
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<td>12-Feb-18</td>
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<td>13</td>
<td>26-Mar-18</td>
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<td>CF</td>
<td>30 March, Good Friday</td>
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<td>2-Apr-18</td>
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<td></td>
<td>EM</td>
<td>2/3 April, Easter Monday/Tuesday</td>
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<td>13 September, Kīngitanga Day</td>
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<td>22-Oct-18</td>
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<td>Exams</td>
<td>22 October, Labour Day</td>
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<td>10-Dec-18</td>
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<td>Term 4 ends (20/12) 51</td>
<td>17-Dec-18</td>
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<td>Teaching Recess</td>
<td>25/26 December, Christmas Day/Boxing Day</td>
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<td>52</td>
<td>24-Dec-18</td>
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<td>31-Dec-18</td>
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</tbody>
</table>
DEAN
Professor Geoff Holmes
BSc(Hons) PhD S’ton

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

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

ASSOCIATE DEAN — EXTERNAL ENGAGEMENT
Professor Yifan Chen
BEng(Hons I) PhD NTU

ASSOCIATE DEAN — RESEARCH
Associate Professor Yuri Litvinenko
MSc Moscow PhD NH

ASSOCIATE DEAN — SOFTWARE ENGINEERING
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Web math.waikato.ac.nz or stats.waikato.ac.nz

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Director: Associate Professor Ryan Ko
Administrator: Tania Robinson
Room G.1.21
Phone +64 7 838 4021
Email nziscs@waikato.ac.nz
Web waikato.ac.nz/security-crime-science

DEPARTMENT OFFICES
Through these offices you can contact the lecturers and co-ordinators for each of your papers.

INSTITUTE OFFICE
This is the first stop for advice on degree planning and enrolment queries.
Why study at the University of Waikato

Our changing world creates new opportunities and faces new challenges every day. At Waikato, we're leading the way with an innovative approach to education that is supported by world-renowned experts and is producing successful graduates across all subject areas.

Check out some of the top reasons that Waikato is a great place to study Computing and Mathematical Sciences:

**HIGH-TECH, STATE-OF-THE ART COMPUTING FACILITIES**

**Faculty Scholarships and prizes for outstanding academic achievement worth over $100,000 annually**

**NZ’s first Institute for SECURITY AND CRIME SCIENCE**

**ABOUT 220 INTERNATIONAL STUDENTS from across 28 countries**

**WORLD-CLASS RESEARCH in MACHINE LEARNING, DIGITAL LIBRARIES & CYBER SECURITY**

**NZ’S FIRST CYBER SECURITY LAB**

**TWO DEDICATED FACULTY CLUBS: LADIES INC & CS³**
UNDERGRADUATE STUDY
OVERVIEW OF QUALIFICATIONS
The Faculty of Computing & Mathematical Sciences offers the following undergraduate degrees.

STUDENTS INTERESTED IN DESIGN SHOULD APPLY FOR THE BDES

BACHELOR OF DESIGN (BDES)
Three-year degree with majors in:
Communication Design
Interface Design
Media Design.

STUDENTS INTERESTED IN COMPUTER SCIENCE, DATA ANALYTICS OR MATHEMATICS SHOULD APPLY FOR EITHER THE BCMS(HONS) OR THE BSC

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

BACHELOR OF SCIENCE (BSC)
Three-year degree with majors in:
Applied Computing
Computer Science
Data Analytics
Mathematics.

Transfers between the BCMS(Hons) and BSc are easy and common. The advantage of the BCMS(Hons) is the honours year which enables strong students to complete higher level papers and a research project.

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 Engineering 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.

Regulations for all these qualifications can be found in the 2018 University of Waikato Calendar or on the following website: calendar.waikato.ac.nz/regulations/index.html
EXAMPLE DEGREE STRUCTURE

This structure is an example of a degree with a single major for new students starting in 2018. Each box represents one paper. Each paper is worth 15 points unless otherwise specified.

Example degree planner  3 years 360 points

Y1  100 level  100 level  100 level  100 level  100 level  100 level  100 level
Y2  200 level  200 level  200 level  200 level  200 level  200 level  100 level or above
Y3  300 level  300 level  300 level  300 level  300 level  300 level  300 level or above

Major  Compulsory  Elective

UNIVERSITY TERMINOLOGY

MAJOR
This is the main subject of the degree. To major in a subject it must be studied at an advanced level. A single major requires 135 points in a three year (360 points) degree.

COMPULSORY PAPER
These are papers that are required by a particular degree and must be completed to gain a degree.

ELECTIVE
Students may have room in their degree to take papers outside of their major. These can be chosen from almost any subject at Waikato.

POINTS
Each paper has been given a points value. A typical full-time year of study equals 120 points. The total student learning hours required for a paper can be calculated at 10 times the point value of the paper, for example a 15 point paper would require 150 hours of study.

EFTS
EFTS stands for Equivalent Full-time Student. This relates directly to points –120 points equate to one EFTS. StudyLink uses this information when looking at your Student Loan and Student Allowance eligibility.
DOUBLE MAJORS

WHAT IS A DOUBLE MAJOR?
A double major is simply two majors completed in one degree. Although it doesn’t necessarily take longer to complete a degree, pursuing a double major will reduce your overall number of elective papers as you study your two majors in depth.

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

DOUBLE MAJOR IN COMPUTER SCIENCE AND MATHEMATICS
Able students may wish to consider doing a double major with one major in Computer Science and the other major in Mathematics, or some other subject. 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 degree planner  
Computer Science and Mathematics 3 years 360 points

<table>
<thead>
<tr>
<th>Year</th>
<th>Courses</th>
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</thead>
<tbody>
<tr>
<td>Y1</td>
<td>COMPX101</td>
</tr>
<tr>
<td>Y2</td>
<td>COMPX201</td>
</tr>
<tr>
<td>Y3</td>
<td>COMPX361</td>
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</tbody>
</table>

Note: Students may include up to 30 points of STATS-coded papers as part of their Mathematics major.

List A: COMPX374, COMPX375, COMPX390, COMPX391, MATHS390, MATHS391 or SCIEN279

MINORS

WHAT IS A MINOR?
A minor is a secondary concentration of papers that complements the major. A minor requires completion of 60 points in the minor subject area, with at least 30 points at 200 level or above. Minors are optional.

For further details about a minor, contact the Faculty Reception cms@waikato.ac.nz
CERTIFICATES AND DIPLOMAS

WHO ARE DIPLOMAS AND CERTIFICATES SUITABLE FOR?
• Students who want an introductory programme in one of our subjects.
• 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
A Certificate is equivalent to the first year of study of a bachelors degree. It’s a great way to gain an introductory qualification in a particular field. Candidates must complete 120 points at 100 level or above.

Certificate (Science) planner 1 year 120 points

DIPLOMAS
A diploma is equivalent to the second year of study of a bachelor’s degree. A diploma is a good way to gain an introductory qualification in a particular field, and is slightly more comprehensive than a certificate programme.

Diploma (Science) planner 1 year 120 points
GENERAL ENTRY REQUIREMENTS (BACHELORS DEGREES)

There are several ways you can gain admission to study at The University of Waikato: University Entrance, Admission at Entrance Level or with credit from previous study, Discretionary Entrance and Special Admission.

If you gain University Entrance you are eligible to apply to enrol in the BCMS(Hons), BDes and BSc without any additional requirements. Note however, that for most students MATHS135 Discrete Structures and STATS121 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 BE(Hons) has additional entry requirements (check the undergraduate degree information on page 50 in this handbook for additional information).

**Numeracy**

- **Level 1 or higher:** 10 credits from specified achievement standards available through a range of subjects OR from a package of three numeracy unit standards (26623, 26626, 26627 – all three required)

**Literacy**

- **Level 2 or higher:** 5 reading credits AND 5 writing credits from the specified list. The credits can come from a range of subjects. For more information go to waikato.ac.nz/go/UEliteracy

**Level 3:**

- 14 credits in one approved subject
- 14 credits in a second approved subject
- 14 credits in a third approved subject

Achieve NCEA Level 3 Certificate (60 credits at Level 3 or above and 20 credits from Level 2 or above)

University Entrance from NCEA
GENERAL ENTRY REQUIREMENTS (BACHELORS DEGREES)

CAMBRIDGE INTERNATIONAL EXAMINATIONS (CIE) STANDARD RECOGNISED BY UNIVERSITIES NEW ZEALAND

PART A
A minimum of 120 points on the UCAS Tariff at A or AS level other than the General Paper, including at least three subjects (other than Thinking Skills) in which no grade is lower than D.

PART B
Literacy: An E grade or better in any one of AS English Language, Language and Literature in English, Literature in English. A D grade or better will satisfy one of the subject requirements of Part A; or as prescribed for University Entrance with NCEA.

Numeracy: Either a D grade or better in IGCSE or GCSE mathematics, or any mathematics passed at AS level. A D grade or better will satisfy one of the subject requirements of Part A; or as prescribed for University Entrance with NCEA.

INTERNATIONAL BACCALAUREATE (IB) STANDARD RECOGNISED BY UNIVERSITIES NEW ZEALAND
Award of the full IB Diploma (24 points or higher).

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, a Future Student Adviser at the University can help you.

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 be eligible for special admission.
GENERAL INFORMATION FOR INTERNATIONAL STUDENTS

Under the Ministry of Education’s Code of Practice for the Pastoral Care of International Students there are statutory requirements in regards to the information we must include in our publications.

ENGLISH LANGUAGE REQUIREMENTS FOR UNDERGRADUATE STUDY IN 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 ARTSC104 Undergraduate Research Writing for ESL Students 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.

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 2016 Code are available from the New Zealand Ministry of Education website at education.govt.nz/quick-links/international-students

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 immigration.govt.nz
INTRODUCTION

In line with new international developments in design education, the Bachelor of Design at Waikato encourages students to reach beyond the boundaries of traditional design, exploring the potential of the digital environment.

The study of Design combines an understanding of human needs and desires, forming creative solutions, prototyping and developing artefacts and evaluating their impact and effectiveness in society. It comprises a well-balanced combination of analytical, technological and creative abilities.

This style of qualification is in increasing demand both within New Zealand and internationally. It follows the widespread use of computers in the design profession, and the growth of the Internet, in areas such as media, electronic commerce, entertainment, or education. The qualification meets the ever-increasing demand for high-quality cross-media design expertise. The structure of the degree has been developed in collaboration with different design industries, 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, needed to articulate design projects effectively. The second year offers the chance to explore the relationship between visual communication and screen-based technologies in areas such as web and mobile design or motion graphics. By the time students enter the third year, they are ready to push the boundaries of design, taking on the more professional challenges of an internship as well as complex, cross media projects.

Students in the Bachelor of Design will get to choose from three majors: Communication Design, Interface Design and Media Design.

CAREER OPPORTUNITIES

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

- Advertising
- Branding and corporate identity
- Interactive media
- Mobile design
- Motion graphics
- Multimedia
- User interface design (UI)
- User experience (UX)
- Web design and development.
CONVENOR OF DESIGN
Tomás García Ferrari tomas.garciaferrari@waikato.ac.nz

SENIOR LECTURERS
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Design theory; design thinking; interaction design; interface design; typography; web design.
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COMMUNICATION DESIGN

WHAT IS COMMUNICATION DESIGN?
Communication Design – also known as visual communication design or graphic design – is concerned with visual symbols, the communication of information in words and images across different media. Communication designers are in charge of arranging typography, form and image on a myriad of communication artefacts, in various type of media. As such, communication design practitioners are recognised for the quality of their intervention in our visual culture.

Communication designers are in charge of areas such as branding, environmental graphics, wayfinding systems, editorial design (newspapers, magazines, books), catalogues, museums displays and every aspect of our visual landscape where there is a communication need.

**BDes degree planner** Communication Design 3 years 360 points

<table>
<thead>
<tr>
<th>Year</th>
<th>Course 1</th>
<th>Course 2</th>
<th>Course 3</th>
<th>Course 4</th>
<th>Course 5</th>
<th>Course 6</th>
<th>Elective</th>
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</tr>
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<tbody>
<tr>
<td>Y1</td>
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<td>DSIGN142</td>
<td>CSMAX170</td>
<td>DSIGN151</td>
<td>DSIGN125 or COMPX101</td>
<td>COMPX161 or MEDIA102</td>
<td>Elective</td>
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<td>Y2</td>
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<td>DSIGN243</td>
<td>DSIGN252</td>
<td>LCOMM292 or DSIGN271</td>
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<tr>
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<td>DSIGN342</td>
<td>DSIGN360</td>
<td>DSIGN350</td>
<td>Elective</td>
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<td>Elective</td>
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</tbody>
</table>

**RECOMMENDED ELECTIVES**
If you need help selecting electives, here is a selection of some complementary papers to enhance your Communication Design major:

- MEDIA100 Understanding Visual Culture
- COMPX221 Programming for Creative Industries
- COMPX222 Internet Applications
- COMPX324 User Experience Design
- MEDIA306 Interactive Media Design
INTERFACE DESIGN

WHAT IS INTERFACE DESIGN?
Interface Design – recognised as User Interface design (UI) – is an area of design developed mainly about digital technologies, where the content is fluid, and there is a need to have interfaces that help users navigate through complex digital experiences. It also relates to the design of user interfaces for different types of machines and software. UI design usually refers to the design of graphical user interfaces, but can also apply to other types of interfaces, such as natural and voice user interfaces.

Interface designers have a high-level of comprehension of digital technologies and work in areas such as editorial design for web and mobile, publication websites, mobile apps, data visualisation and the design and development of digital products.

BDes degree planner  Interface Design 3 years 360 points

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<tr>
<th>Year</th>
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<th>Course 2</th>
<th>Course 3</th>
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<td>Y2</td>
<td>DSIGN241</td>
<td>COMPX221</td>
<td>COMPX222</td>
<td>DSIGN252</td>
<td>LCOMM292 or DSIGN271</td>
<td>Elective</td>
<td>Elective</td>
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<td>Y3</td>
<td>COMPX322</td>
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<td>DSIGN341</td>
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<td>DSIGN350</td>
<td>Elective</td>
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</table>

RECOMMENDED ELECTIVES

If you need help selecting electives, here is a selection of some complementary papers to enhance your Interface Design major:

DSIGN125 Introduction to Communication Design Production
DSIGN242 Design 4: Interactive Environments
DSIGN243 Visual Language and Information Design
DSIGN342 Design 6
WHAT IS MEDIA DESIGN?
Media Design is an area that works in the design of multi-modal media content for screen and multi-media platforms. It operates in the amalgamation of different tools and techniques such as 2D and 3D animation, film and video production, and motion graphics.

Media designers work in the core design issues and principles associated with the creation, construction and production of audio-visual media content for effective communication in the creative industries.

BDes degree planner Media Design 3 years 360 points

RECOMMENDED ELECTIVES
If you need help selecting electives, here is a selection of some complementary papers to enhance your Media Design major:

DSIGN142 Design 2
DSIGN242 Design 4: Interactive Environments
DSIGN243 Visual Language and Information Design
DSIGN341 Design 5
DSIGN342 Design 6
PAPERS
100 LEVEL

Our Design papers provide specialised professional education in design, the process used to plan and improve the artificial world around us using creative and innovative approaches. The papers offered comprise a core of basic design material and techniques, together with contemporary computer software skills. They provide a valuable experience in the context of design history.

COMPX101-18A (HAM) & 18B (HAM)
INTRODUCTION TO COMPUTER SCIENCE
15 points
Please see page 53 for more information.

COMPX161-18B (HAM)
COMPUTING MEDIA
15 points
Please see page 53 for more information.

CSMAX170-18A (HAM) & 18B (HAM)
FOUNDATIONS IN COMPUTING AND MATHEMATICAL SCIENCES
15 points
Please see page 53 for more information.

DSIGN125-18A (HAM)
INTRODUCTION TO COMMUNICATION DESIGN PRODUCTION
15 points
This paper enables students to perform basic computing operations and to operate software packages for the manipulation of visual images and text for use in print and screen-based applications. Students will be introduced to basic computing concepts and provided with software tutorials and related exercises.
Equivalent paper(s) COMP125

DSIGN141-18A (HAM)
DESIGN 1
15 points
This paper develops the student’s ability to recognise and utilise the basic elements and principles of design both two and three dimensionally. It explores topics related to ‘thinking’ and creativity with an emphasis on raising a student’s creativity consciousness and attitude. The work will primarily be abstract in nature and will be resolved in both traditional and computer based media.
Equivalent paper(s) CGRD141
Restricted paper(s) CGRD161
PAPERS
100 LEVEL

DSIGN142-18B (HAM)
DESIGN 2
15 points
This paper develops the student's ability to put into graphic application the basic elements and principles of design. It will also provide an introduction to typography. The emphasis of the study is to apply these basics to 2D and 3D mediums. The work will be resolved in both traditional and computer technology.
Equivalent paper(s) CGRD142
Prerequisite paper(s) CGRD141 or DSIGN141

DSIGN151-18B (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 twentieth century modernism, through the study of visual images and critical theory.
Equivalent paper(s) CGRD151

MEDIA100 - 18A (HAM)
UNDERSTANDING VISUAL CULTURE
15 points
Our lives are dominated by images and visual technologies. This paper will constitute an important first step in learning to understand how images variously work to convey ideas, and their impact and influence on our behaviour, society and culture. It also draws on a broad theoretical platform from aesthetics, art history, psychology of perception, vision science and more.
Equivalent paper(s) SMST101

MEDIA102 - 18A (HAM) & 18B (HAM)
FILM PRODUCTION 1: AUDIO-VISUAL COMMUNICATION
15 points
A hands-on practical paper in which students learn to apply film production theory to communicate ideas and tell stories. Students gain experience capturing, constructing and manipulating both audio and moving image in the process of making digital short films.
Equivalent paper(s) SMST112
PAPERS
200 LEVEL

DSIGN241-18A (HAM)
DESIGN 3: ASPECTS OF WEB DESIGN
15 points
This paper presents the students with the challenge of designing, developing and publishing content for the World Wide Web, working with content management systems (CMS). The students are challenged to combine their typographic skills and their knowledge of design in order to practically solve communication design projects.

Restricted paper(s) CGRD241
Prerequisite paper(s) At least one of CGRD142, COMP126, COMPX161 or DSIGN142

DSIGN242-18B (HAM)
DESIGN 4: INTERACTIVE ENVIRONMENTS
15 points
This paper presents the students with the challenge of designing interactive media environments of different types. The students are challenged to experiment beyond their previously acquired knowledge, designing for interactive computer screens and mobile devices.

Restricted paper(s) CGRD242
Prerequisite paper(s) At least one of CGRD241, DSIGN241, MEDIA203, or SMST217

DSIGN243-18B (HAM)
VISUAL LANGUAGE AND INFORMATION DESIGN
15 points
This paper offers students the possibility to explore the area of information design. By using their knowledge of principles of design, visual communication using typography and image, students will design information graphics (infographics): visual representations of information, working in the passage from data to information utilizing graphic means, to enhance the human capability of seeing and understanding patterns and trends.

Prerequisite paper(s) CGRD142 or DSIGN142

DSIGN252-18A (HAM)
CULTURAL PERSPECTIVES FOR DESIGN
15 points
The paper provides students with an understanding of culture-specific perspectives on design issues and the ability to apply these in diverse contexts.

Restricted paper(s) CGRD353, CGRD252
PAPERS
200 LEVEL

COMPX221-18A (HAM)
PROGRAMMING FOR CREATIVE INDUSTRIES
15 points
Please see page 54 for more information.

COMPX222-18B (HAM)
INTERNET APPLICATIONS
15 points
Please see page 55 for more information.

MEDIA202-18B (HAM)
FILM PRODUCTION 2: EXPERIMENTING WITH SIGHT AND SOUND
15 points
Students work in small production teams to write, produce, direct and edit short films from initial concept to screening and peer review, thereby developing practical and critical understanding of the production process. Students are introduced to theories of creativity and ideas for enhancing the creative process. Students will then experience and learn to work around creative obstructions in order to produce novel and creative responses.

Restricted paper(s) SMST212
Prerequisite paper(s) MEDIA102 or SMST112

MEDIA203-18A (HAM)
MEDIA AND DIGITAL PRACTICES
15 points
This paper focuses on cultural paradigms, theoretical concepts and critical perspectives relevant to (new) digital media practice. The discussion is complemented by the integration of digital tools and techniques in the realisation of individual and group creative projects.

Restricted paper(s) SMST217
PAPERS

300 LEVEL

CGRD343-18A (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

CGRD344-18B (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

CGRD350-18A (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

CGRD360-18B (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
PAPERS
300 LEVEL

CGRD361-18B (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
Note(s) This paper is only available to GradCert(CGD) or GradDip(CGD) students

COMP325-18B (HAM)
HUMAN-COMPUTER INTERACTION
20 points
Please see page 60 for more information.

COMP333-18A (HAM)
WEB APPLICATIONS DEVELOPMENT
20 points
Please see page 61 for more information.

COMP336-18B (HAM)
GRAPHICS AND COMPUTER GAMES
20 points
Please see page 61 for more information.
PAPERS

500 LEVEL

CGRD532-18B (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

CGRD551-18A (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 learned in lectures to the management of a client-driven project by supervising a project team.

Prerequisite paper(s) CGRD350 or equivalent

CGRD581-18A (HAM)
DESIGN RESEARCH METHODS
30 points

Write a report based on the investigation of a topic that is negotiated with a supervisor.
PAPERS
500 LEVEL

CGRD591-18C (HAM)
DESIGN DISSERTATION AND EXHIBITION
30 points
Restricted paper(s) CGRD592

CGRD592-18C (HAM)
DESIGN DISSERTATION AND EXHIBITION
60 points
Restricted paper(s) CGRD591

CGRD593-18C (HAM)
DESIGN THESIS AND REALISATION
90 points

CGRD594-18C (HAM)
DESIGN THESIS AND REALISATION
120 points
COMPUTER SCIENCE
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.

Software Tester: Software testers analyse newly-developed computer software and systems to identify potential problems and help come up with solutions to fix them.

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, cyber-security management and performance analysis.

The computing facilities in the Department are among the best in New Zealand, ranging from phones and tablets for mobile application development to cloud computing.

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 Computer Science Scholarship exam, see page 140 for more information.

Students interested in studying Computer Science can choose from programmes in:
Applied Computing (page 37)
Computer Science (page 38)
Software Engineering (page 50)
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Professor David Bainbridge david.bainbridge@waikato.ac.nz

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Bronwyn Webster bronwyn.webster@waikato.ac.nz

PROFESSORS
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Geoff Holmes geoffrey.holmes@waikato.ac.nz
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Bernhard Pfahringer bernhard.pfahringer@waikato.ac.nz
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Ian Witten ian.witten@waikato.ac.nz
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Annika Hinze annika.hinze@waikato.ac.nz
Dipl.Math.Techn. TU Berlin PhD FU Berlin PGCertTT Waik
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**APPLIED COMPUTING**

**WHAT IS APPLIED COMPUTING?**
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 major concentrates on using existing tools and software libraries to build systems in the database, internet, game and multimedia areas.

**BSc degree planner** Applied Computing 3 years 360 points

<table>
<thead>
<tr>
<th>Year</th>
<th>Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1</td>
<td>COMPX101, COMPX161, CSMAX170, MATHS135, STATS111 or STATS121, 100 level Science*</td>
</tr>
<tr>
<td></td>
<td>100 level Science*</td>
</tr>
<tr>
<td>Y2</td>
<td>COMPX221, COMPX222, COMPX223, DSIGN241, CSMAX270</td>
</tr>
<tr>
<td>Y3</td>
<td>COMPX322, COMPX324, One from List A, COMPX375, 300 level Science</td>
</tr>
</tbody>
</table>

*Science papers should be recognised papers offered by the Faculty of Science and Engineering, Faculty of Computing and Mathematical Sciences, or selected Psychology and Philosophy papers; see page 40.

List A: COMPX305, COMPX306, COMPX323

**STUDY IN TAURANGA**

**PATHWAY OPTIONS**
Start your major in Applied Computing in Tauranga by first enrolling with Toi Ohomai Institute of Technology in the Level 5 Diploma in Applied Computing or, the NZ Diploma in Web Development and Design (Level 5) which credits to the first year of the BSc in Applied Computing. You can then enrol with Toi Ohomai Institute of Technology in the Level 6 Diploma in Applied Computing or, the NZ Diploma in Software Development (Level 6), which credits to the second year of the BSc in Applied Computing.

Complete your major in Applied Computing in Tauranga by studying your final year University of Waikato papers at the Bongard Centre or by studying at The University of Waikato Hamilton campus.

Once you have commenced your Diploma, we recommend you discuss your intended degree programme with University staff who will advise you on degree and subject requirements.
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.

BCMS(Hons) degree planner Computer Science 4 years 480 points

<table>
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<th>Year</th>
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<tbody>
<tr>
<td>Y1</td>
<td>COMPX101, COMPX102, CSMAX170, MATHS135, COMPX374, COMPX375, COMPX390, COMPX391, COMPX301, COMPX304, COMPX306, COMPX307, COMPX321, COMPX322, COMPX323, COMPX341</td>
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<tr>
<td>Y2</td>
<td>COMPX201, COMPX202, COMPX203, COMPX204, CSMAX270, Elective, Elective, Elective</td>
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<td>Y3</td>
<td>COMPX361, Choose one from List B, 300 level COMPX, 300 level COMPX, MATHS or STATS, Elective, Elective, Elective</td>
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<tr>
<td>Y4</td>
<td>COMPX520, Research Project 45 points, 500 level COMPX, Elective, Elective, Elective, Elective</td>
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</table>

List A: COMPX374, COMPX375, COMPX390, COMPX391
List B: COMPX301, COMPX304, COMPX306, COMPX307, COMPX321, COMPX322, COMPX323, COMPX341
### BSc degree planner  
Computer Science 3 years 360 points

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<tr>
<th>Year</th>
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<td>Y1</td>
<td>COMPX101</td>
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<td>CSMAX170</td>
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<td>300 level Science</td>
<td>Elective</td>
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<td>Elective</td>
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List A: COMPX374, COMPX375, COMPX390, COMPX391
List B: COMPX301, COMPX304, COMPX306, COMPX307, COMPX321, COMPX322, COMPX323, COMPX341

### BSc(Tech) degree planner  
Computer Science 3 years 360 points

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<tbody>
<tr>
<td>Y1</td>
<td>COMPX101</td>
<td>COMPX102</td>
<td>CSMAX170</td>
<td>MATHS135, STATS111 or STATS121</td>
<td>100 level Science*</td>
<td>Elective</td>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td>Y2</td>
<td>COMPX201</td>
<td>COMPX202</td>
<td>COMPX203</td>
<td>COMPX204</td>
<td>SCIEN279</td>
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<td>Y3</td>
<td>COMPX361</td>
<td>Choose one from List B</td>
<td>300 level COMPX</td>
<td>CSMAX270 or SCIEN305</td>
<td>COMPX371 Work Placement</td>
<td>Elective</td>
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<td>Elective</td>
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* Science papers should be recognised papers offered by the Faculty of Science and Engineering, Faculty of Computing and Mathematical Sciences, or selected Psychology and Philosophy papers; see page 40.

List B: COMPX301, COMPX304, COMPX306, COMPX307, COMPX321, COMPX322, COMPX323, COMPX341
SCIENCE PAPERS
100 LEVEL

The Bachelor of Science requires that at least two of your electives at 100 level are Science papers. Here is a list of the first year papers that are classified as Science papers. Some papers have prerequisites that need to be met for entry.

APHYS111
PHYSICS IN CONTEXT

BIOEB101
CONCEPTS OF BIOLOGY

BIOBE102
INTRODUCTION TO ECOLOGY AND BIODIVERSITY

BIOMO101
INTRODUCTION TO MOLECULAR AND CELLULAR BIOLOGY

CHEMY100
CHEMISTRY IN CONTEXT

CHEMY101
STRUCTURE AND SPECTROSCOPY

CHEMY102
CHEMICAL REACTIVITY

COMPX101
INTRODUCTION TO COMPUTER SCIENCE

COMPX102
OBJECT-ORIENTED PROGRAMMING

COMPX161
COMPUTING MEDIA

EARTH101
INTRODUCTION TO EARTH SYSTEM SCIENCES

EARTH102
DISCOVERING PLANET EARTH

ENGEND111
ELECTRICITY AND ELECTRONICS

ENGEND112
MATERIALS SCIENCE AND ENGINEERING

ENGEND180
FOUNDATIONS OF ENGINEERING

ENVSC101
ENVIRONMENTAL SCIENCE

MATHS111
INTRODUCTION TO CALCULUS

MATHS121
INTRODUCTION TO ALGEBRA

MATHS165
GENERAL MATHEMATICS

PHYSC100
GENERAL PHYSICS

PHYSC101
PHYSICS FOR ENGINEERS AND SCIENTISTS

PSYCH100
BRAIN, BEHAVIOUR AND COGNITION

PSYCH101
SOCIAL, HEALTH AND INDIGENOUS PSYCHOLOGY

STATS111
STATISTICS FOR SCIENCE

STATS121
INTRODUCTION TO STATISTICAL METHODS
FOCUS AREAS IN COMPUTER SCIENCE

BUT WAIT, THERE’S MORE...
There are several focus areas in Computer Science that may interest you. Identifying a focus area can help you to select your elective papers:

Artificial Intelligence
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.

To focus on Artificial Intelligence, we would recommend that you take the following papers:

100 LEVEL
MATHS101 Introduction to Calculus
PSYCH100 Brain, Behaviour and Cognition

300 LEVEL
COMP313 Topics in Programming Languages (20 points)
COMP316 Artificial Intelligence Techniques and Applications (20 points)
COMP317 Design and Analysis of Algorithms (20 points)

500 LEVEL (BCMS(HONS) ONLY)
Recommended to take at least three of:
COMP521 Machine Learning Algorithms
COMP523 Data Stream Mining
COMP555 Bioinformatics
COMP556 Metaheuristic Algorithms
FOCUS AREAS IN COMPUTER SCIENCE
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 summarise the extracted information.

To focus on Data Mining, we would recommend that you take the following papers:

100 LEVEL
MATHS101 Introduction to Calculus

200 LEVEL
COMPX223 Database Practice and Experience

Plus it is highly recommended to take at least one of:
STATS221 Statistical Data Analysis
STATS226 Bayesian Statistics

300 LEVEL
COMP321 Practical Data Mining (20 points)
COMP329 Database Systems (20 points)
COMP317 Design and Analysis of Algorithms (20 points)
COMP316 Artificial Intelligence Techniques and Applications (20 points)

500 LEVEL (BCMS(HONS) ONLY)
COMP521 Machine Learning Algorithms
COMP523 Data Stream Mining
COMP555 Bioinformatics
COMP556 Metaheuristic Algorithms

Recommended additional papers:
COMP532 Information Visualisation
COMP553 Extremely Parallel Programming
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.

To focus on Games and Multimedia, we would recommend that you take the following papers:

100 LEVEL
Highly recommended to take at least two of:
- DESIGN125 Introduction to Communication Design Production
- COMPX161 Computing Media
- MUSIC140 Music and Computers
- MEDIA100 Understanding Visual Culture
- MEDIA101 Media, Culture and Society
- MEDIA102 Film Production 1: Audio-Visual Communication

200 LEVEL
- DESIGN243 Visual Language and Information Design
- COMPX251 Information Discovery
- MEDIA202 Film Production 2: Experimenting with Sight and Sound
- MEDIA203 Media and Digital Practices

Recommended to also take at least one of:
- MATHS201 Continuing Calculus
- MATHS202 Linear Algebra
- MATHS203 Differential Equations and Modelling
- STATS221 Statistical Data Analysis
- STATS226 Bayesian Statistics

300 LEVEL
- COMP325 Human-Computer Interaction (20 points)
- COMP336 Graphics and Computer Games (20 points)
- 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)
FOCUS AREAS IN COMPUTER SCIENCE
GAMES AND MULTIMEDIA

500 LEVEL (BCMS(HONS) ONLY)
COMP536 Advanced Graphics and Computer Games

Plus at least one of:
COMP532 Information Visualisation
COMP548 Developing Mobile Applications
COMP550 Location-Based Systems as Context-Aware Systems
INFORMATION SYSTEMS

This 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.

To focus on Information Systems, we would recommend that you take the following papers:

100 LEVEL
STMGT101 Introduction to Management
ACCTN101 Accounting for Management

200 LEVEL
COMPX223 Database Practice and Experience

Recommended to also take at least one of:
HRMGT201 Organisational Behaviour
PHILO218 Ethics at Work

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)

500 LEVEL (BCMS(HONS) ONLY)
COMP542 Web Search: Technical and Social Issues
COMP543 Information Management

Plus at least one of:
COMP532 Information Visualisation
COMP550 Location-Based Systems as Context-Aware Systems
FOCUS AREAS IN COMPUTER SCIENCE

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 and psychology.

To focus on Interaction Design, we would recommend that you take the following papers:

100 LEVEL

Highly recommended to also take at least two of:

- COMPX161 Computing Media
- DESIGN125 Introduction to Communication Design Production
- PSYCH100 Brain, Behaviour and Cognition
- MEDIA102 Film Production 1: Audio-Visual Communication

200 LEVEL

Highly recommended to also take at least one of:

- COMPX222 Internet Applications
- PSYCH204 Behavioural Psychology and Perception
- STATS221 Statistical Data Analysis

300 LEVEL

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)

500 LEVEL (BCMS(HONS) ONLY)

COMP524 Interaction Design

Plus at least one of:

- COMP532 Information Visualisation
- COMP539 Usability Engineering
- COMP548 Developing Mobile Applications
- COMP550 Location-Based Systems as Context-Aware Systems

THE UNIVERSITY OF WAIKATO
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.

To focus on Internet Applications, we would recommend that you take the following papers:

200 LEVEL
COMPX222 Internet Applications
COMPX223 Database Practice and Experience

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

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

500 LEVEL (BCMS(HONS) ONLY)
COMP513 Topics in Computer Networks
COMP542 Web Search: Technical and Social Issues

Recommended to also take:
COMP518 Cyber Security
COMP548 Developing Mobile Applications
COMP550 Location-Based Systems as Context-Aware Systems
Focus Areas in Computer Science
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.

To focus on Networks, we would recommend that you take the following papers:

200 LEVEL
ENGEE233 Digital Systems

300 LEVEL
COMP301 Operating Systems (20 points)
COMP312 Computer Networks (20 points)
COMP311 Computer Systems Architecture

500 LEVEL (BCMS(HONS) ONLY)
COMP513 Topics in Computer Networks
COMP514 Carrier and ISP Networks
COMP518 Cyber Security
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.

To focus on Software Development, we would recommend that you take the following papers:

100 LEVEL
PHILO102 Introduction to Logic

200 LEVEL
PHILO218 Ethics at Work

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)

500 LEVEL (BCMS(HONS) ONLY)
COMP513 Topics in Computer Networks
COMP540 Software Engineering Methodologies
COMP548 Developing Mobile Applications
COMP552 Model Checking
COMP553 Extremely Parallel Programming
COMP554 Specification Languages and Models
SOFTWARE 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.

At the end of 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.

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. 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.

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.

For further information on Engineering at Waikato see the website eng.waikato.ac.nz
**BE(Hons) degree planner**  
Software Engineering 4 years 480 points

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<thead>
<tr>
<th>Year</th>
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<tr>
<td>Y1</td>
<td>COMPX101, COMPX102, ENGEN170, ENGEN180, ENGEN183, ENGEN184, MATHS135</td>
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<tr>
<td>Y2</td>
<td>COMPX203, COMPX204, COMPX241, COMPX242, COMPX223, COMPX361, ENGEN201, ENGEN270</td>
</tr>
<tr>
<td>Y3</td>
<td>COMPX301, COMPX304, COMPX307, COMPX324, COMPX341, COMPX374, ENGEN301, ENGEV342</td>
</tr>
<tr>
<td>Y4</td>
<td>ENGEN592 Research and Dev Project 45 points, COMP526, COMP552 or COMP554, COMP524, COMP539 or COMP548, Any 500 level COMP, Any 500 level COMP, ENGEN570</td>
</tr>
</tbody>
</table>

**Note:** Second Year includes ENGEN271 - Industry Placement 1 and Third Year includes ENGEN371 - Industry Placement 2 which are compulsory.

*100 level elective can be chosen from: APHYS111, CHEMY100, CHEMY101, CHEMY102, ENGEN110, ENGEN111, ENGEN112, PHYSC100 or PHYSC101.

For more information on the compulsory ENGEN papers, please see The 2018 Engineering Handbook or the online catalogue of papers.

**STUDENT PROFILE**

**ALENA CHOONG, BACHELOR OF ENGINEERING (HONOURS) GRADUATE**

**SOFTWARE DEVELOPER, SMARTRAK**

"I grew up playing computer games and when I decided to pursue software engineering I came into it thinking that I was only going to make computer games once I graduated. What I really liked about the software engineering programme at Waikato University was the breadth of computer science topics taught. Whilst I was studying, I thought it was a shame that you couldn’t pick any electives until fourth year - but after my first work placement at the Bay of Plenty Regional Council, I realised that the degree structure at Waikato prepares you to become an engineer fit for any industry. I am currently working at Smartrak where I help create and maintain software used in tracking and aiding over 23,000 assets across Australasia each day. I go to work everyday excited to work with intelligent and creative people on various projects to help customers make smart business decisions remotely. I absolutely love my job and am happy that I chose to study at the University of Waikato."
If you intend to take only two or three Computer Science papers as support for another major subject, you should enrol initially in COMPX151 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 a paper in Computer Science and have no previous experience.

COMPX101-18A (HAM) & 18B (HAM)
INTRODUCTION TO COMPUTER SCIENCE
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, cyber security, computer gaming, databases, mobile computing and current research and challenges in computer science.

Equivalent paper(s) COMP103
Restricted paper(s) ENGEN103, ENGG182

COMPX102-18B (HAM) & 18S (HAM)
OBJECT-ORIENTED PROGRAMMING
15 points
This paper continues from COMPX101, expanding upon data organisation and algorithms, and in addition to object oriented programming, introduces computer architecture, Boolean algebra, assembly language, and program analysis.

Equivalent paper(s) COMP104
Prerequisite paper(s) One of COMPX101, COMP103, ENGEN103, or ENGG182
COMPX151-18A (HAM) & 18B (HAM) & 18S (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 extensively. 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.

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

COMPX161-18B (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.

Equivalent paper(s) COMP126

CSMAX170-18A & 18B (HAM)
FOUNDATIONS IN COMPUTING AND MATHEMATICAL SCIENCES
15 points
The objective of this paper is to provide students with the academic foundations for computing and mathematical sciences. The paper will cover the following areas: Effective academic reasoning and communication, information literacy and research skills, academic integrity, techniques and tools in the computing and mathematical sciences discipline.

DSIGN125-18A (HAM)
INTRODUCTION TO COMMUNICATION DESIGN PRODUCTION
15 points
Please see page 23 for more information.

MATHS135-18B (HAM)
DISCRETE STRUCTURES
15 points
Please see page 79 for more information.
PAPERS
200 LEVEL

COMP221-18A (HAM), 18B (HAM) & 18S (HAM)
INTRODUCTION TO 3D MODELLING AND ANIMATION
10 points
This paper 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) At least one of COMP103, COMPX101, COMP123, COMPX151, ENGG182 or ENGEN103
Restrictions Students who have already passed one of COMP223/COMP278/COMPX251 or COMPX252 and passed the 3D Modelling and Animation practical modules are not permitted to take this paper.

COMPX201-18A (HAM)
DATA STRUCTURES AND ALGORITHMS
15 points
This paper introduces programming with data structures using Java. Students 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) COMPX102 or COMP104
Restricted paper(s) COMP203, COMP241, COMPX241

COMPX202-18B (HAM)
MOBILE COMPUTING AND SOFTWARE ARCHITECTURE
15 points
This paper covers object-oriented programming, primarily as seen in Java, but also touching on alternative approaches. It introduces software development methodologies and the use of support tools, particularly repositories and a testing framework. Project work starts with GUI development in Java and works through to the construction of mobile applications.

Prerequisite paper(s) COMP203 or COMPX201
Restricted paper(s) COMP204, COMP242, COMPX242

COMPX203-18A (HAM)
COMPUTER SYSTEMS
15 points
This paper provides an overview of the operation of computer systems. The central theme is the way in which the hardware and software co-operate to allow the execution of programs written in a high-level language.

Prerequisite paper(s) At least one of COMP104, COMPX102, (COMPX101 and ENGEN111), (COMP103 and ENEL111), (ENGEN103 and ENGEN111), or (ENGG182 and ENEL111)
Restricted paper(s) COMP200
**COMPX204-18B (HAM)**  
**PRACTICAL NETWORKING AND CYBER SECURITY**  
*15 points*  
This paper provides an overview of the technologies and protocols involved in computer communications and cyber security. Practical work includes network programming.  

Prerequisite paper(s) COMPX102 or COMP104  
Restricted paper(s) COMP202

**COMPX221-18A (HAM)**  
**PROGRAMMING FOR CREATIVE INDUSTRIES**  
*15 points*  
A fundamental grounding in object-oriented programming that uses Processing software to creative visual outputs for creative industries.  

Prerequisite paper(s) At least one of COMP103, COMPX101, ENGEN103, or ENGG182  
Restricted paper(s) COMP258

**COMPX222-18B (HAM)**  
**INTERNET APPLICATIONS**  
*15 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.  

Prerequisite paper(s) At least one of COMP103, COMPX101, ENGEN103, or ENGG182  
Restricted paper(s) COMP233

**COMPX223-18A (HAM)**  
**DATABASE PRACTICE AND EXPERIENCE**  
*15 points*  
This paper approaches the subject of databases from a practical perspective: how do I create a database and how do I retrieve/update data? Both aspects are heavily addressed in this paper. Database creation and querying, using SQL, will be introduced in lectures as you will master practical skills associated with a commercial Database product (Microsoft SQL Server). The paper also introduces Microsoft’s extension to SQL, Transact-SQL, which provides a user interface to SQL Server. This is to promote both understanding and practice of the different tools used to build, access and maintain a database within a Client/Server database computing environment.  

Prerequisite paper(s) COMP103, COMPX101, ENGG182 or ENGEN103  
Restricted paper(s) COMP219
PAPERS
200 LEVEL

COMPX241-18A (HAM)
SOFTWARE ENGINEERING DEVELOPMENT
15 points
Students will learn how to program in Java and design, analyse, and apply commonly used data structures. Broader software engineering practices will be developed through a group project.
Prerequisite paper(s) COMP104 or COMPX102
Restricted paper(s) COMP203, COMP241, COMP201

COMPX242-18B (HAM)
SOFTWARE ENGINEERING PROCESS
15 points
This paper covers object-oriented programming, primarily as seen in Java, but also touching on alternative approaches. It introduces software development methodologies and the use of support tools, particularly repositories and a testing framework. Project work starts with GUI development in Java and works through to the construction of mobile applications.
Prerequisite paper(s) COMP241 or COMPX241
Restricted paper(s) COMP204, COMP242, COMP202

COMPX251-18A (HAM), 18B (HAM) & 18S (HAM)
INFORMATION DISCOVERY
15 points
This paper enables students to widen their experience of computer software using an intensive laboratory programme. Students select from a variety of themes, including video editing, website design, digital library development, computer game construction, animation and 3D modelling.
Restricted paper(s) COMP223

COMPX252-18A (HAM), 18B (HAM) & 18S (HAM)
INTERACTIVE COMPUTING
15 points
This paper provides an opportunity to explore several software applications in depth. It is based on an intensive laboratory programme, where students tailor their choices to their own needs and interests by selecting two themes from a set of modules.
Prerequisite paper(s) At least one of COMP103, COMP123, COMPX101, COMPX151, ENGEN103, or ENGG182
Restricted paper(s) COMP278
CSMAX270-18B (HAM)
CULTURAL PERSPECTIVES FOR COMPUTING AND MATHEMATICAL SCIENCES
15 points
The paper provides students with an understanding of scientific and culture-specific perspectives on computing and mathematical science issues and the ability to apply these in diverse contexts.

ENGEE233-18A (HAM)
DIGITAL SYSTEMS
15 points
This paper provides students with an introduction to digital electronics and microprocessors. It covers combinatorial and sequential logic, hardware description languages, and processor architecture and construction.

Prerequisite paper(s) (ENGEN111 or ENEL11) or (COMPX102 or COMP104)
Restricted paper(s) ENEL212
PAPERS
300 LEVEL

If Computer Science is your major subject, you will need at least 45 points at 300 level in Computer Science. Unless you are double majoring, you are strongly urged to consider taking 75 points in Computer Science, especially if you intend to go on to graduate study. Selecting appropriate papers to match your needs, inclinations, and aptitudes is therefore most important. This choice will not only dictate the area of computing in which you will be competent, it will also dictate the kind of employment in computing for which you will be best equipped.

COMP301-18B (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 memory management and device drivers.

Prerequisite paper(s) COMP200, and one of COMP203 or COMP241

COMP311-18B (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 or COMP241

COMP312-18A (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
COMP313-18A (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

COMP314-18B (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

COMP315-18B (HAM) & 18B (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

COMP316-18A (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
PAPERS

300 LEVEL

COMP317-18A (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

COMP321-18B (HAM) & 18B (TGA)
PRACTICAL DATA MINING
20 points
This paper is a practical introduction to data mining. It covers important aspects of the data mining process such as feature selection, model building, parameter tuning and final evaluation.

Prerequisite paper(s) (COMP103 or ENGG182) and 20 points at 200 level in Computer Science

COMP325-18B (HAM) & 18B (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

COMP329-18A (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
COMP333-18A (HAM) & 18A (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

COMP336-18B (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

COMP390-18A (HAM) & 18B (HAM) & 18C (HAM)
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.

COMPX361-18B (HAM)
LOGIC AND COMPUTATION
15 points
Please see page 82 for more information.
PLACEMENT PAPERS
300 LEVEL

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

COMP371-18C (HAM)
COMPUTER SCIENCE PLACEMENT 1
20 points
This paper is only available to BSc(Tech) students.

COMP372-18C (HAM)
COMPUTER SCIENCE PLACEMENT 2
20 points
This paper is only available to BSc(Tech) students.

COMP373-18C (HAM)
COMPUTER SCIENCE PLACEMENT 3
20 points
This paper is only available to BSc(Tech) students.

SCIE379-18A (HAM)
REFLECTION ON PROFESSIONAL WORKPLACE EXPERIENCE
10 points
This paper is only available to BSc(Tech) students.
PAPERS

400/500 LEVEL

COMP401/501-18A (HAM)
TOPICS IN OPERATING SYSTEMS
15 points

One or more topics in operating systems implementation at an advanced level.

Prerequisite paper(s) COMP301 and a further 40 points at 300 level in Computer Science papers

COMP402/502-18A (HAM)
CRYPTOGRAPHY
15 points

An introduction to cryptographic methods.

Prerequisite paper(s) COMP235 or MATH258
Restricted paper(s) MATH320

COMP413/513-18B (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

COMP414/514-18A (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

COMP418/518-18A (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 (eg malware analysis, social engineering, intrusion detection and prevention), offensive security (eg penetration testing, web app security) and preventative security (eg 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
**PAPERS**

**400/500 LEVEL**

**COMP421/521-18A (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)** Either COMP316 or COMP321, and a further 40 points at 300 level in Computer Science

**COMP423/523-18A (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)** Either COMP316 or COMP321, and a further 40 points at 300 level in Computer Science

**COMP426/526-18B (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

**COMP427/527-18B (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)** COMP301, COMP312
COMP432/532-18B (HAM)
INFORMATION VISUALISATION
15 points
This paper aims to provide an awareness of the potential offered by information 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) 60 points at 300 level in COMP or CGRD papers
Restricted paper(s) CGRD532

COMP436/536-18A (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

COMP439/539-18A (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) COMP325 and a further 40 points at 300 level in Computer Science
Restricted paper(s) COMP425 and COMP525

COMP440/540-18B (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) Either COMP314 or COMP315 and a further 60 points at 300 level in Computer Science
PAPERS
400/500 LEVEL

COMP442/542-18A (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 combating it, and social issues raised by centralised search engines.

Prerequisite paper(s) Either COMP204 or COMP242 and a further 60 points at 300 level in Computer Science

COMP443/543-18B (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, Leadership Communication or Management Systems

COMP448/548-18A (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

COMP450/550-18A (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
COMP452/552-18A (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

COMP453/553-18A (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

COMP454/554-18B (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

COMP455/555-18B (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 and relevant statistical methods.

Prerequisite paper(s) STAT111 or STAT121, and 60 points at 300 level in Biology and/or Computer Science including either COMP317 or BIOL310
PAPERS
400/500 LEVEL

COMP456/556-18A (HAM)
METAHEURISTIC ALGORITHMS
15 points
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

COMP460/560-18C (HAM)
TURING TOPICS IN COMPUTER SCIENCE
15 points
One or more special topics in computer science, at an advanced level.
Prerequisite paper(s) 60 points at 300 level in Computer Science
Note(s) Admission to this paper is at the discretion of the Chairperson of Department

COMP477-18A (HAM) & 18B (HAM)
REPORT OF AN INVESTIGATION
20 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) At least 60 points in Computer Science at 300 level or above
Restricted paper(s) COMP420, MATH420 and MATH477
Note(s) This paper is available only to students undertaking a non-honours degree programme for the BCMS who enrolled pre-2018.

ENEL417/517-18A (HAM)
MECHATRONICS
20 points/30 points
This paper covers an advanced treatment of the control of electromechanical systems, especially robotics.
Prerequisite paper(s) ENEL317
PAPERS

500 LEVEL

COMP520 - 18C (HAM), 18D (HAM) & 18Y (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

COMP568-18A (HAM) & 18C (HAM)
PROGRAMMING FOR INDUSTRY
30 points
An examination of object-oriented programming and design. Key principles of object-oriented programming: typing, encapsulation, inheritance, polymorphism and composition. Fundamental object-oriented modelling and design techniques. Students will develop application software of reasonable complexity that draws on object-oriented language features, and contemporary APIs, frameworks and tools.

Corequisite(s) COMP569
Note(s) Admission to this paper is restricted to students enrolled in the PGCertInfoTech

COMP569-18A (HAM) & 18C (HAM)
PROGRAMMING WITH WEB TECHNOLOGIES
30 points

Corequisite(s) COMP568
Note(s) Admission to this paper is restricted to students enrolled in the PGCertInfoTech

COMP575-18A (HAM) & 18B (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
PAPERS

500 LEVEL

COMP576-18A (HAM) & 18B (HAM)
PROGRAMMING FOR RESEARCH 2
15 points
A paper where research programming techniques are applied to a specific (elective) field in Computer Science.

Restricted paper(s) COMP589

COMP585-18A (HAM) & 18B (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

COMP586-18A (HAM) & 18B (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

COMP587-18A(HAM)
INFORMATION TECHNOLOGY COMMUNICATION FOR INDUSTRY
15 points
A paper about developing the communication skills necessary for a person working in the ICT industry. Students will gain skills in reading and critiquing technical reports, planning industry projects, developing a proposal, carrying out literature surveys, and giving presentations. This paper is for students enrolled in the Master of Information Technology.

Restricted Paper(s) COMP585
CSMAX570-18A (HAM) & 18B (HAM)
PREPARING FOR THE ICT INTERNSHIP
15 points
This paper will enable learners to develop the key soft and transferable skills and competencies important to be work-ready and prepared for the internship component of the Master of Information Technology (MInfoTech) programme. These skills and competencies will be primarily developed through a software development project within a real-world context.

Prerequisite Paper(s) Any 60 points at 500 level from the MInfoTech programme

ENGG501-18A (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

FCMS596-18A (BLK), 18B (BLK) & 18C (BLK)
COMPUTER SCIENCE INTERNSHIP
60 points
This internship enables the development of practical knowledge and hands-on experience through a supervised internship in the IT industry.

Note(s) Admission to this paper is restricted to students enrolled in the MInfoTech

LAW526-18A (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.
PAPERS

500 LEVEL

COMP591-18C (HAM) & 18D (HAM)
DISSERTATION
30 points

COMP592-18C (HAM)
DISSERTATION
60 points

COMP593-18C (HAM)
COMPUTER SCIENCE THESIS
90 points

COMP594-18C (HAM)
COMPUTER SCIENCE THESIS
120 points
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(HONS) MATHEMATICS AND ANTHROPOLOGY
CHAIRPERSON OF MATHEMATICS AND STATISTICS
Sean Oughton sean.oughton@waikato.ac.nz

SECRETARY
Glenys Williams glenys.williams@waikato.ac.nz

PROFESSOR
Ernie Kalnins ernie.kalnins@waikato.ac.nz
BSc(Hons) Cant MSc PhD W Ont FRSNZ
Special functions; quantum groups; general relativity; superintegrability.

EMERITUS PROFESSOR
Kevin Broughan kevin.broughan@waikato.ac.nz
BSc MSc Auck MA PhD Col MIPENZ FNZMS
Analytic and algebraic number theory; mathematical software; symbolic computation; dynamical systems.

ASSOCIATE PROFESSORS
Daniel Delbourgo daniel.delbourgo@waikato.ac.nz
BSc(Hons) Tas PhD Camb
Elliptic curves; modular forms; Iwasawa theory.

Stephen Joe stephen.joe@waikato.ac.nz
BSc(Hons) MSc Massey PhD NSW
Lattice methods for multiple integration; numerical multiple integration.

Yuri Litvinenko yuri.litvinenko@waikato.ac.nz
MSc Moscow PhD NH
Solar activity; magnetohydrodynamics of astrophysical plasmas; magnetic reconnection.

Sean Oughton sean.oughton@waikato.ac.nz
BSc(Hons) Well PhD Del
Turbulence and nonlinear dynamics in conducting fluids and space physics.

SENIOR LECTURERS
Nicholas Cavenagh nicholas.cavenagh@waikato.ac.nz
BSc(Hons) MSc PhD Qld
Combinatorics: latin squares; defining sets; graph decompositions; graph labellings.
Ian Hawthorn ian.hawthorn@waikato.ac.nz
BSc(Hons) MSc Auck PhD Minn
Group theory; classes of finite groups; symmetry.

Woei Chet Lim woeichet.lim@waikato.ac.nz
BMath(Hons) MMath PhD Waterloo
Inhomogeneous cosmology; numerical partial differential equations; general relativity; dynamical systems.

Tim Stokes tim.stokes@waikato.ac.nz
BSc(Hons) PhD Tas
Semigroups with additional structure: radical theory for general algebras; free surface problems in fluid mechanics.

SENIOR TUTOR
Keith Allen keith.allen@waikato.ac.nz
BSc(Maths) DipEd Sheff

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

John Turner
MSc Leeds DPhil Waik
**MATHEMATICS**

With a 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. 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.

**BCMS(Hons) degree planner** Mathematics 4 years 480 points

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<thead>
<tr>
<th>Year</th>
<th>Course 1</th>
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<th>Course 3</th>
<th>Course 4</th>
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<td>CSMAX170</td>
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<td>MATHS202</td>
<td>200 level MATHS</td>
<td>CSMAX270</td>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td>Y3</td>
<td>MATHS301 or MATHS302</td>
<td>300 level MATHS</td>
<td>300 level MATHS</td>
<td>Choose one from List A</td>
<td>Elective</td>
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<tr>
<td>Y4</td>
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<td>500 level MATHS</td>
<td>Elective</td>
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</tr>
</tbody>
</table>

List A: COMPX374, COMPX375, MATHS390, or MATHS391

**Note:** Students may include up to 30 points of STATS-coded papers as part of their Mathematics major

**BSc degree planner** Mathematics 3 years 360 points

<table>
<thead>
<tr>
<th>Year</th>
<th>Course 1</th>
<th>Course 2</th>
<th>Course 3</th>
<th>Course 4</th>
<th>Elective 1</th>
<th>Elective 2</th>
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<tr>
<td>Y1</td>
<td>MATHS101</td>
<td>MATHS102</td>
<td>CSMAX170</td>
<td>MATHS135</td>
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<td>MATHS202</td>
<td>200 level MATHS</td>
<td>CSMAX270</td>
<td>Elective</td>
<td>Elective</td>
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<td>Y3</td>
<td>MATHS301 or MATHS302</td>
<td>300 level MATHS</td>
<td>300 level MATHS</td>
<td>Choose one from List A</td>
<td>Elective</td>
<td>Elective</td>
</tr>
</tbody>
</table>

* Science papers should be recognised papers offered by the Faculty of Science and Engineering, Faculty of Computing and Mathematical Sciences, or selected Psychology and Philosophy papers; see page 40.

List A: COMPX374, COMPX375, MATHS390, or MATHS391

**Note:** Students may include up to 30 points of STATS-coded papers as part of their Mathematics major
PAPERS

100 LEVEL

CSMAX170-18A & 18B (HAM)
FOUNDATIONS IN COMPUTING AND MATHEMATICAL SCIENCES
15 points

Please see page 53 for more information.

MATHS101-18A (HAM) & 18B (HAM)
INTRODUCTION TO CALCULUS
15 points

A study of the fundamental techniques of calculus, including differentiation and integration for functions of one real variable, with applications to rate problems, graph sketching, areas and volumes.

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. Introduction to real analysis: sequences, series and constructions of the real numbers.

Prerequisite paper(s) At least a B- grade in MATHS165, MATH165, MATHS166, MATH166, CAFS004, or FOUND007; or MATHS102 or MATH102; or 16 credits of NCEA Level 3 Calculus including at least 11 credits from AS91577, AS91578 and AS91579; or equivalent.

Restricted paper(s) ENGG184, ENGEN184

Equivalent paper(s) MATH101

MATHS102-18A (HAM) & 18B (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. Mathematical induction. Modular arithmetic and its applications.

Prerequisite paper(s) Any one of MATHS165, MATH165, MATHS166, or MATH166; or at least a B- grade in CAFS004 or FOUND007; or 16 credits of NCEA Level 3 Calculus; or equivalent

Restricted paper(s) ENGG183, ENGEN183

Equivalent paper(s) MATH102
MATHS135-18B (HAM)

DISCRETE STRUCTURES
15 points

An introduction to a number of the structures of discrete mathematics with wide applicability in areas such as: computer logic, analysis of algorithms, telecommunications, networks and public key cryptography. In addition it introduces a number of fundamental concepts which are useful in Statistics, Computer Science and further studies in Mathematics. Topics covered are: sets, binary relations, directed and undirected graphs; propositional and some predicate logic; permutations, combinations, and elementary probability theory; modular arithmetic.

Prerequisite paper(s) At least one of MATHS165, MATHS166, MATH165, MATH166, or 16 credits in NCEA Level 3 Mathematics.

Restricted paper(s) COMP235, MATH258

MATHS165-18A (HAM) & 18B (HAM)

GENERAL MATHEMATICS
15 points

This paper is an introduction to algebra, calculus and applications. This paper is provided for students who have not attained entry for MATHS101, MATHS102 or MATHS135.


Equivalent paper(s) MATH165, MATH166, MATH166

Prerequisite paper(s) 18 credits at Level 2 in NCEA Mathematics, or 10 credits at Level 3 in NCEA Calculus, or 14 credits at Level 3 in NCEA Mathematics, or at least a B- in MATH168 or MATHS168, or equivalent.

Note(s) This paper may not be taken concurrently with or subsequent to obtaining a pass in MATHS101 or MATHS102

MATHS166-18A (HAM) & 18B (HAM)

MANAGEMENT MATHEMATICS
15 points

An introduction to algebra and calculus for students in Management or Social Sciences. Students who meet the prerequisites of MATHS101 and/or MATHS102 may wish to take these paper(s) instead.

Equivalent paper(s) MATH165, MATHS165, MATH166

Prerequisite paper(s) 18 credits at Level 2 in NCEA Mathematics, or 10 credits at Level 3 in NCEA Calculus, or 14 credits at Level 3 in NCEA Mathematics, or at least a B- in MATHS168 or MATH168

Note(s) This paper may not be taken concurrently with or subsequent to obtaining a pass in MATHS101 or MATHS102
PAPERS
100 LEVEL

MATHS168-18A (HAM) & 18B (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 papers such as MATHS165, MATHS166, STATS111 and STATS121. If you are using MATHS168 as preparation for any mathematics or statistics paper, you should aim for a B- grade or better.

Equivalent paper(s) MATH168

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.
PAPERS

200 LEVEL

CSMAX270-18B (HAM)
CULTURAL PERSPECTIVES FOR COMPUTING AND MATHEMATICAL SCIENCES
15 points

Please see page 57 for more information.

MATHS201-18B (HAM)
CONTINUING CALCULUS
15 points

Calculus of several variables and its applications. Vector calculus (Green's, Gauss' and Stokes' theorems). Taylor's Theorem in n dimensions. The Gamma and Beta functions.

Prerequisite paper(s) (MATH101 or MATHS101) and (MATH102 or MATHS102)
Restricted paper(s) MATH251, ENGG285, ENGEN201

MATHS202-18A (HAM)
LINEAR ALGEBRA
15 points

A formal approach to linear algebra, with applications. Topics include: axioms of a vector space, linear independence, spanning sets and bases. Linear transformations, the Gram-Schmidt process.

Prerequisite paper(s) MATH102 or MATHS102
Restricted paper(s) MATH253 and ENGG283

MATHS203-18B (HAM)
DIFFERENTIAL EQUATIONS AND MODELLING
15 points


Prerequisite paper(s) (MATH101 or MATHS101) and (MATH102 or MATHS102)
Restricted paper(s) ENGG284, ENGEN201
PAPERS
300 LEVEL

COMPX361 can be counted towards a mathematics major. Well prepared students may also, with the approval of the Chairperson of the Department of Mathematics and Statistics, enrol in appropriate papers at 500 level for credit towards an undergraduate degree.

COMPX361-18B (HAM)
LOGIC AND COMPUTATION
15 points
The syllabus includes: further development of predicate logic with application to program verification; mathematical induction including structural induction; finite state automata and regular languages; Kleene's Theorem; Turing machines, the Church-Turing thesis, universal Turing machines and the halting problem; formal grammars and the Chomsky hierarchy.

Prerequisite paper(s) MATHS135
Restricted paper(s) COMP235 and COMP340

MATH310-18B (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

MATH311-18A (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
MATH320-18A (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) COMP402, COMP502 and MATH319

MATH329-18A (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.

Prerequisite paper(s) MATH251 and MATH253

MATH331-18B (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
Recommended paper(s) MATH311
PAPERS
300 LEVEL

MATH334-18Y (HAM)
CLASSICAL AND QUANTUM MECHANICS
20 points

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

Corequisite paper(s) MATH311 is recommended
Prerequisite paper(s) Admission to this paper is at the discretion of the Chairperson of Mathematics and Statistics
Restricted paper(s) MATH555 and MATH556

MATH380-18A (HAM) & 18B (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 at the discretion of the Chairperson of Mathematics and Statistics
PAPERS
500 LEVEL

If you intend to take the below papers you must consult with one of the Mathematics Graduate Advisers within the Department of Mathematics and Statistics.

MATH501-18A (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

MATH505-18B (HAM)
ADVANCED TOPICS IN PURE MATHEMATICS
15 points
A study at an advanced level of one or more topics in Pure Mathematics. For more information about the content in 2018, please consult the Department of Mathematics and Statistics.

Prerequisite paper(s) Admission to this paper is at the discretion of the Chairperson of Mathematics and Statistics

MATH513-18A (HAM)
FINITE GROUPS
15 points
An in-depth study of the theory of finite groups.

Prerequisite paper(s) MATH310 or equivalent

MATH516-18B (HAM)
TOPICS IN DISCRETE MATHEMATICS
15 points
An introduction to graph theory and combinatorics, including network optimisation algorithms.

Prerequisite paper(s) MATH320

MATH517-18A (HAM)
STOCHASTIC DIFFERENTIAL EQUATIONS WITH APPLICATIONS TO FINANCE
15 points
A study of stochastic differential equations and their applications to the physical sciences and finance.

Prerequisite paper(s) Admission to this paper is at the discretion of the Chairperson of Mathematics and Statistics
PAPERS
500 LEVEL

MATH520-18C (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
Note(s) This paper is available only to students undertaking a BCMS(Hons) degree programme by permission of the Dean

MATH541-18B (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

MATH555-18A (HAM)
ADVANCED CLASSICAL MECHANICS
15 points

The theory of classical mechanics from a variational point of view.

Prerequisite paper(s) MATH311
Restricted paper(s) MATH334

MATH556-18B (HAM)
QUANTUM MECHANICS
15 points

The fundamentals of quantum mechanics and quantisation for elementary systems.

Prerequisite paper(s) MATH311
Restricted paper(s) MATH334
MATH581-18A (HAM) & 18B (HAM)  
SPECIAL TOPIC IN MATHEMATICS 1  
15 points

MATH582-18A (HAM) & 18B (HAM)  
SPECIAL TOPIC IN MATHEMATICS 2  
15 points

MATH591-18C (HAM)  
DISSERTATION  
30 points

MATH592-18C (HAM)  
DISSERTATION  
60 points

MATH593-18C (HAM)  
MATHEMATICS THESIS  
90 points

MATH594-18C (HAM)  
MATHEMATICS THESIS  
120 points
PAPERS NOT OFFERED IN 2018

MATH319
TOPICS IN PURE MATHEMATICS

MATH333
CLASSICAL FIELD THEORY

MATH342
NUMERICAL MATHEMATICS

MATH506
COMBINATORICS

MATH509
NUMBER THEORY

MATH511
SEMIGROUPS AND UNIVERSAL ALGEBRA

MATH512
CONTINUOUS GROUPS

MATH515
ANALYTIC NUMBER THEORY

MATH518
RINGS AND MODULES

MATH542
ADVANCED PARTIAL DIFFERENTIAL EQUATIONS

MATH543
NONLINEAR DYNAMICS AND CHAOS

MATH553
FLUID DYNAMICS

MATH554
ASTROPHYSICAL FLUIDS

MATH564
SPECIAL RELATIVITY

MATH565
GENERAL RELATIVITY
DATA ANALYTICS
INTRODUCTION

Enhance productivity and help make more informed decisions, while using your Computer Science and Statistical Analysis skills, through Data Analytics.

WHAT IS DATA ANALYTICS?

Data analytics conjures up images of lots of statistics, and tables of numbers or graphs. However data analytics is more than that – it is the combination of computer science skills with the ability to use statistical techniques and interpret the statistical output. Statistical analyses are 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. With the technological advances that have been made in recent years, there has been a massive increase in the amount of data that is collected. Thus for the modern student who is studying Statistics, there is a need to have more computing skills to enable them to use and manipulate the datasets prior to performing statistical analyses. The Data Analytics programme will provide the students with the skills and techniques for administering and manipulating large databases to extract useful information for statistical analyses, and the ability to use statistical techniques for knowledge discovery.

When you study data analytics, you will become familiar with the use of software for handling and extracting information from large databases and powerful statistical software packages, which aid the analysis of data. Statistical analysis is vital to the understanding of almost all facets of life. People with the skills from an education in data analytics are highly sought after both in government and industry.

CAREERS IN DATA ANALYTICS?

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 data analyst is working with people from other areas (chemists, biologists, medical professionals, managers and production workers) and continually learning about their disciplines, their work and the problems they face.

CAREER OPPORTUNITIES

Career prospects in Data Analytics are excellent, with opportunities in many areas:

- Agriculture and horticulture
- Industry
- Finance and insurance
- Market research
- Government
STAFF

CONVENOR OF STATISTICS
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SECRETARY
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Steven Miller steven.miller@waikato.ac.nz
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HONORARY FELLOWS
William Bolstad
BA Missouri MSc Stan DPhil Waik

Murray Jorgensen
BSc(Hons) Cant MA PhD Br Col

Ray Littler
MSc Auck PhD Monash
# DATA ANALYTICS

## WHAT IS DATA ANALYTICS?
Data analytics is the combination of computer science skills with the ability to use statistical techniques and interpret the statistical output. Statistical analyses are used to make informed decisions in most areas of human endeavour such as agriculture, industry and commerce, law, medicine, forestry, psychology, insurance and economics.

## BCMS(Hons) degree planner
Data Analytics 4 years 480 points

<table>
<thead>
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<th>Year</th>
<th>Courses</th>
<th>Elective</th>
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<tr>
<td>Y1</td>
<td>STATS11 or STATS121, COMPX101, CSMAX170, MATHS135, 100 level COMPX, MATHS or STATS, 100 level COMPX, MATHS or STATS</td>
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<td></td>
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<tr>
<td>Y2</td>
<td>STATS221, STAT5226, COMPX223, CSMAX270, 200 level COMPX, MATHS or STATS</td>
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<tr>
<td>Y3</td>
<td>COMPX305 or STATS321, 300 level Data Analytics, 300 level Data Analytics, 300 level Data Analytics, Choose one from List A</td>
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<tr>
<td>Y4</td>
<td>STATSS20 Research Project 45 points, 500 level STATS</td>
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</table>

List A: COMPX375, COMPX390, COMPX391, STATS390, STATS391

## BSc degree planner
Data Analytics 3 years 360 points

<table>
<thead>
<tr>
<th>Year</th>
<th>Courses</th>
<th>Elective</th>
<th>Elective</th>
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<tbody>
<tr>
<td>Y1</td>
<td>STATS11 or STATS121, COMPX101, CSMAX170, MATHS135, 100 level Science*, 100 level Science*</td>
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<tr>
<td>Y2</td>
<td>STATS221, STAT5226, COMPX223, CSMAX270, 200 level Science</td>
<td></td>
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</tr>
<tr>
<td>Y3</td>
<td>COMPX305 or STATS321, 300 level Data Analytics, 300 level Data Analytics, 300 level Data Analytics, Choose one from List A</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

* Science papers should be recognised papers offered by the Faculty of Science and Engineering, Faculty of Computing and Mathematical Sciences, or selected Psychology and Philosophy papers; see page 40.

List A: COMPX375, COMPX390, COMPX391, STATS390, STATS391
PAPERS

100 LEVEL

COMPX101-18A (HAM) & 18B (HAM)
INTRODUCTION TO COMPUTER SCIENCE
15 points
Please see page 52 for more information.

CSMAX170-18A (HAM) & 18B (HAM)
FOUNDATIONS IN COMPUTING AND MATHEMATICAL SCIENCES
15 points
Please see page 53 for more information.

MATHS135-18B (HAM)
DISCRETE STRUCTURES
15 points
Please see page 79 for more information.

STATS111-18B (HAM)
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, MATHS168, 18 credits of NCEA Level 2 Mathematics, or 14 credits of NCEA Level 3 Statistics, Calculus or Mathematics
Restricted paper(s) STAT111, STAT121, STATS121, STAT160

STATS121-18A (HAM)
INTRODUCTION TO STATISTICAL METHODS
15 points
An introduction to statistical data collection and analysis. Topics include general principles for statistical problem solving; some practical examples of statistical inference; and the study of relationships between variables using regression analysis.

Prerequisite paper(s) MATH168, MATHS168, 18 credits of NCEA Level 2 Mathematics, or 14 credits of NCEA Level 3 Statistics, Calculus or Mathematics
Restricted paper(s) STAT111, STAT121, STAT160 and STATS121
PAPERS
200 LEVEL

COMPX223-18A (HAM)
DATABASE PRACTICE AND EXPERIENCE
15 points
Please see page 55 for more information.

CSMAX270-18B (HAM)
CULTURAL PERSPECTIVES FOR COMPUTING AND MATHEMATICAL SCIENCES
15 points
Please see page 57 for more information.

STATS221-18A (HAM)
STATISTICAL DATA ANALYSIS
15 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.

This paper introduces students to the R programming language which is used to investigate a collection of real data sets. Analysis of variance, multiple regression, non parametric methods and time series are covered.

Prerequisite Paper(s) At least one of STAT111, STAT121, STATS111, STATS121
Restricted paper(s) STAT221

STATS226-18B (HAM)
BAYESIAN STATISTICS
15 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, MATHS101, MATHS102, STAT111, STAT121, STATS111, or STATS121
Restricted paper(s) STAT226
PAPERS
300 LEVEL

COMP329-18A (HAM)
DATABASE SYSTEMS
20 points
Please see page 60 for more information.

STAT321-18B (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

STAT323-18A (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
PAPERS
300 LEVEL

STAT326-18B (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

STAT352-18A (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

STAT390-18A (HAM) & 18B (HAM) & 18Y (HAM)
DIRECTED STUDY
20 points

With the special permission of the lecturer and the Convenor of Statistics.
PAPERS
500 LEVEL

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 Convenor. Entry to all graduate papers is by way of permission of the Convenor of Statistics.

STAT501-18A (HAM)
QUANTITATIVE METHODS FOR SECURITY AND CRIME SCIENCE
15 points
This paper considers quantitative techniques that can be used to analyse crime data.
Prerequisite paper(s) Admission into the Master of Security and Crime Science

STAT502-18B (HAM)
ADVANCED QUANTITATIVE METHODS FOR SECURITY AND CRIME SCIENCE
15 points
This paper considers advanced quantitative techniques that can be used to identify and forecast crime event patterns.
Prerequisite paper(s) STAT501

STAT521-18A (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

STAT522-18B (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.
Prerequisite paper(s) Admission is at the discretion of the Convenor of Statistics

STAT525-18A (HAM)
TOPICS IN STATISTICS
30 points
Prerequisite paper(s) Admission is at the discretion of the Convenor of Statistics
STAT531-18B (HAM)
MULTIVARIATE ANALYSIS
30 points
This paper will develop skills in the use of statistical packages for data analysis and modelling and an understanding of the key inferential concepts of interval estimation, significance testing, and model selection. The emphasis is on observational rather than experimental data.

Prerequisite paper(s) Admission is at the discretion of the Convenor of Statistics
Restricted paper(s) STAT321

STAT533-18A (HAM)
STUDY DESIGN AND STATISTICAL INFERENCE
30 points
This paper outlines the principles and practicalities of designing and analysing experiments and surveys, with emphasis on the design. The concepts of statistical inference are presented, with an emphasis on estimation.

Prerequisite paper(s) Admission is at the discretion of the Convenor of Statistics
Restricted paper(s) STAT323

STAT536-18B
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.

Prerequisite paper(s) Admission is at the discretion of the Convenor of Statistics
Restricted paper(s) STAT326

STAT590-18C (HAM)
DIRECTED STUDY
30 points

STAT591-18C (HAM)
DISSERTATION
30 points

STAT592-18C (HAM)
DISSERTATION
60 points
STAT593-18C (HAM)
STATISTICS THESIS
90 points

STAT594-18C (HAM)
STATISTICS THESIS
120 points

PAPERS NOT OFFERED IN 2018

STAT389
DIRECTED STUDY

STAT524
STATISTICAL CONSULTING
GRADUATE STUDY
CONTACTS

COMPUTER SCIENCE AND COMPUTER GRAPHIC DESIGN
Department of Computer Science, The University of Waikato,
Private Bag 3105, Hamilton 3240, New Zealand

Phone  +64 7 838 4021
Email   cms@waikato.ac.nz
Web     cs.waikato.ac.nz or cgd.waikato.ac.nz

MATHEMATICS AND STATISTICS
Department of Mathematics and Statistics, The University of Waikato,
Private Bag 3105, Hamilton 3240, New Zealand

Phone  +64 7 838 4713
Email   cms@waikato.ac.nz
Web     math.waikato.ac.nz or stats.waikato.ac.nz

FACULTY OF COMPUTING & MATHEMATICAL SCIENCES
The University of Waikato, Private Bag 3105,
Hamilton 3240, New Zealand

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Email   cms@waikato.ac.nz
Web     cms.waikato.ac.nz
GRADUATE AND POSTGRADUATE QUALIFICATIONS SUMMARY

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

- Bachelor of Design with Honours (BDes(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 Security and Crime Science (MSCS)
- Master of Science (Research)(MSc(Research))
- Master of Science (MSc)
- Master of Philosophy (MPhil)
- Doctor of Philosophy (PhD).

Most graduate programmes require candidates to have completed a bachelors degree with a major in the relevant subject.

INTERNATIONAL STUDENT 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 OR a TOEFL iBT score of 90 (with a writing score of 22).

What follows is a brief description of each qualification. Precise details of the regulations can be found in the 2018 University of Waikato Calendar.
## GRADUATE AND POSTGRADUATE QUALIFICATIONS

### 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 45 points at 300 level or above. At least 45 points must be in your subject area.

**GradCert Planner** 60 points 6 months

<table>
<thead>
<tr>
<th>100 level or above</th>
<th>300 level</th>
<th>300 level</th>
<th>300 level</th>
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</table>

### GRADUATE DIPLOMAS

The Graduate Diploma (GradDip) is a qualification for graduates with at least a bachelors 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 75 points at 300 level or above. At least 90 points must be in your subject area.

**GradDip Planner** 120 points 1 year

<table>
<thead>
<tr>
<th>100 level or above</th>
<th>200 level</th>
<th>200 level</th>
<th>300 level</th>
<th>300 level</th>
<th>300 level</th>
<th>300 level</th>
<th>300 level</th>
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</thead>
</table>

### POSTGRADUATE CERTIFICATES

The Postgraduate Certificate (PGCert) is a qualification for graduates with at least a bachelors degree in a related subject. 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.

**PostGrad Cert Planner** 60 points 6 months

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<thead>
<tr>
<th>500 level</th>
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</thead>
</table>
POSTGRADUATE CERTIFICATE IN INFORMATION TECHNOLOGY (PGCERTINFOTECH)

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. The PGCertInfoTech is offered in A Semester (February) and C Semester (November) each year.

**PGCertInfoTech Planner** 60 points 6 months

- **COMP568**
- **COMP569**

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POSTGRADUATE DIPLOMAS

The Postgraduate Diploma (PGDip) is a qualification for graduates with at least a bachelors degree in a related subject. It normally takes one year of full-time study. 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

- **500 level**
- **500 level**
- **500 level**
- **500 level**
- **500 level**
- **500 level**
- **500 level**
- **500 level**
HONOURS QUALIFICATIONS

BACHELOR OF DESIGN WITH HONOURS (BDES(HONS))
The BDes(Hons) is a one-year, 120pt, graduate qualification available to students who have completed the BDes, or equivalent qualification.

Intending candidates for the degree should discuss these requirements with the Design Graduate Adviser in the Department of Computer Science. See page 102 for department contact details.

BACHELOR OF SCIENCE WITH HONOURS (BSC(HONS))
The BSc(Hons) is a one-year, 120pt, graduate qualification available to students who have completed a BSc 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 102 for department contact details.

BSC(HONS) ENTRY REQUIREMENTS
BSc(Hons) students are required to complete 120pts at 500 level including a 30 point dissertation (e.g. COMP591). Each subject has its own entry and programme requirements for the degree. For 2018 these are:

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

Mathematics: Candidates will require an average grade of B in at least 80 points at 300 level Mathematics.

Statistics: Candidates will require B grades or better in at least 60 points in 300 level Statistics papers in the BSc and must have passed the prerequisites for the 500 level papers they wish to enrol in. See page 92.

BSC(HONS) DEGREE PLANNER

COMPUTER SCIENCE 120 points 1 year

<table>
<thead>
<tr>
<th>Course</th>
<th>Points</th>
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<tbody>
<tr>
<td>COMP591</td>
<td>30pt</td>
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<tr>
<td>COMP5XX</td>
<td>15pt</td>
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<tr>
<td>COMP5XX</td>
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<tr>
<td>500 level</td>
<td>30pt</td>
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<td>500 level</td>
<td>30pt</td>
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</tbody>
</table>
MASTERS QUALIFICATIONS

You will need to discuss the choice of your 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 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 an advanced degree that emphasises graphic design theory, technology and original research.

For students with an undergraduate degree, the MCGD requires a total of 180 points at 500 level. Students with an honours degree or a postgraduate diploma are required to take 120 points at 500 level.

Students taking 180 points for the MCGD are required to include CGRDS81 (30 points). Students not wishing to complete a research-led MCGD degree could take CGRDS91 (30 points) if CGRDS81 is in their programme of study, or could take CGRDS92 (60 points). The remaining papers should be chosen from appropriate 500 level taught papers.

**MCGD Degree Planner** 1.5 years 180 points

<table>
<thead>
<tr>
<th>Course</th>
<th>Points</th>
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<tbody>
<tr>
<td>CGRDS81</td>
<td>30pt</td>
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<tr>
<td>Research - at least 30pt</td>
<td></td>
</tr>
<tr>
<td>Taught papers</td>
<td></td>
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</tbody>
</table>

MASTER OF CYBER SECURITY (MCS)

Our MCS 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). Additionally, 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.

For admission, students will need to have completed a relevant bachelors degree, normally in Computer Science or in Computer Engineering, and will need an average of at least a B in their 300 level or higher Computer Science papers (or equivalent subject).

The 180 point MCS consists 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 can complete a 120pt MCS including a 60-point dissertation. Dissertations may be co-supervised with relevant IT or security institutions in New Zealand. Very capable students may opt for a research-intensive 90-point thesis as an alternative to the 60-point dissertation.

**MCS Degree Planner** 1.5 years 180 points

<table>
<thead>
<tr>
<th>Course</th>
<th>Points</th>
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<tbody>
<tr>
<td>COMP592</td>
<td>60pt</td>
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<tr>
<td>COMP518</td>
<td>15pt</td>
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<tr>
<td>COMP527</td>
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<tr>
<td>LAWS526</td>
<td>30pt</td>
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<tr>
<td>COMP501, COMP513 or COMP514</td>
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<tr>
<td>45pts at 500 level</td>
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</table>
MASTER OF INFORMATION TECHNOLOGY (MINFOTECH)

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 internship paper linking all specialisations, and ensuring students gain industry specific skills and experience.

For students with an undergraduate degree, the MInfotech requires a total of 180 points consisting of 90 points of 500 level taught Computer Science papers, 30 points of appropriate 500 level taught “soft skills” papers, and concludes with a 60 point internship (FCMS596). The two “soft skills” papers recommended are: CSMAX570 - Preparing for the ICT Internship and ENMP585 - Industrial Technology and Innovation 1.

Students who have gained the equivalent of an Honours degree in Computer Science are able to complete the 120pt MInfoTech programme.

**MInfoTech Degree Planner** 1 to 1.5 years 180 points

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ENMP585</td>
<td>15pt</td>
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<tr>
<td>CSMAX570</td>
<td>15pt</td>
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<tr>
<td>500 level</td>
<td>90pt</td>
</tr>
<tr>
<td>Internship</td>
<td>60pt</td>
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</table>

MASTER OF SECURITY AND CRIME SCIENCE (MSCS)

In the MSCS, you will develop the skills and core competencies required to become a leader in the security, intelligence and crime-prevention areas in the public and private sectors.

You will incorporate learning from different disciplines such as Statistics, Computer Science, Geographic Information Systems, Population Studies, Psychology and Management, to learn how to deal with real-world crime issues and develop analytical and creative methods to improve security in an ever-changing society.

For admission, students will need to have completed a relevant bachelor’s degree or postgraduate diploma with at least a B+ or higher in their final year majoring papers.

**MSCS Degree Planner** 1.5 years 180 points

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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ISCS501</td>
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<tr>
<td>ISCS502</td>
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<td>IRSST501</td>
<td>15pt</td>
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<tr>
<td>Compulsory papers</td>
<td>30pt</td>
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<tr>
<td>Elective papers</td>
<td>45pt</td>
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<tr>
<td>ISCS592</td>
<td>60pt</td>
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</tbody>
</table>
MASTERS QUALIFICATIONS

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 take a 120 point 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

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

*The MSc and MSc(Research) regulations may change for 2018.
HIGHER RESEARCH DEGREES

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 Research Committee is conditional for an initial period of six months. Confirmation of enrolment by the Postgraduate Research 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 waikato.ac.nz/study/apply/higher-research-degrees-application-process

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. You may be required to take up to two preliminary papers.

It is sometimes possible to transfer from an 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 Postgraduate Research Committee.

TE MATA KAIRANGI SCHOOL OF GRADUATE RESEARCH
Te Mata Kairangi School of Graduate Research, The University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand

Phone  + 64 7 858 5096
Email    sgr@waikato.ac.nz
Web      waikato.ac.nz/students/research-degrees/
INTRODUCTION

GRADUATE STUDY IN DESIGN

Design is everywhere in our world, on almost every surface, material or digital that we touch and see. In the process of conveying messages from commerce, education, government and society, educating us, entertaining us, interacting with us. In the midst of emerging media, liquid culture and accelerating technology, design works in the process of making sense of material and virtual objects.

Design at a graduate level applies theory and practice to research in areas related to how designers think, how they practice and what they produce. Design at The University of Waikato is unique in New Zealand as a specialist design qualification that offers an integration of design and computer science.

Graduate level study in design is an opportunity to plan, develop and carry out a large-scale 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 design further.

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

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

Graduate students have a dedicated lab space and access to all of our undergraduate facilities, including 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 GRADDIP, PGDIPCGD, AND MCGD

Students seeking entry to graduate qualifications should have a bachelors degree and/or relevant experience in a related discipline.

What is involved in a Graduate Programme in Design?

Graduate programmes are highly tailored to the needs of the student. Honours and Masters qualifications in Design combine taught papers with a research component.

Students accepted to a graduate qualification in Design should plan to communicate with a graduate advisor before the start of the semester that they will enter the University of Waikato. The advisor will assist the student to develop a programme of study for their qualification. The individual research is undertaken by students as a dissertation or thesis and is developed with an individual research supervisor and topics are made available to students at the appropriate point in their individual qualification.

Acceptance to graduate programmes requires an agreed upon programme of study.

Do you need to submit a portfolio?

Applicants who have not completed another graphic design qualification at The University of Waikato must submit a portfolio containing 10 pieces of work created by the applicant. 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.

You can submit your portfolio as digital files via email or on a USB stick. Please do not submit originals. Original pieces can be photographed and submitted digitally and labelled clearly. Each of the 10 pieces should be accompanied by a title and a short (100 word max.) description of the work and its purpose and process of production.
Portfolio pieces might include:

- Animation
- Computer-generated images
- Drawings or Sketches
- Interactive Prototypes
- Photographs
- Websites

**Do you need to submit a research proposal?**

On application you do not require a research proposal. Students do not have to settle on a preferred research topic before application or enrolment to The University of Waikato.

Research topics are often lead by staff supervisors areas of expertise.

These might include research relating to:

- Book & eBook Design
- Creativity
- Design processes
- Design theory
- Design thinking
- Information design & information search
- Interaction design (IxD)
- Interface design (UI)
- Motion graphics
- Printed and digital books
- Typography
- User experience design (UX)
- Virtual reality (VR)
- Visual communication
- Web design.

Please email cms@waikato.ac.nz to discuss study options.

**RESEARCH DIRECTIONS**

**DESIGN RESEARCH GROUP**

Tomás García Ferrari, Simon Laing, Keith Soo, Claire Timpany, Emmanuel Turner, Nicholas Vanderschantz.

Research in design is focused on theory, visual communication and interactivity. Central to all investigations are considerations of the user and the experiences of their engagement with both the message and the media. The research encompasses interface and information design for children and adults across a range of digital and traditional media. Typography use and development is explored as well as advanced media experimentation and installation. Members of the Design Research Group of the Faculty of Computing and Mathematical Sciences work closely with related research groups in the faculty including the Digital Library Group, Human-Computer Interaction (HCI) Group, and the Information Systems and Databases Group.
Research and collaboration opportunities exist for graduate and undergraduate students as well as visiting scholars investigating the following areas:

- Creativity
- Design processes
- Design theory
- Design thinking
- Information design & information search
- Interaction design (IxD)
- Interface design (UI)
- Motion graphics
- Printed and digital books
- Typography
- User experience design (UX)
- Virtual reality (VR)
- Visual communication
- Web design.

Further details and publications can be obtained from the profiles of the members of the group (see page 19).

GRADUATE STUDENT PROFILE

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 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
GRADUATE STUDY IN COMPUTER SCIENCE

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. A sixth group is concerned with Cyber Security. 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, Asia 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 cs.waikato.ac.nz

GRADUATE STUDENT PROFILE
SJOERD DE FEIJTER, BCMS(HONS) & MCS

Anyone who downloads the latest version of the Gallagher Command Centre Mobile App, created to make it easier for customers to manage security control, will notice a few new features. The most impressive is that it’s programmed to work Gallagher’s innovative Mobile Reader – a seemingly simple piece of hardware that looks like your average phone case, yet is at the forefront of agri-technology in New Zealand. The reader allows customers to scan all Gallagher encoded Mifare cards to simplify ID verification for cardholders. And it was developed and tested by one of Waikato’s Bachelor of Computing and Mathematical Sciences (BCMS) graduates.

Sjoerd de Feijter began an internship with Gallagher in October last year, after being awarded the Sir William Gallagher Cyber Security Scholarship. Sjoerd was tasked with creating mobile application prototypes to test different mobile readers that were already on the market. This way Gallagher could decide if the reader was something they wanted to incorporate into their own product line, which it was. The success of the internship led to Sjoerd being offered further work at the company, where he is now a Junior Software Engineer in the Mobile Development Team.
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, Vimal Kumar, Chaitanya Joshi, Richard Nelson, Bill Rogers.

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 user intuitive 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 crow.org.nz
DIGITAL LIBRARY GROUP
Mark Apperley, David Bainbridge, Sally Jo Cunningham, Annika Hinze, 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 (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 (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 nzdl.org
ENERGY INFORMATICS GROUP
Mark Apperley, 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 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 cs.waikato.ac.nz/research/fm
HUMAN-COMPUTER INTERACTION GROUP
Mark Apperley, Judy Bowen, Sally Jo Cunningham, Annika Hinze, Lyn Hunt, Te Taka Keegan, Simon Laing, 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 cs.waikato.ac.nz/research/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, 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 hand-crafted 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’ fertiliser decisions, and processing natural language to extract keywords from documents.

Further details on the group can be obtained from the group’s website at cs.waikato.ac.nz/~ml
NEW ZEALAND INSTITUTE FOR SECURITY AND CRIME SCIENCE
Ryan Ko, Joe Burton, Geoff Holmes, Chaitanya Joshi, Maryanne Garry, Devon Polaschek, Nigel McCarter

Crime Science is an emerging field of study that aims to develop a scientific approach to crime prevention and utilisation of Police resources.

The NZ Institute for Security and Crime Science incorporates four interlinked components; theories in Crime Science, modelling and analysis of data on crime and security issues in New Zealand, the use of computer science to assist evidence-based Police work, and research in psychology relevant to criminal behaviour and Police processes (such as taking evidence from witnesses).

Dean of the Faculty of Computing & Mathematical Sciences Professor Geoff Holmes says the Institute is a great opportunity to do high-impact, cross-disciplinary research and teaching. “Staff and students will have the chance to use their skills directly for the benefit of society.”

The Institute, which will be based at the University of Waikato’s Hamilton campus, will work in conjunction with the Wellington-based Centre for Evidence Based Policing, a joint University of Waikato and New Zealand Police initiative.

The multi-disciplinary nature of Crime Science means Waikato is well-suited to launching the country’s first dedicated research institute, calling on expertise in Geography, Demography, Psychology, Political Science and Public Policy, Sociology, Economics, Computer Science and Software Engineering, Cyber Security, Mathematics, Statistics, Law and Engineering.

Access to big data is a crucial component in crime analysis, so of particular importance to the Institute will be the strengths found in NIDEA – with its access to the Integrated Data Infrastructure Suite providing direct secure access to Statistics NZ’s datasets – and FCMS’ Machine Learning Group and Centre for Open Source Innovation (COSI) which contains the world-leading WEKA and MOA pattern analysis tools.

The first outcome of the Institute has been the development of a new masters programme. The Master of Security and Crime Science (MSCS) is the first qualification of its kind in New Zealand and will be targeted at current and future law enforcement and security practitioners, and has the support of the NZ Police.

Further details on the group can be obtained from the Institute’s website at waikato.ac.nz/security-crime-science
WAND COMPUTER NETWORKS GROUP

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 wand.net.nz
MATHEMATICS
INTRODUCTION
GRADUATE STUDY IN 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 subject 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, Python, Java, MPI and R.

You can find out more about the Mathematics and Statistics Department on our website math.waikato.ac.nz

LIAM McMAHON
PHD MATHEMATICS
RESEARCH DIRECTIONS

The following 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 and Statistics.

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=x^2+y^4 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 cms.waikato.ac.nz/people/kab
NICHOLAS 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 cms.waikato.ac.nz/people/nickc

DANIEL DELBOURGO
NUMBER THEORY
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 cms.waikato.ac.nz/people/delbourgo
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 cms.waikato.ac.nz/people/hawthorn

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 cms.waikato.ac.nz/people/stephenj
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 cms.waikato.ac.nz/people/e.kalnins

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 cms.waikato.ac.nz/people/wclim
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 cms.waikato.ac.nz/people/yuril

SEAN OUGHTON
TURBULENCE AND SPACE PHYSICS
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 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 (e.g. mercury) and plasmas (e.g. 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 cms.waikato.ac.nz/people/seano
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 cms.waikato.ac.nz/people/stokes
INTRODUCTION

GRADUATE STUDY IN STATISTICS

Statistics is the science of collecting, analysing, and interpreting data subject to uncertainty. We live in a world where variability is everywhere. To make informed decisions we must understand the nature of this variability, and make the use of meaningful information.

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 subject 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 subject on our website stats.waikato.ac.nz
RESEARCH DIRECTIONS

The following pages will give prospective research students an indication of the research interests of the staff in Statistics. If you are considering a research-based degree, you are invited to discuss your interests with the Convenor 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 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’. I am keen to continue the development of models and 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.

**MEDICAL STATISTICS**  
I am also interested in using statistical methods and data mining methods to extract useful information from medical data. Recently I have worked on a project that investigated whether different surgical approaches were associated with different clinical outcomes. These projects aim to improve healthcare through the analysis of the data collected.

Further details on sample publications can be obtained from [stats.waikato.ac.nz/people/lah](http://stats.waikato.ac.nz/people/lah)

CHAITANYA JOSHI  
**COMPUTATIONAL BAYESIAN INFEERENCE 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 [stats.waikato.ac.nz/~cjoshi](http://stats.waikato.ac.nz/~cjoshi)
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 stats.waikato.ac.nz/people/smiller
FURTHER INFORMATION
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 Design student (see page 141);
- 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 SCHOLARSHIPS

COMPUTER SCIENCE UNDERGRADUATE SCHOLARSHIP
UP TO $5,000
Each year the Computer Science Department offers up to 10 tuition fees scholarships for first year undergraduate students studying towards a BCMS(Hons), BSc or BE(Hons) degree. The scholarship will not be refundable to recipients who withdraw from their degree 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 a New Zealand Secondary School.

The Scholarships are awarded on the basis of examination results of each applicant in the Waikato University Computer Science Scholarship Examination. 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 (COMPX101) at Waikato University, which gives students a basic level of competence in computer programming and computing concepts.

Information on the Waikato University Computer Science Scholarship Examination is sent each year to schools around New Zealand. Please enquire with your school for further information, contact the Computer Science Department, or email cs-scholarship@waikato.ac.nz

DESIGN FEES SCHOLARSHIP
$5,000
The Design Fees Scholarship is open to applicants who are enrolling in the first year of study towards the Bachelor of Design at The University of Waikato. All students wishing to be considered for the Design Fees Scholarships must apply on the official Scholarship application form and submit this with their portfolio. The scholarship form can be found at waikato.ac.nz/scholarships/s/design-fees-scholarship

MATHEMATICS 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 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
$1,500-$2,500

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 and 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; and
• 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.

STUDENT EXCHANGE TO ARIZONA STATE UNIVERSITY
NICOLE CHAN, BCMS(HONS) COMPUTER SCIENCE

“An exchange is a unique opportunity to immerse yourself in another culture, where the opportunities for learning, and travel are limitless. Make the most of every moment, do what you love, make friends for life from all walks of life, all while paying Waikato fees!”

SCHOLARSHIPS OFFICE
The Scholarships Office is located in W Block 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      waikato.ac.nz/scholarships
POSTGRADUATE SCHOLARSHIPS

COMPUTER SCIENCE DEPARTMENT GRADUATE ASSISTANTSHIPS
Selected students may receive Graduate Assistantships. These are allocated on a competitive basis and the number varies from year to year. A graduate assistant receives $7,125 per year for a total of 256 hours work.

HEALTHALLIANCE CYBER SECURITY SCHOLARSHIP
UP TO $25,000
This Scholarship was established in 2017 and will provide students studying in the Master of Cyber Security (MCS) with both financial support and industry experience through a research project at healthAlliance. The Scholarship will cover student tuition fees and a stipend. The value of the Scholarship will be NZ$25,000 for students undertaking a 180 point MCS and NZ$20,000 for students undertaking a 120 point MCS.

SIR WILLIAM GALLAGHER CYBER SECURITY SCHOLARSHIP
UP TO $25,000
The Sir William Gallagher Cyber Security Scholarship was established in 2015 to support academically talented students studying towards a Master of Cyber Security (MCS) qualification at The University of Waikato. The value of the Scholarship will be NZ$25,000 for students undertaking a 180 point MCS and NZ$20,000 for a 120 point MCS.

THE A ZULAUF TRUST SCHOLARSHIP
UP TO $5,000
This Scholarship was established in 2011 to promote the study of Mathematics at The University of Waikato. 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.

SOURCES OF FUNDING FOR DOCTORAL STUDY

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 A- (80%). Both international and domestic students are eligible to apply.

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

INTERNATIONAL STUDENTS
International PhD students are eligible for domestic fees for their PhD studies. Conditions apply.

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.
AWARDS AND PRIZES

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.

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. The amount of the prize depends on the level of study.

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 of Mathematics and who in the opinion of the Chairperson of Mathematics and Statistics is the most outstanding second year mathematics student and worthy of the award.

GORDON HARRIS BACHELOR OF DESIGN PRIZE
$250
The Gordon Harris Bachelor of Design Prize is awarded every second year, to the top second-year student of the BDes.

HILBERT PRIZE IN MATHEMATICS
$250
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 research project and report for the BCMS (Hons) paper COMP520 or MATH520 Report of an Investigation.
AWARDS AND PRIZES

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 the 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 the award.

MILLENIUM PRIZE IN MATHEMATICS
$250
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.

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 Honours with the best overall performance.

VON NEUMANN PRIZE IN MATHEMATICS
$250
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 Mathematics and who is, in the opinion of the Chairperson of the Department of Mathematics and Statistics, 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 the award.
UNIVERSITY OF WAIKATO AND OTHER SCHOLARSHIPS

SIR EDMUND HILLARY SCHOLARSHIP PROGRAMME
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. The scholarship is up to $10,000 per annum for the duration of an undergraduate qualification, subject to continuing to meet the Scholarship’s requirements.

THE UNIVERSITY OF WAIKATO SCHOOL LEAVER SCHOLARSHIP
Up to $7,000 for students commencing full-time study in the first year of an undergraduate degree at the University of Waikato. The scholarship is based on academic achievement and will provide support towards either tuition fees or accommodation in the University’s Halls of residence. An application to enrol at the University will be taken as a scholarship application, and no separate application is required.

UNIVERSITY OF WAIKATO MASTERS RESEARCH SCHOLARSHIP
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 waikato.ac.nz/scholarships

UNIVERSITY OF WAIKATO TAUGHT POSTGRADUATE FEES SCHOLARSHIP
The University of Waikato established the Taught Postgraduate Fees Scholarship to support students studying at postgraduate level, primarily undertaking coursework. Preference will be given to students on a pathway to research qualifications at The University of Waikato. Awards will be determined on academic merit.

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

COMMONWEALTH SCHOLARSHIP
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.
THE STUDENT CENTRE/ TE MANAWA

STUDENT ASSISTANCE
The Student Administration Desk is located on Level 2 of the Student Centre. Come here if you need any help, including the following:

- All student enquiries
- StudyLink liaison
- Academic records
- Academic credit
- ID Cards
- International Student Services.

PAYMENTS
The Payment Office is located on Level 2 of the Student Centre. The following can be paid here:

- Tuition Fees
- Library invoices
- Course related costs including lab coats and science equipment
- Student visas for International students.

THE LIBRARY

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.

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.

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 clive.wilkinson@waikato.ac.nz
UNIVERSITY SUPPORT

CAREER DEVELOPMENT SERVICES
Career Development Services offers free advice to University of Waikato students, recent graduates and alumni. Our team can help you with career planning, developing your CV and cover letter, interview skills, social media, and personal brand. We also connect students and graduates with employers through Careers Fairs, employer campus visits and promoting employment opportunities.

Please email careers@waikato.ac.nz to attend a workshop or to book a one-on-one consultation.

CHAPLAINCY
There is a chaplaincy service available at The University of Waikato. This service is available to students and staff of all religious backgrounds in the spirit of mutual respect and deepening understanding.

Email chaplain@waikato.ac.nz

CHILDCARE SERVICES
We have a crèche on campus available for children aged three months to five years. We also have a Kohanga Reo (preschool taught in te reo Māori) near the Hamilton campus.

Call +64 7 856 2982 for more information.

CULTURAL HOUR
Cultural Hour is every Wednesday 1.00 – 2.00 pm and is a time free of lectures and tutorials so clubs and societies can meet and other student and University activities can be held.

STUDENT COUNSELLING SERVICE
The Student Counselling Service aims to ensure that your time at University is the best it can be. Counselling can help with a range of issues, big and small. Some of the life issues the counsellors deal with are; loneliness, living arrangements, anger, study overload, grief, stress, anxiety, relationships, sexuality and depression. The Counselling service also offers workshops and seminars to assist you in preparing for exams and other issues.

Most appointments last for one hour. You can make a confidential appointment by phoning 07 838 4037.

DISABILITY SUPPORT SERVICES
Disability Support Services – Te Tari Kai Awhina Hauā provides you with access to a range of services, including lecture material, learning support, alternative examination arrangements, access to assistive technology, alternative formatting, ergonomic furniture, hearing equipment, specialist staffing and much more.

The Students with Disability Handbook provides comprehensive information about access arrangements and support available at the University. Contact the disability support staff by emailing disability@waikato.ac.nz to discuss any arrangements or accommodations you require.

JUSTICE OF THE PEACE
We have many Justices of the Peace (JPs) on campus who can verify your documents for enrolment or other purposes. If you require the services of a JP, visit the Student Centre for more information.
SPECIAL CONSIDERATION FOR IMPAIRED PERFORMANCE OR MISSED EXAMINATION

The Assessment and Graduation Office is responsible for the special consideration process for formal examinations only.

Application forms are available from: The University’s Student Health Service, Student Counselling Service or the Student Administration Counter in the Student Centre.

If you need help with completing the form or you need further information on special consideration, contact staff in the Assessment and Graduate Office. on 07 838 4941.

For missed or impaired performance in items of internal assessment, including tests, applications should be made in writing to the examiner of the relevant paper no later than three days after the date on which the item of internal assessment is due.

STUDENT LEARNING

The Student Learning team provides a University-wide service to support students’ academic learning needs. We actively seek opportunities to collaborate with staff to embed appropriate and effective learning development opportunities within Faculties, and we also work closely with the Library. Our overall goal is to help students acquire the skills, knowledge and attributes to become independent, successful learners.

STUDENT HEALTH SERVICE

We have a team of qualified doctors and nurses on our Hamilton campus to look after your healthcare needs. Routine consultations and prescriptions are free if you enrol with the Student Health Service. No appointment is necessary, simply drop-in to see them.

STUDYLINK SUPPORT

Contact our StudyLink Liaison Officer for help and advice on how best to use StudyLink services. Email nadine.hayes@waikato.ac.nz or call 07 838 4790 for free and confidential support.
FACULTY SUPPORT

ENROLMENT AND PROGRAMME ADVICE
The FCMS Faculty Office is available to help you make the best choices for your programme of study, answer any questions you may have about choosing papers, changing your enrolment, graduating from university, and more. We are available Monday – Friday, 8.30am – 5.00pm, FG Link Ground Floor. Email cms@waikato.ac.nz

CLASS REPRESENTATION
All papers in the University should have at least one class representative, and possibly more depending on the size of the paper. Class representatives are mainly concerned with academic matters, things that can impact on the quality of your education, and the ability to study effectively.

The election of class representatives leads to a greater spread of interest, involvement and responsibility among members of the student body. It results in greater student participation in the running of the University. Student involvement in the governance and management of the University is essential to the high quality of academic and institutional life, of which class representatives are an integral part. For more information relating to class representatives, email student.reps@waikato.ac.nz

INTERNAL ASSESSMENT EXTENSIONS
Applications for an extension must be made no later than 48 hours before the deadline. After this you should hand in what you’ve done and request the marker take your circumstances into consideration. An application is to be made on the appropriate Application for an Extension of Deadline Form available from cs.waikato.ac.nz

TE PAETATA – MĀORI STUDENT SUPPORT SERVICE
Te Paetata is a support service available to all Māori Students doing papers in the Faculty of Computing and Mathematical Sciences. This includes advice and support, whether study orientated or otherwise. Please drop in to the support office on the ground floor of R Block (R.G.22) or use our contact details. And remember 'Sooner is Better than Later'.

MENTOR CO-ORDINATOR – BRONWYN POKI
R.G.22, R Block, The University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand
Phone +64 7 858 5092
Email bronwyn.poki@waikato.ac.nz
FACULTY CLUBS AND SOCIETIES

CS³
The Computer Science Student Society (CS³) is a social organisation who run events and advertise opportunities for students in Computer Science, Data Analytics, Design, Mathematics, Statistics and Software Engineering.

Social events include BBQs, LANs, trampolining, and the yearly pubcrawl. We also provide information on upcoming networking, internship, and graduate positions.

Check out cs3.org.nz or facebook.com/cscubed for more information.

LADIES INC
Ladies Inc is a social club at the University of Waikato which aims to support women studying and working in science, technology, engineering and mathematical (STEM) related fields.

Our goal is to build a support network of women in which we can encourage and inspire each other through social and industry events. Along the way we hope to encourage women to continue pursuing careers in these areas as women are under-represented in the computing industry.

Check out facebook.com/groups/LadiesInCNZ for more information.
CONDITIONS OF USE OF FCMS COMPUTER LABS

By using our computing facilities, you agree to abide by the Computer Regulations as listed in the 2018 University of Waikato Calendar as well as the following additional conditions and requests.

PLEASE DO NOT:

• Use another person’s account, even with their explicit permission
• Do anything in the name of another user, including sending email messages
• Deliberately disrupt or adversely affect the use of the facilities by other students
• Unplug lab computers
• Attempt to gain access to any system within, or external to, the University to which you are not entitled
• Copy or interfere with software on the computers
• Install or attempt to use any unlicensed software
• Attempt to “break” any software or hardware protection
• Act in a manner likely to cause damage to equipment – this includes the chairs
• Use the computer systems to access, download or store any material that might be deemed inappropriate or be in violation of copyright law.

Please 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.

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

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, low odor 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.

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 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.