THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Graduate Handbook – Mathematics

Computing & Mathematical Sciences

Rorohiko me ngā Pūtaiao Pāngarau

GO WITH THE FLOW

Kirk Spragg

GRADUATE	BCMS IN APPLIED MATHEMATICS
VOCATION	PHD STUDENT
LOCATION	GRENOBLE, FRANCE
CHALLENGE	DOCTORATE IN MAGNETOHYDRODYNAMICS

Levitating blobs of mercury and shape-changing liquid metals is part of Kirk Spragg's everyday life. No, he's not watching Terminator II, instead the Waikato PHD student is studying magnetohydrodynamics.

And if you think that's a mouthful in English, try saying it in French. Which is just what Kirk is doing when he works at the prestigious Madylam lab in France.

Mathematics has given Kirk the opportunity of a lifetime. Having finished a Bachelor of Computing & Mathematical Sciences with first class honours in Applied Mathematics at Waikato University, he decided to study Magnetohydrodynamics (MHD) for his Doctorate, looking at the motions of liquid metals and their interactions with magnetic fields.

His supervisor, Professor Alfred Sneyd, is an expert in the field of MHD and works with research groups across the globe. Impressed with Professor Sneyd's work, the University of Grenoble in France set up a student exchange programme, which has led to Kirk's eighteen-month study at Madylam.

Kirk is contributing some New Zealand ideas to the international research arena of MHD. "In the Mathematics Department here at Waikato we work very closely with our supervisors, meaning we are able to benefit from their knowledge while building on our own ideas. In turn, they do a lot of collaborative work with international researchers, so I know that my background is more than up to standard."

On his return, Kirk and Professor Sneyd plan to work with New Zealand's steel and aluminium industries. With their mathematical equations they hope to discover better ways of working with liquid metal – which could save millions of dollars in electricity costs.

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NZ'S LEADING COMPUTING & MATHEMATICS SCHOOL

INTRODUCTION

Mathematics today has a multitude of applications: car, aircraft, and ship design, cryptography, error-correcting codes, climate modelling and weather forecasting, improving the efficiency of industrial processes, power scheduling and energy modelling, financial and market prediction, and astrophysics, to name just a few. But mathematics also has interest for its own sake, because of the depth and beauty of the problems. High-profile pure mathematics problems solved in recent years include the Four Colour Problem, Fermat's Last Theorem, and the Poincaré Conjecture.

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

This handbook explains the various graduate degrees and 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 XP Professional. Software includes: Maple, Mathematica, Matlab, Fortran 90, Java, and the NAG scientific subroutine library. Internet services are provided.

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

KEVIN BROUGHAN, GRADUATE ADVISOR

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PROFESSORS

Ian Craig

BSc(Hons) PhD *Lond*

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Astrophysical plasmas; magnetohydrodynamics and radiation theory; inverse problems and remote sensing; magnetic reconnection in superconducting plasmas.

Ernie Kalnins

BSc(Hons) *Cant* MSc PhD *W Ont* FRSNZ

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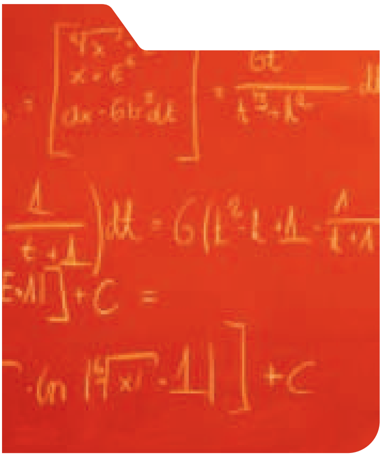
Special functions; quantum groups; general relativity.

Alfred Sneyd

BA BSc MSc *Auck* PhD *Camb*

Email sneyd@math.waikato.ac.nz

Fluid mechanics; astrophysical and industrial magnetohydrodynamics.



ASSOCIATE PROFESSORS

Kevin Broughan

BSc MSc *Auck* MA PhD *Col* MACM MIPENZ FNZMS

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Analytic and algebraic number theory; mathematical software; symbolic computation; dynamical systems.

Stephen Joe

BSc(Hons) MSc *Massey* PhD NSW

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Lattice methods for multiple integration; numerical multiple integration.

Sean Oughton

BSc(Hons) *Well* PhD *Del*

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Turbulence and nonlinear dynamics in conducting fluids and space physics.

SENIOR LECTURERS

Ian Hawthorn

BSc(Hons) MSc *Auck* PhD *Minn*

Email hawthorn@math.waikato.ac.nz

Group theory; classes of finite groups; symmetry.

Tim Stokes

BSc(Hons) PhD *Tas*

Email stokes@math.waikato.ac.nz

Algebraic representations of partial maps; radical theory for general algebras; free surface problems in fluid mechanics.

HONORARY FELLOW

John Turner

MSc *Leeds* DPhil *Waikato*

HONORARY RESEARCH ASSOCIATE

A. Ross Barnett

MSc *Well* DPhil *Oxf*

RESEARCH DIRECTIONS AND SAMPLE PUBLICATIONS

The list below 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. For details consult the Graduate Advisor.

ASSOCIATE PROFESSOR KEVIN BROUGHAN

ELEMENTARY NUMBER THEORY

The recent 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 Golfeld and others) where one of the many unsolved problems might be attacked. The Waikato work has a strong computational flavour.

SAMPLE PUBLICATIONS

Broughan, K.A. (2006) "Relaxations of the ABC conjecture using integer k'th roots" *NZ Journal of Mathematics* 35, 121-136.

Broughan, K.A. and Casey, R.J. (2005) "Harmonic sets and the harmonic prime number theorem" *Bulletin of the Australian Mathematical Society* 71, 127-137.

Broughan, K.A. and Barnett, A.R. (2004) "The holomorphic flow of the Riemann zeta function" *Mathematics of Computation* 73, 987-1004.

Broughan, K.A. (2003) "Holomorphic flows on simply connected regions have no limit cycles" *Meccanica* 38, 699-709.

Broughan, K.A. (2003) "Adic topologies for the rational integers" *Canadian Journal of Mathematics* 55, 711-723.

Broughan, K.A. (2003) "Characterizing the sum of two cubes" *Journal of Integer Sequences* 6, 1-7.

Broughan, K.A. (2002) "The gcd-sum function" *Journal of Integer Sequences* 4, 1-19.

PROFESSOR IAN CRAIG

ASTROPHYSICS

The containment of hot plasmas by strong cosmic fields is not well understood. Research topics include the structure and stability of magnetic fields in the solar corona.

MAGNETIC FIELD LINE RECONNECTION

A problem of great interest in astrophysics is magnetic reconnection. The central idea is to release magnetic energy bound up in the topology of solar and stellar plasmas. Although it is known that reconnection is the only mechanism which allows topological change in the magnetised plasma, the real challenge for astrophysicists is to demonstrate a mechanism that can explain the explosive release of a solar or stellar flare.

SAMPLE PUBLICATIONS

Fruit, G. and Craig, I.J.D. (2006) "Visco-resistive shear wave dissipation in magnetic X-points" *Astronomy and Astrophysics* 448, 753-761.

Fruit, G. and Craig, I.J.D. (2006) Rapid dissipation in a current sheet driven by footpoints motions *Astronomy and Astrophysics* 458, 307-315.

Pontin, D.I. and Craig, I.J.D. (2006) "Dynamic three dimensional reconnection in a separator geometry with two null points" *Astrophys. Jnl* 642, 568-578.

RESEARCH DIRECTIONS AND SAMPLE PUBLICATIONS

Senanayake, T. and Craig, I.J.D. (2006) "Hall current reconnection in planar magnetic X-points" *Astronomy and Astrophysics* 451, 1117-1124.

Wheatland, M.S. and Craig, I.J.D. (2006) "Including flare sympathy in a model for solar flare statistics" *Solar Physics* 238, 73-86.

Craig, I.J.D. and Fruit, G. (2005) "Wave energy dissipation by phase mixing in magnetic coronal plasmas" *Astronomy & Astrophysics* 440, 357-366.

Craig, I.J.D. and Litvinenko, Y.E. (2005) "Current singularities in planar magnetic X-points of finite compressibility" *Physics of Plasmas* 12, 032301-1 -031301-10.

Craig, I.J.D. and Sneyd, A.D. (2005) "The Parker problem and the theory of Coronal heating" *Solar Phys.* 232, 41-62.

Craig, I.J.D. and Watson, P.G. (2005) "Exact models of Hall current reconnection with axial guide fields" *Physics of Plasmas* 12, 012306-1 -012306-11.

Craig, I.J.D., Litvinenko, Y.E. and Senanayake, T. (2005) "Viscous effects in planar magnetic X-point reconnection" *Astronomy & Astrophysics* 433, 1139-1143.

Pontin, D.I. and Craig, I.J.D. (2005) "Current singularities at finitely compressible three dimensional magnetic null points" *Physics of Plasmas* 12, 072112-1 -072112-12.

RESEARCH DIRECTIONS AND SAMPLE PUBLICATIONS

DR IAN HAWTHORN

GENERALISED SYLOW THEOREMS

Sylow's theorem is one of the most useful tools in a group theorist's toolkit. It has now been generalised in a multitude of ways. The problem today is one of classifying the different generalisations and seeking a better understanding of the underlying principles that give rise to various categories of generalised Sylow theorems.

SOLVABLE GROUP THEORY

The composition series structure within a solvable group equips the group with a kind of a 'scaffold'. This allows us to employ inductive arguments. Hence solvable group theory has quite a distinct flavour from the more difficult theory of finite groups in general. I have particular interest in the area of Fitting classes of solvable groups where there are a number of unsolved problems of current interest.

OTHER TOPICS

I also have interests in group theory in general. In particular I am interested in symmetry groups, Coxeter groups and Lie groups of relevance to theoretical physics. Research projects at a less advanced level are possible in these areas.

SAMPLE PUBLICATIONS

Hawthorn, I.J. (1997) "More generalised Sylow Theorems" *J Austral. Math. Soc. (Series A)* 62, 84-92.

Hawthorn, I.J. (1998) "The Existence and Uniqueness of Injectors for Fitting Sets of Solvable Groups" *Proc. Amer. Math. Soc.* 126, 2229-2230.

RESEARCH DIRECTIONS AND SAMPLE PUBLICATIONS

ASSOCIATE PROFESSOR STEPHEN JOE

LATTICE RULES

Lattice rules are used for the numerical integration of multiple integrals in hundreds or even thousands of variables. There has been much recent work on lattice rules and one of the main results is that the generating vectors for these lattice rules may be constructed by using a component-by-component algorithm.

There is now a need to do numerical testing of these lattice rules to see how they perform. Besides standard test problems, these lattice rules could be tested out on integrals arising from practical situations such as those from financial models.

Lattice rules are usually constructed for integrands over the unit cube. However, there are some applications in which one wants to approximate integrals where the integration region is all of Euclidean space. A question that arises is whether to use lattice rules for the unit cube and then do some mapping to Euclidean space or whether to use lattice rules designed for Euclidean space in the first place.

Of course, there are many other unanswered questions on lattice rules (such as those to do with their structure) and these are worthy of exploration as well.

SAMPLE PUBLICATIONS

Sinescu, V. and Joe, S. (2007) "Good lattice rules based on the general weighted star discrepancy" *Math. Comp.* 76, 989-1004.

Joe, S (2006) "Construction of good rank-1 lattice rules based on the weighted star discrepancy" in *Monte Carlo and Quasi-Monte Carlo Methods 2004* (H. Niederreiter and D. Talay, eds.), Springer Verlag (2006), 181-196.

RESEARCH DIRECTIONS AND SAMPLE PUBLICATIONS

PROFESSOR ERNIE KALNINS

PERTURBATIONS AND STABILITY IN GENERAL RELATIVITY

I am interested in the theory of perturbations in the vicinity of compact astrophysical objects such as black holes, and the stability of such structures with respect to such perturbations. In addition to these studies the solution of Einstein's equations for bounded rotating masses is being actively pursued. In particular, the gravitational field in the vicinity of such configurations both classically and relativistically is under study. Affiliated to these ideas is the study of atoms in high magnetic fields and the relation to quantum chaos. These are important quantum mechanical problems to be solved here in an astrophysical sense.

QUANTUM GROUPS AND SPECIAL FUNCTIONS

Another interest is the study of quantum groups and quadratic algebras. This study is of actual quantum mechanical and classical mechanical systems which admit explicit solution and have definite algebraic properties. Also associated with this study are the properties of the special functions that arise in the solution of these problems and the consequences for the corresponding algebra. Of particular interest are generalisations of ellipsoidal harmonics in the case of quantum algebras.

SAMPLE PUBLICATIONS

Kalnins, E.G. Kress, J.R. and Miller, W. Jr. (2005) "Jacobi Ellipsoidal coordinates and superintegrable systems" *J. Nonlinear Math. Phys.* 12, 209-229.

Kalnins, E.G. Thomova, Z. and Winternitz, P. (2005) "Subgroup type coordinates and the separation of variables in Hamilton-Jacobi and Schrodinger equations" *J. Nonlinear Math. Phys.* 12, 178-208.

Kalnins, E.G. and Kress, J.R. (2005) "Second order superintegrable systems in conformally flat spaces. 1. 2D classical structure theory" *J. Math. Phys.* 46, 053509.

Kalnins, E.G. and Kress, J.R. (2005) "Second order superintegrable systems in conformally flat spaces. 2. The classical 2D Stackel transform" *J. Math. Phys.* 46, 053510.

Kalnins, E.G. and Kress, J.R. (2005) "Second order superintegrable systems in conformally flat spaces.3. 3D classical structure theory" *J. Math. Phys.* 46, 103507.

Kalnins, E.G. and Miller, W. Jr (2005) "Jacobi elliptic coordinates, functions of Heun and Lamé type and the Niven transform" *Regular and Chaotic Dynamics,* 10, 487-508.

Kalnins, E.G. Pogosyan, G.S. Vicent, L.E. and Wolf, K.B. (2005) "Superintegrability: A Survey" *XXV International Colloquium on Group theoretical Methods in Physics.*

ASSOCIATE PROFESSOR SEAN OUGHTON

My current research interests centre on understanding the behaviour of turbulent flows. Physically we all have a good understanding of what a turbulent flow is. For example, white water rapids are clearly turbulent, whereas a (stationary) jar of honey is not. In fact, on the earth most flows, at most times, are turbulent. Mathematically, one might say that a turbulent flow is characterized by motions which occur over a broad range of length (and time) scales and that these motions interact nonlinearly. It is this nonlinear nature of the problem that makes it simultaneously so rich and so challenging.

A particular interest is magnetofluid turbulence, where the fluid is electrically conducting so that one must consider not just the behaviour of the fluid's velocity, but also that of its magnetic field. Examples of magnetofluids include liquid metals (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.

SAMPLE PUBLICATIONS

Oughton, S., Matthaeus, W.H. and Dmitruk, P. (2006) "A two-component phenomenology for homogeneous magnetohydrodynamic turbulence" *Phys. Plasmas* 13, 042306.

Breech, B. Matthaeus, W.H. Minne, J. Oughton, S. Parhi, S. Bieber, J.W. and Bavassano, B. (2005) "Radial evolution of cross helicity at low and high latitudes in the solar wind" *Connecting Sun and Heliosphere* Vol. ESA SP-592 p. 597-600. ESA. Noordwijk, The Netherlands.

Dmitruk, P. Matthaeus, W.H. and Oughton, S. (2005) "Direct comparisons of compressible magnetohydrodynamics and reduced magnetohydrodynamics turbulence" *Phys. Plasmas* 12, 112304.

Horbury, T. Forman, M.A. and Oughton, S. (2005) "Spacecraft observations of solar wind turbulence: An overview" *Plasma Phys. Controlled Fusion* 47, B703-B717.

Oughton, S. Dmitruk, P. and Matthaeus, W.H. (2005) "A two-component phenomenology for the evolution of MHD turbulence" *Connecting Sun and Heliosphere* Vol. SP-592 p. 633-636. ESA. Noordwijk, The Netherlands.

Oughton, S. and Matthaeus, W.H. (2005) "Parallel and perpendicular cascades in solar wind turbulence" *Non-Linear Processes in Geophysics* 12, 299-310.

RESEARCH DIRECTIONS AND SAMPLE PUBLICATIONS

Verdi, A. Velli, M. and Oughton, S. (2005) "Propagation and dissipation of Alfvén waves in stellar atmospheres permeated by isothermal winds" *Astron. Astophys.* 444, 233-244.

Verdini, A. Velli, M. and Oughton, S. (2005) "Nonlinear evolution of Alfvén waves in the solar atmosphere". *Connecting Sun and Heliosphere* Vol. SP-592 p. 567-570. ESA. Noordwijk, The Netherlands.

PROFESSOR ALFRED SNEYD

SOLAR MAGNETIC FIELDS

Solar flares occur when energy in the strong magnetic fields in the solar corona is suddenly released as a burst of radiation. The aim of the work is to understand how the energy is released, by analysing simplified mathematical models, and by carrying out more detailed numerical simulations.

INDUSTRIAL MAGNETOHYDRODYNAMICS (MHD)

Magnetic fields are important in modern liquid-metal technology. For example, the strong electric currents in the cells (or pots) in which aluminium is manufactured, can create havoc by stirring the liquid aluminium too strongly. Mathematics is used to model the flow and improve cell design. Alternating magnetic fields are used to stir steel during continuous casting, and even to levitate lumps of liquid metal. Mathematical modelling is essential in understanding these processes.

COASTAL MODELLING

Man-made changes in harbours or estuaries, for example, may have unexpected effects. Mathematical modelling of tidal flow and sediment transport can be used to predict such effects, and plays an increasing role in coastal engineering. Mathematics is also used to help understand tsunamis, breaking surf, and coastal currents.

FLUID MECHANICS

For a Masters degree there are many suitable topics in wave motion, boundary layer analysis, or aerodynamics of sails.

SAMPLE PUBLICATIONS

Craig, I.J.D. and Sneyd, A.D. (2005) "The Parker problem and the theory of Coronal heating" *Solar Phys.* 232, 41-62.

Fautrelle, Y. and Sneyd, A.D. (2004) "Surface waves created by low-frequency magnetic fields" *J. Fluid Mech.* 24, 91-112.

DR TIMOTHY STOKES

ALGEBRA OF PARTIAL MAPS

An important topic in algebra is to abstractly represent certain concrete kinds of structure. For example, a well-known fact from group theory is that every group can be represented as a group of permutations of a set, and conversely, every collection of permutations closed under composition and inverse is a group. One of my main research interests is to generalise this correspondence to other situations. There are connections with the theory of relation algebras, of importance in Computer Science.

RADICAL THEORY

The Jacobson radical of ring theory is the key to unlocking much information about the structure of rings (algebraic objects generating the familiar number systems, which include polynomials and matrices as examples). I am interested in the generalisation of these ideas to other kinds of algebraic systems.

FREE SURFACE PROBLEMS

A very basic problem in the theory of ideal fluids is the behaviour of a free surface in response to the withdrawal of fluid through a submerged sink. The steady state case has received much attention in past decades, although recently a lot of work has been done in the unsteady case with the flow initiated from a quiescent situation. I am interested in this problem in two and three dimensions, for both finite and infinite depth situations.

SAMPLE PUBLICATIONS

Jackson, M. and Stokes, T. (2006) "Identities in the Algebra of Partial Maps" *Int. J. Algebra and Computation* 16, 1131-1159.

McConnell, N.R. and Stokes, T. (2006) "Radicals of 0-regular algebras" *Acta Math. Hungar.* 113, 19-37.

Stokes, T. (2006) "On EQ-monoids" *Acta Sci. Math. (Szeged)* 72, 481-506.

Stokes, T. Hocking, G.C. and L.K. Forbes (2005) "Unsteady flow induced by a withdrawal point beneath a free surface" *ANZIAM Journal* 46, 185-202.

PAPERS

The Department offers a wide variety of papers in pure and applied mathematics. Papers at the graduate level include lectures and assignments, and may also include practical work, special readings and projects. The papers offered each year vary according to staff availability and student interest. For details of papers offered in the current year, please consult the School of Computing & Mathematical Sciences Undergraduate Handbook, where the 500 Level papers are described in detail.

A complete list of papers is available from the web page
http://papers.waikato.ac.nz/subjects/math

MATH501 Metric Spaces

15 Points

Axioms of a metric space, open and closed sets, cluster points etc. Completeness, continuity, connectedness and compactness in metric spaces (including sequential compactness, Heine-Borel, and Bolzano-Weierstrass property). Construction of Cantor sets. Contraction mapping and Baire Category Theorems and applications. Further topics may include Banach spaces.

MATH505 Topics In Analysis And Topology

15 Points

A selection of topics in analysis and topology including some of: general topology, linear functional analysis (Banach and Hilbert spaces), algebraic topology (classification of surfaces), knot theory, complex analysis (Riemann surfaces).

MATH509 Topics In Number Theory

15 Points

Topics in advanced analytic number theory chosen from: arithmetic functions and their averages, Dirichlet's divisor sum problem, Chebychev's prime number theorem, the prime number theorem, Dirichlet's theorem on primes in an arithmetic progression, the ABC and H conjectures, elliptic curves, cryptography and partitions.

MATH511 Advanced Algebra

15 Points

Following the study of group theory at the undergraduate level, this paper considers a number of other important algebraic structures, including semigroups, rings and lattices. Like groups, these structures arise in a range of different settings as diverse as computer science, physics and logic, as well as throughout modern mathematics.

MATH512 Continuous Groups

15 Points

An introduction to the study of Lie groups and Lie algebras starting with matrix groups. Continuous groups involve symmetries like rotations that can be performed gradually. These types of symmetries are particularly important in mathematical physics.

PAPERS

MATH533 Relativity

30 Points

The first half of this paper provides an introduction to the methods and theory of special relativity. Topics include the relationship with Newtonian physics, Galilean and Lorentz invariance, Einstein kinematics, invariance of the speed of light, four-vectors, Minkowski space-time and the equivalence principle. The second half covers the theory of gravitational fields and cosmology using the methods of general relativity. Topics include curved space time, geodesics, the classical tests and verification of general relativity, and recent experimental confirmation.

MATH534 Classical And Quantum Mechanics

30 Points

One half of this paper deals with the theory of classical mechanics from a variational point of view including: the central force problem, rigid body kinematics, Hamilton's equations of motion, canonical transformations, Hamilton-Jacobi theory and the Lagrange formulation for continuous systems and fields. The other half deals with the fundamentals of quantum mechanics and quantisation for elementary systems including: vector representations of states, spin, observables having continuous spectra, time variation of states, angular momentum, perturbation methods, Dirac's relativistic equation for the electron.

MATH536 Fluid Mechanics

30 Points

This paper develops mathematical methods used to describe the mechanics of continuous materials, such as rubber, water or air, and applies them to problems in elasticity and fluid mechanics. The syllabus includes: index notation for Cartesian tensors; the stress tensor; strain and rate of strain tensors; equations for conservation of mass, momentum, angular momentum, and energy; equations of linear elasticity, solution of problems in elasticity such as stretching or bending of beams, spherical pressure vessel, twisting of shafts, elastic waves. Hydrostatics, isothermal and adiabatic atmospheres; equations of fluid mechanics, solutions for viscous flow in pipes and straight channels, vorticity, Kelvin's circulation theorem, potential flow; and water waves. A selection of more advanced topics in fluid mechanics will also be considered.

MATH537 Partial Differential Equations

30 Points

This paper will consider topics in the theory of partial differential equations which may include the following: classification of equations; Green's and Neumann's functions for elliptic equations; characteristics for hyperbolic equations and the Riemann function; characteristic methods for nonlinear first-order equations; the Burgers equation; the Korteweg de Vries equation; the Sine Gordon equation and inverse scattering theory; asymptotic methods; perturbation methods; generalised functions; group-theoretic methods; numerical methods.

Other possible papers could cover: finite groups, dynamical systems, integration, magnetohydrodynamics, and functional analysis.

GRADUATE THESES

THESES IN PROGRESS*

PHD STUDENTS	
T. Senanayake	*Solar Magnetohydrodynamics*
V. Sinescu	*Construction and testing of lattice rules for multiple integration*
K. Spragg	*Applications of Industrial Magnetohydrodynamics*
Q. Zhou	*Multiperfect numbers of low abundancy*

*Theses in progress at the time this document went to print, June 2007

RECENT PHD THESES (SINCE 2001)

F. Ali	*Current Sheet Formation in Uniformly Twisted Magnetic Flux Tubes*
D. Harder	*Geodesic Geometry of Some Static Axisymmetric Vacuum Spacetimes*
J. Heerikhuisen	*Coronal Magnetic Energy Release by Current Sheet Reconnection*
F. Kuo	*Constructive Approaches to Quasi-Monte Carlo Methods for Multiple Integration*
M. Saad	*Electromagnetic Stirring using a Travelling Magnetic Wave*
G. Slezakova	*Geodesic Geometry of Black Holes*
S. Somasundaram	*Almost Weak Asplund Spaces*

RECENT MASTERS THESES/DISSERTATIONS (SINCE 2001)

Y. Chau	*Magnetohydrodynamic Driven Flows in Thin Layers*
M. Domijan	*Dynamical Probing of Mechanisms Underlying Calcium Oscillations*
M. Kaufusi	*Infinity of Prime Numbers in an Arithmetical Progression*
Y. Lin	*The Weighted L2 Discrepancy for Sobol Sequences*
I. MacDonald	*Edge-waves on Beaches of Arbitrary Profile*
T. Senanayake	*Equilibrium Solutions of the Restricted Three-Body Problem*
J. Theobald	*A Survey of Numerical Methods for Solving Systems of Nonlinear Equations*
L. Zhou	*Optimal Portfolio Selection: A Study of the Hong Kong Stock Market*
Q. Zhou	*Two Arithmetic Functions and Their Applications*

The information contained in this handbook is correct at the time of printing (July 2007). However, it is subject to a continuous process of review and improvement. A new handbook is produced in June/July every year and students should use the latest handbook available. The University's document of authority for information contained in this handbook is the 2008 University Calendar.

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

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