CONTENTS

WELCOME TO LOGIC AND COMPUTATION

It is reasonable to hope that the relationship between computation and mathematical logic will be as fruitful in the next century as that between analysis and physics in the last.

John McCarthy, recipient of the ACM Turing Award, writing in 1963.

The utterly pure theory of mathematical proof and the utterly technological theory of machine computation are at bottom one, and the basic insights of each are insights of the other.

W.V.O. Quine, *On The Application of Modern Logic*

WHAT IS LOGIC?

Logic is the broad field concerned with all aspects of *reasoning*. It is fundamental to Computer Science, Mathematics, Philosophy, Linguistics and other disciplines.

While scientific knowledge is obtained by experiment and observation, mathematical knowledge is obtained by using reasoning to prove theorems. *Mathematical* logic develops symbolic languages that are used to express statements about the properties of mathematical systems and to identify correct patterns of reasoning (proofs). As well as clarifying the nature of proof and deduction, this leads to powerful new methods for advancing mathematical knowledge. It is also important for the study of the *foundations of Mathematics*, which investigates the basic axioms and principles underlying the universe of mathematical objects.

The role played by logic in Computer Science has been compared to that played by calculus and differential equations in Physics and Engineering. Logic provides technical tools needed to model computer systems and understand their construction. Formalized reasoning *about* computer programs is used to logically specify their intended behaviour and prove their correctness. Programs themselves can be viewed as proofs in a suitable logical system. The process of finding proofs can be automated, allowing for theorem-proving by the computer. Mathematical models can be used to provide a semantics (or theory of meaning) for programs, leading to a better understanding of the nature and design of programming languages.

Logic and argument are also vital tools for the work of philosophers. *Philosophical* logic is concerned with the critical analysis and explanation of such concepts as *truth, meaning*, and *inference*.

VUW'S CENTRE FOR LOGIC, LANGUAGE AND COMPUTATION

Victoria University has a strong interdisciplinary group in Logic, with a long tradition of teaching and research in computational, mathematical, and philosophical dimensions of the discipline. The **Centre for Logic, Language and Computation (CLLC)** has been established to provide focus for this activity and maintain VUW's position as the leading New Zealand university for research in Logic. Information about the current members of the Centre and their activities can be found at the website **www.clic.vuw.ac.nz**

CLLC staff offer the subject **Logic and Computation** (LOCO), which may be taken as a distinct programme for Honours (either the BSc(Hons) or BA(Hons) degree), Masters (MSc or MA), and PhD. The aim of this programme is to provide students with a solid grasp of the major concepts and methods of Logic and their use in aspects of Computer Science, Mathematics and Philosophy. Also offered is the subject **Logic** (LOGI), available for BA(Honours), MA and PhD, and focused more on philosophical logic: see Prof Mares for this option.

IMPORTANT DATES 2014

Trimester 1	3 Mar
Good Friday	18 Apr
Easter Monday	21 Apr
Anzac Day	25 Apr
Mid trimester break	21 Apr – 03 May
Graduation	13 – 15 May
Queen's Birthday	2 Jun
Examinations	13 Jun – 02 Jul
Mid year break	3 Jul – 12 Jul
Trimester 2	14 Jul
Mid trimester break	25 Aug – 6 Sep
Examinations	24 Oct – 15 Nov
Labour Day	27 Oct
Trimester 3	17 Nov
Graduation	10 – 11 Dec

TIMETABLE

The **timetable for 400-level MATH courses in 2014** will be set by email discussion prior to the start of each trimester.

The general university timetable is online at **www.victoria.ac.nz/timetables/**

Centre for Logic, Language and Computation

Schools:	School of Mathematics, Statistics and Operations Research *Te Kura Mātai Tatauranga, Rangahau Pūnaha* School of Engineering and Computer Science *Te Kura Mātai Pūkaha, Pūrorohiko*
Location:	School Office: Cotton Building, Floor 3, Room 358 School Office hours: 8:30am to 5:00pm Staff Members: Cotton Building, Floors 2-5
Telephone:	(04) 463-5341 from NZ, +64-4-463-5341 from overseas
Fax:	(04) 463-5045 from NZ, +64-4-463-5045 from overseas
Website**:**	**www.cllc.vuw.ac.nz/**

STAFF CONTACTS

STAFF	RESEARCH INTERESTS	ROOM	CONTACT
Dr Adam Day	*Computability Theory*	442	463 5658
Prof Rod Downey	*Computability, Complexity, Combinatorics, Algebra*	324	463 5067
Prof Rob Goldblatt	*Mathematical Logic, General Algebra*	438	463 5660
Dr Noam Greenberg	*Computability Theory, Set Theory*	436	463 6778
A/Prof Lindsay Groves	*Formal Software Development*	257	463 5656
Prof Edwin Mares	*Non-Classical Logics, Relevant Logic, Probability Logic*	MY618	463 5234
Dr David Pearce	*Programming Languages, Compilers, Program Analysis*	231	463 5833
Dr David Streader	*Formal Modelling, Semantic Transformation*	260	463 5655
Dr Alex Usvyatsov	*Model Theory, Logic, Combinatorics, Banach Space Geometry*	427	463 9543

Email: all staff can be reached at the address *firstname.lastname@vuw.ac.nz* where *firstname* and *lastname* are as in the list above.

PROGRAMME COORDINATORS

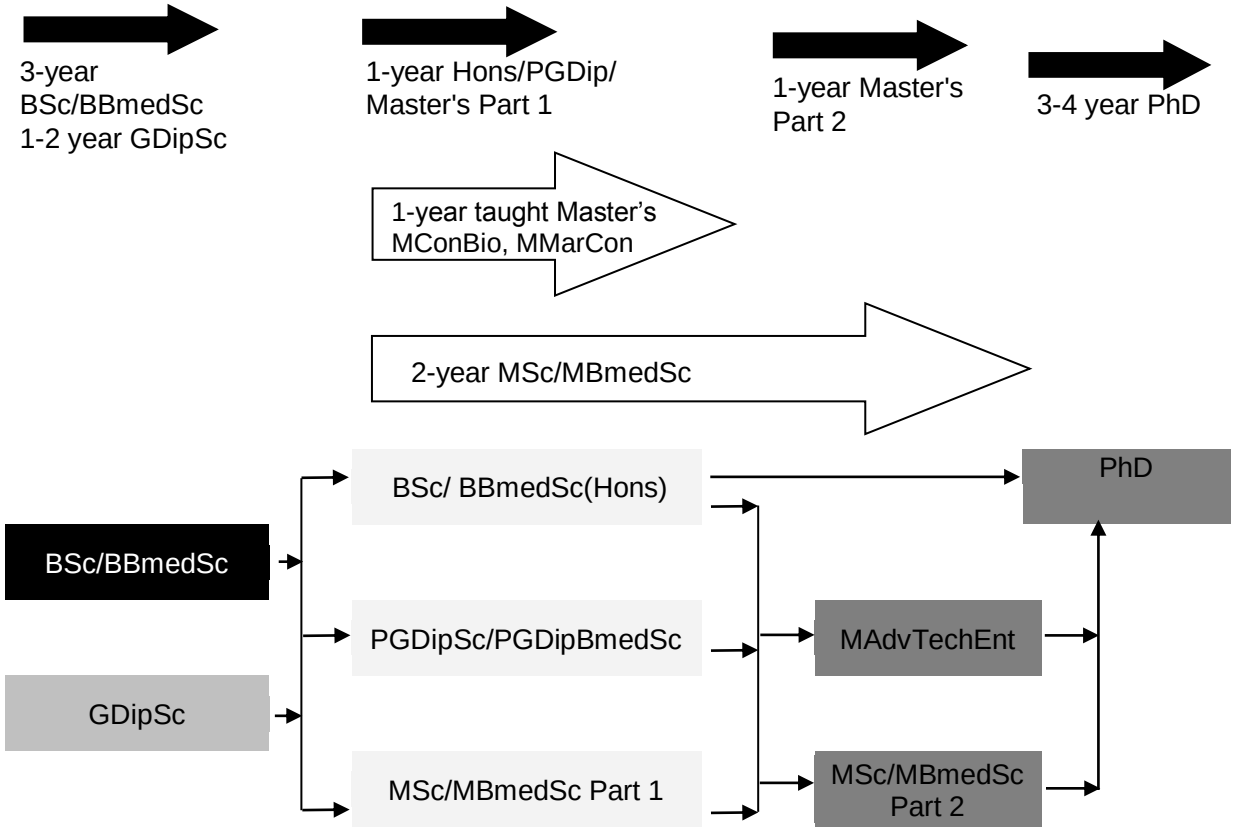
Enquiries should be directed to one of the following:

Prof Rob Goldblatt,
Cotton room 438, phone 463-5660,
email: **rob.goldblatt@vuw.ac.nz**

A/Prof Lindsay Groves
Cotton room 257, phone 463-5656,
email: **lindsay.groves@vuw.ac.nz**

QUALIFICATIONS AVAILABLE

The diagram below represents the structure of postgraduate study in science.



- Undergraduate
- Postgraduate - course work and research (Hons/Master's Part 1, taught Master's – MConBio/MMarCon)
- Graduate (enables transfer to undergraduate study in another subject)
- Postgraduate - research

HONOURS DEGREES AND MSc PART 1 DEGREE

The prerequisite for entry to BSc(Hons), BA(Hons) or MSc Part 1 in Logic and Computation is 60 points in approved 300-level COMP, SWEN, MATH, or PHIL courses. An average grade of at least B+ in these courses is normally required, and students should also have completed any specific prerequisites for their proposed courses of study. An equivalent background will be required for a student whose undergraduate study has been undertaken elsewhere.

Each student's programme consists of **120 points**, comprising

At least 60 points from the CORE LIST given below

The rest from 400-level COMP, SWEN, MATH courses, or PHIL 421, 422.

Overall approval of the programme is required from one or both of the Programme Coordinators, both at enrolment and at such time as the student makes any change to the programme of study.

THE CORE LIST

COMP 425	Computational Logic
MATH 433	Model Theory
MATH 434	Set Theory
MATH 435	Computability and Complexity
MATH 439	Category Theory
SWEN 421	Formal Software Engineering
SWEN 431	Advanced Programming Languages
PHIL 421	Formal Logic
PHIL 422	Philosophical Logic

Each of these courses is worth 15 points. Details of course contents are described later in this document. Availability of particular courses may vary according to availability of staff. When only one or two students request a particular course it could be offered as a supervised reading course rather than in lecture format.
For full information about all graduate courses in COMP, SWEN and MATH, including prerequisites etc., consult the following documents available from the School Office.

Postgraduate Engineering and Computer Science

Postgraduate Mathematics

or the web pages **www.ecs.vuw.ac.nz/courses** and **www.msor.vuw.ac.nz/courses**

MASTER'S DEGREES: MSc PART 2 OR MA

This programme consists of the preparation and presentation of a thesis under the direct supervision of a staff member. The thesis will typically be a survey of recent research in a particular area of current interest, to which the student may make some original contributions by way of new theory, or new development of existing theory. The thesis must be submitted for examination within 12 months of enrolment for the Masters degree.

Intending students are encouraged to discuss possible thesis topics with members of staff with a view to identifying a supervisor, and to consult one of the Programme coordinators about their intentions.

For more information on Masters by Thesis, see the following page at the website of the **Faculty of Graduate Research**: **www.victoria.ac.nz/fgr/masters**

ENTRY REQUIREMENTS

Students entering this programme will normally have completed BSc(Hons) or BA(Hons) with a class of Honours of 2(2) or better, or MSc Part 1.

MASTER OF ADVANCED TECHNOLOGY ENTERPRISE

The Master of Advanced Technology Enterprise (MATE) is an interdisciplinary one year research programme, the first of its kind in New Zealand. The programme explores the relationship between scientific research and commercial product development by establishing teams developing high-value enterprises from research projects with real commercial potential.

Through its unique practical approach, the programme explores the many challenges of creating successful technology enterprises, such as coping with an extended development time-frame and technology risks, balancing the often conflicting relationship between research and commercial product development, and applying best practice business activities focussed around advanced technology.

The MATE programme is open to graduates of science, engineering, design, commerce and law, and graduates from other disciplines with appropriate backgrounds. MATE creates an entrepreneurial team environment to allow students to gain knowledge, skills and experience in taking an advanced technology to market.

Within the enterprise, each student assumes individual responsibilities that, when combined, form a dynamic team capable of developing a viable product concept. Students from any discipline are invited to apply to the MATE programme. In each case the individual will inject specific discipline expertise into the team. Their role will draw on expertise gained from previous study and work experiences, and will be shaped by the needs of the particular project and enterprise.

MATE FOR SCIENTISTS

Scientists are the link between scientific research and the advanced technology enterprise. Goals of research and commerce are quite different, so the scientist must manage the relationship with the research team and ensure that research and commercial development activities are mutually compatible. The scientist understands the scientific method and, while they may not possess expertise in the particular research science, they become the technology expert within the enterprise.

Supervision, mentoring and governance for the teams and individuals within the MATE programme is provided by staff from throughout Victoria University of Wellington, and by external commercial partners. Students learn from experienced technology entrepreneurs, academics and business experts, and build their own professional support network.

At the end of the year, teams present their enterprise to an audience of VUW staff, external programme supporters and potential investors. They aim to prove value added and development of the research towards a viable product—to secure further investment for the enterprise.

Individual research builds on the student’s prior knowledge. Research investigates the role of a discipline expert within a multi-disciplinary team, the team function, and entrepreneurship within an advanced technology enterprise. Students create a Master’s research thesis focussed on their role, and aligned with the team outcomes.

Graduates leave having developed their discipline-specific skills within an advanced technology enterprise, added a deep understanding of advanced technology business

practice, and developed into confident professionals capable of leading the next wave of new technology businesses.

ENTRY REQUIREMENTS

1. A four-year degree, honours degree or relevant postgraduate diploma with a B+ average at 400-level from a university in New Zealand or, at the discretion of the Associate Dean (Students) of the Faculty of Science, another university

2. Approved by the Programme Director and the MAdvTecEnt Board of Studies as capable of proceeding with the proposed programme of study.

3. Requirement 1 may be waived by the Associate Dean (Students) of the Faculty of Science, for a candidate who has had extensive practical, professional or scholarly experience of an appropriate kind.

GENERAL REQUIREMENTS

1. The course of study for the MAdvTecEnt shall consist of courses worth at least 135 points, comprising:
   - Part 1: ATEN 501 - a 15-point course run intensively over 4 weeks
   - Part 2: ATEN 591 - a 120-point thesis & development of business plan
2. Entry to Part 2 requires the successful completion of Part 1 with at least a B+ grade and acceptance by the Programme Director and Board of Studies.
3. Candidates must:
   - enrol full-time for Part 1 and Part 2; and
   - complete Part 1 and enrol in Part 2 in consecutive trimesters.

ENROLMENT

1. Apply online at http://www.victoria.ac.nz/home/admisenrol
2. Programme start date is 21 January 2014

Application / Enquiry Contact Details

Paul Smith: paul.smith@vuw.ac.nz 04 4635479	Programme director
Shona de Sain: shona.desain@vuw.ac.nz 04 4635092	Associate Dean (Students)

LOGIC FOR HONOURS AND MASTERS

The alternative subject **Logic** (LOGI) can taken for BA(Hons), and for MA by research thesis. This Honours programme has a greater emphasis on Philosophy and requires 60 points from the Core List of the previous page and typically a further 60 points taken from PHIL 401-489. Enquiries about this option should be directed to Prof Ed Mares, Philosophy Programme.

POSTGRADUATE CERTIFICATE IN SCIENCE

The postgraduate certificate in science (PGCertSc) is offered in all subjects offered for the MSc, including Logic & Computation. Entry requirements are the same as for the MSc but the qualification consists of only 60 points of graduate courses in the relevant subject, so provides a shorter coursework postgraduate qualification. It may be suitable for a student in full-time work or managing other commitments and may also be used for those who wish to exit early from another graduate qualification. Conversely, a PGCertSc may later be abandoned in favour of a PGDipSc if the requirements for that qualification are subsequently met. A candidate in PGCertSc shall normally be enrolled for at least one trimester and shall complete the requirements within two years.

POSTGRADUATE DIPLOMA IN SCIENCE

The postgraduate diploma in science (PGDipSc) is offered in all subjects offered for the MSc, including Logic & Computation. Entry requirements are the same as for the MSc and the qualification consists of 120 points of postgraduate courses in the relevant subject. The PGDipSc requires 120 points of postgraduate study and can be completed full-time in two trimesters or part-time over four years and hence provides an alternative to the Honours and Masters degrees for students who are working full-time or are managing other commitments.

FURTHER STUDY

Supervision for the degree of PhD in Logic and Computation, or in Logic, is also available for suitably qualified students.

Extensive information about the PhD programme, including application forms, details of available funding, and application dates is available on the **Faculty of Graduate Research** website at **www.victoria.ac.nz/fgr**

PLANNING A PROGRAMME

The Honours degree is intended to be a **coherent** programme of study and is not merely the aggregation of a specified number of unrelated courses. When courses are substituted from other subjects, they must be relevant and complementary to the rest of the course. At most 60 points may be substituted, i.e. **at least 60** points must be from the Core List.

Students intending to spread their Honours/Masters Part 1 over more than one year should obtain prior approval for this from the Programme Coordinators. The maximum time for BSc(Hons) is two years, for BA(Hons) four years.

COURSE INDEX INFORMATION

Course code ↓	Course reference number ↓	Title ↓	Points ↓	Trimester ↓
COMP 425	CRN 990	**COMPUTATIONAL LOGIC**	15 PTS	1/3

400-LEVEL COURSES

COMP 425 CRN 990 **COMPUTATIONAL LOGIC** **15 PTS** **1/3**

Prerequisites: COMP 304; one further 300-level COMP, NWEN or SWEN course; (MATH 309 or PHIL 211/334/335 recommended)

Coordinator: A/Prof Lindsay Groves

This course is concerned with the application of formal logic to problems in Computer Science, and with techniques for mechanising logical reasoning. Topics may include: systems of reasoning; logic programming; the application of temporal and modal logics; and the relationship between proofs, programs, specifications and types.

Note: COMP 425 may not be available in 2014.

MATH 433 CRN 7674 **MODEL THEORY** **15 PTS** **1/3**

Coordinator: Dr Alex Usvyatsov

Prerequisite: MATH 309

Reading (recommended): David Marker: *Model Theory: An Introduction*
Leonid Libkin: *Elements of Finite Model Theory*

Model theory investigates connections between “theories” (collections of axioms) and “models” (mathematical objects satisfying these axioms). The course builds upon ideas first presented in MATH 309 in developing unified methods that can be applied to the study of objects from different areas in mathematics. It offers general tools for understanding the structure of models through the properties of theories, and vice versa. We will discuss some applications to algebra and analysis, and, upon request, theoretical computer science.

MATH 434 CRN 7675 **SET THEORY** **15 PTS** **2/3**

Prerequisite: MATH 309
Coordinator: Dr Adam Day
Reference: Kunen, *Set Theory: An Introduction to Independence Proofs*.

Set theory lies at the foundations of mathematics - all objects of mathematical interest can be construed as sets. Contemporary set theory explores some of the rich structure of the class of all sets, and the limitations of the theory. We will consider one small model of set theory as a base point. And we will consider the method of forcing - used to modify existing models and so obtain limitative results.

MATH 435 CRN 7676 **COMPUTABILITY AND COMPLEXITY** **15 PTS** **2/3**

Prerequisite: MATH 335
Coordinator: Prof Rod Downey
Reading (recommended): Carl Smith: *A Recursive Introduction to the Theory of Computation*, Garey and Johnson: *Computers and Intractability*, Hartley Rogers, Jr: *Theory of Recursive Functions and Effective Computability*, R.I. Soare: *Recursively Enumerable Sets and Degrees.*

This is a course about the algorithmic content of mathematics. That is, the part of mathematics that could be, theoretically at least, performed upon a machine.
It will build on the foundation of MATH 335, although it could be attempted by students with alternative suitable backgrounds. It is about the underlying mathematics of algorithms and hence the mathematical ideas behind the discipline of computer science. Structural complexity and computation are studied at a more advanced level. Some study of the theory of distributed systems may be included.

MATH 439 CRN 13578 **CATEGORY THEORY** **15 PTS** **1/3**

Prerequisite: MATH 311
Coordinator Prof Rob Goldblatt
Useful references: Goldblatt: *Topoi: the Categorial Analysis of Logic* (copies of relevant chapters will be provided in class);
Mac Lane: *Categories for the Working Mathematician*;
Barr & Wells: *Category Theory for Computing Science.*

Category theory studies the algebra of functions under the operation of composition, and develops the viewpoint that most mathematical objects can be defined by the way they connect to other objects in their external environment through functions, rather than by referring to their internal set-membership structure.

A category might be a single object, like a group, vector space or topology; or it might be the whole universe of entities representing an entire branch of mathematics, such as the category of all vector spaces, representing linear algebra. Categories occur everywhere. Their study reveals new mathematical concepts, and provides a powerful language that has become essential for describing many parts of mathematics, as well as playing an important role in the foundations of logic, computer science, theoretical physics, and other subjects.

SWEN 421 CRN 18661 **FORMAL SOFTWARE ENGINEERING** 15 PTS **1/3**

Prerequisites: SWEN 224, 30 300-level pts from (COMP, SWEN)
Restrictions: COMP 426
Coordinator: Dr David Streader

This course addresses the use of mathematical logic in the specification and construction for software systems. It presents an introduction to the area of formal methods; the formal specification of software systems; the refinement of specifications to code; and their semantic foundations.

SWEN 431 CRN 18669 **ADVANCED PROGRAMMING LANGUAGES** **15 PTS** **2/3**

Prerequisites: COMP 304, 15 further 300-level COMP or SWEN pts
Restrictions: COMP 432
Coordinator: A/Prof Lindsay Groves

This course develops and extends understanding of the functional programming paradigm, by studying both its theoretical foundations and the practical aspects of programming in a functional language.

PHIL 421 CRN 17224 **FORMAL LOGIC** **15 PTS** **1/3**

Prerequisite: Permission of the Head of School
Restriction: PHIL 402
Coordinator: Prof Ed Mares

This course covers advanced topics in formal logic. Topics covered will vary from year to year but in recent years the course has covered substructural logic, advanced topics in modal logic, and Gödel's theorems.

PHIL 422 CRN 17222 **PHILOSOPHICAL LOGIC** **15 PTS** **2/3**

Prerequisite: Permission of the Head of School
Restriction: PHIL 402
Coordinator: Prof Ed Mares

Topics covered will vary from year to year but may include vagueness, conditionals, the relationship between logic and natural language, and the philosophy of mathematics.
The course assessment will be based on two essays.

INDIVIDUAL STUDY, SPECIAL TOPICS, PROJECTS, AND OTHER COURSES

Directed Individual Study and Special Topic labels can be used to create courses tailored to the interests of individual students, or to introduce new topics that may be offered in a particular year. COMP, SWEN and MATH each have several labels that can be used for such purposes (COMP 440, 441; COMP 471-3; SWEN 438-9; MATH 440, 460, 480-483).

Projects may also be included, leading to the production of a written report that forms a readable and self-contained presentation of a single topic. A project may be undertaken as a full-year 30-point course (COMP 489 or MATH 489) or in the case of Mathematics as a 15-point one-trimester course (MATH 488).

Students interested in exploring a particular topic through Directed Individual Study, Project or Special Topic arrangements should discuss this with the Programme Coordinators.

Computer Science students may wish to combine courses from the Core List with other courses in such topics as programming languages, artificial intelligence, or theoretical computer science. Some may find courses in abstract algebra, and/or topology fit with their interests.

Mathematics students interested in Logic and Foundations may find courses in algebra, category theory, combinatorics and/or topology are also appropriate.

It should also be remembered that, with approval, up to half of the programme for Honours in any subject can consist of courses substituted from other postgraduate programmes.

GENERAL INFORMATION

Students are encouraged to view the websites for current information.

POSTGRADUATE RESEARCH SUPERVISION

Academic Board requires all supervisors to provide six-monthly written reports on students enrolled in Master's by thesis and PhD courses. These reports are expected to identify what has been achieved, outline agreed timetables for future work and identify any problems with a student's performance that require to be rectified. Copies of the formal written reports are provided to the student and the School's Postgraduate Coordinator, and put on file in the Faculty Student Administration Office.

Theses are prepared and written in close consultation with a staff member who acts as supervisor. Research students are expected to participate in and contribute to research-in-progress seminars organised from time to time by the School.

FUNDING

The Research Funding Guide is published by the University's Research Policy Office and is available on the University website at
www.victoria.ac.nz/home/publications/research_funding_guide.pdf
The Postgraduate Students' Association has information on StudyLink funding.
www.victoria.ac.nz/pgsa

POSTGRADUATE SCHOLARSHIPS, PRIZES AND GRANTS

Students should check out the University's Prizes and Scholarships database, accessible at:
www.victoria.ac.nz/scholarships
Faculty Research Grants and Summer Scholarships may also be available.
margot.neas@vuw.ac.nz: Contact Margot Neas for more information
www.victoria.ac.nz/science/study/summer-scholarships.aspx: Summer scholarships

POSTGRADUATE STUDENTS' ASSOCIATION

www.victoria.ac.nz/pgsa: Provides representation and other services for all Victoria's postgraduate students.
pgsa-members-subscribe@vuw.ac.nz: Subscribe to the PGSA email list

VICTORIA OVERSEAS EXCHANGE (VIC OE)

Students studying course-taught postgraduate studies are able to participate in an exchange, however not all of our partner universities are open to postgraduate students – please talk to the Student Exchange Office about which universities will be open to you.
www.victoria.ac.nz/exchange/

WHO TO CONTACT

Student Services provides a range of services to all students to help you make the most of your time at university. If you have an issue, need guidance to get through your studies, help is available.

www.victoria.ac.nz/home/viclife/studentservice/default.aspx

STUDENT AND ACADEMIC SERVICES - FACULTY OF SCIENCE

Te Wāhanga Pūtaiao

Address: Level 1, Cotton Building
Phone: 04-463 5101
Email: **science-faculty@vuw.ac.nz**
Web: **www.victoria.ac.nz/science**
Hours: 8.30 am – 5 pm Monday, Wednesday, Thursday, Friday
9.30 am – 5 pm Tuesday

At the Faculty of Science Student Administration Office **student advisers** can help with admission requirements, degree planning, changing courses, transfer of credit from other tertiary institutions, and anything else that may crop up during your time at Vic. They also deal with other aspects of student administration such as enrolment, exams organisation and the maintenance of student records.

Patricia Stein manages all postgraduate students:

patricia.stein@vuw.ac.nz 04-463 5982

Johan Barnard	Manager, Student and Academic Services	Tel: 04-463 5980
Shona de Sain	Associate Dean (Students & PG Research)	Tel: 04-463 5092

TE RŌPŪ ĀWHINA

Address: Cotton Building, Kelburn Parade, Room 148,
Phone: 04-463 5987
Email: **teropuawhina@gmail.com**
Web: **www.victoria.ac.nz/science/awhina**

Te Rōpū Āwhina whānau in the Faculties of Science, Engineering and Architecture and Design at Victoria University of Wellington was established in 1999. Āwhina is about people and collective success. The kaupapa of Āwhina is to produce Māori and Pacific science, engineering, architecture and design professionals to contribute to Māori and Pacific community and leadership development. Anyone who assists the building of Āwhina is part of the whānau.