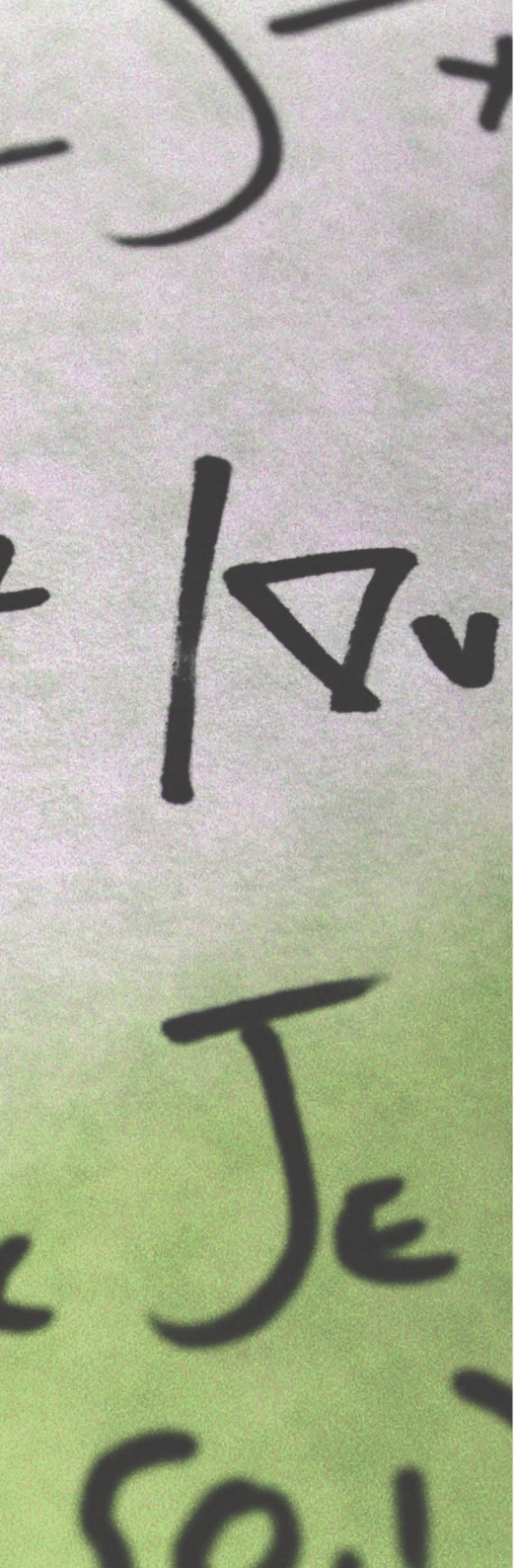
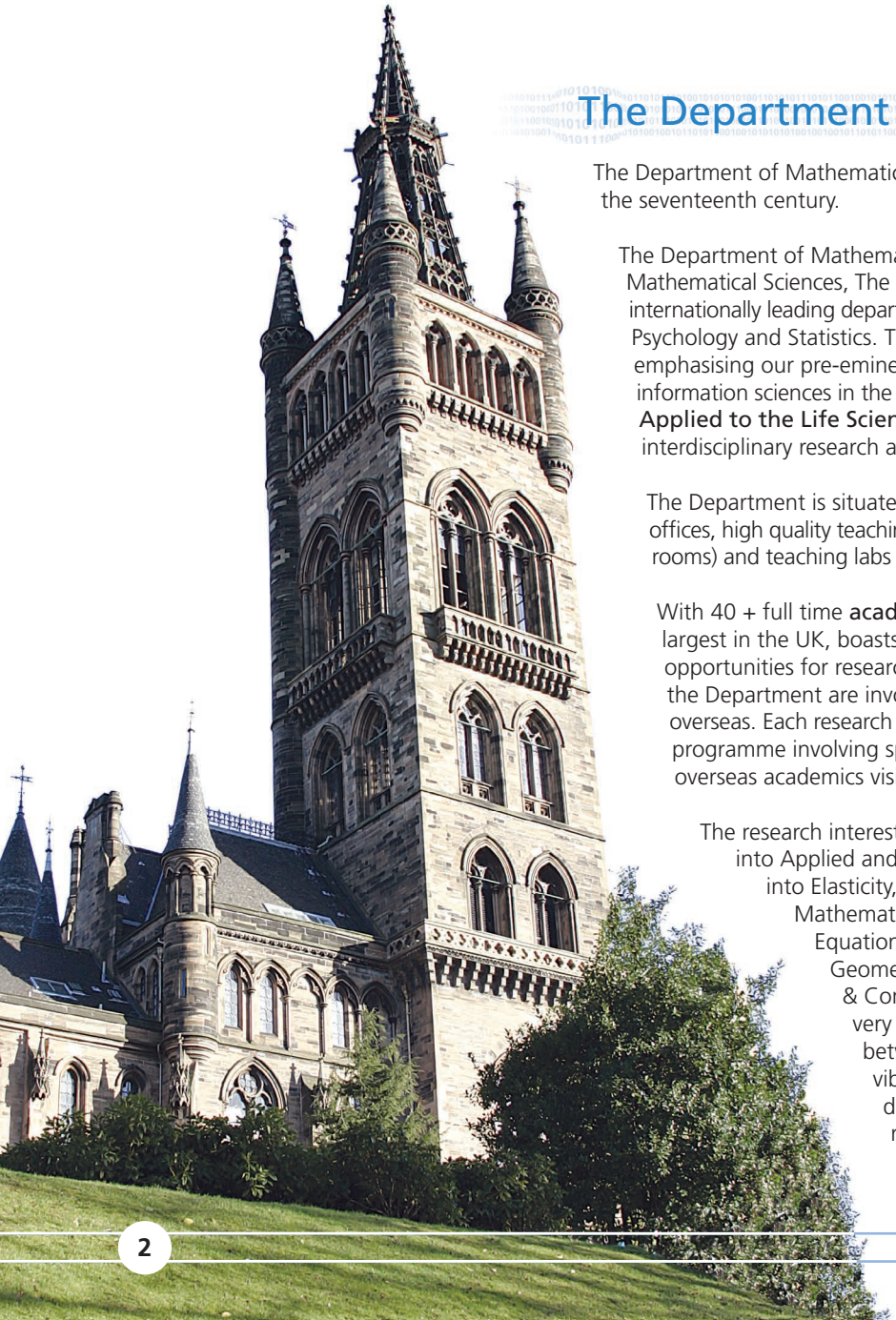


Introduction

The purpose of this booklet is to provide information for those interested in pursuing postgraduate research in mathematics in the University of Glasgow. This booklet should be used in conjunction with the University of Glasgow Postgraduate Prospectus which contains further information as well as the application and referee forms.

This booklet is designed to provide prospective students with more detailed information about our Department, specifically Research Interests and the Academic Staff working within each research field.



The Department

The Department of Mathematics has existed at the University of Glasgow since the seventeenth century.

The Department of Mathematics is within the Faculty of Information and Mathematical Sciences, The Faculty brings together staff and students in four internationally leading departments, namely, Computing Science, Mathematics, Psychology and Statistics. The Faculty hosts three major research centres emphasising our pre-eminence in the application of mathematical and information sciences in the bio-medical area. The **Centre for Mathematics Applied to the Life Sciences** has recently been established to promote interdisciplinary research and scholarship in Mathematical Biology.

The Department is situated in University Gardens in which houses staff offices, high quality teaching spaces (eight lecture theatres and two seminar rooms) and teaching labs with networked multi-media computing facilities.

With 40 + full time **academic staff**, the Department is one of the largest in the UK, boasts world-class groups in several areas, and offers opportunities for research in a number of different topics. Members of the Department are involved in many collaborations with researchers overseas. Each research area within the Department has a lively seminar programme involving speakers from throughout the UK (including overseas academics visiting the UK) as well as from the Department.

The research interests of the Department can roughly be divided into Applied and Pure Mathematics and respectively subdivided into Elasticity, Fluid Dynamics & Magnetohydrodynamics, Mathematical Biology and Nonlinear Differential Equations (Applied). Algebra, Analysis, Category Theory, Geometry & Algebraic Topology and Number Theory & Combinatorics (Pure). Such a division is of course very crude and ignores many important intersections between the different areas. These give an added vibrancy to the research activity in this large department. It is internationally leading for research in Pure and Applied Mathematics and received the top ranking "five" grade in the last Research Assessment Exercise for both areas.

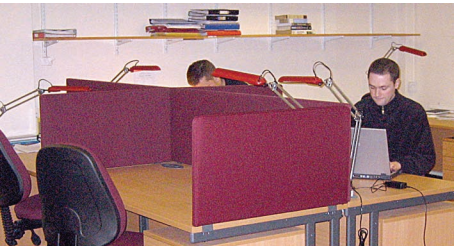
The Glasgow Mathematical Journal
Since 1951 the *Glasgow Mathematical Journal* has been edited by members of the Department, and, partly because of exchange arrangements with the *Glasgow Mathematical Journal* the Department and University Libraries are exceptionally well stocked with mathematics journals and periodicals. The *Journal* has a wide international circulation, and is published by Cambridge University Press.

The Glasgow Mathematical Association
This association is open to all interested in Mathematics and Mathematics Education. It is affiliated to the Mathematical Association. Talks covering a wide range of subjects are held each year.

Postgraduate Study

The Department of Mathematics invites applications from well-qualified students to carry out research leading to a PhD or MSc in Pure or Applied Mathematics.

The Department has shown strong growth in its number of PhD students in recent years. Currently there are over 30, with further growth planned. A very high proportion of our PhD students complete their thesis within, or close to, three years. In a recent University survey of postgraduate students, the Mathematics Department came top, with a satisfaction rating of 96%.



Our newly refurbished department provides comfortable working conditions for your studies. Additionally, if you need a further inducement to study Mathematics here in Glasgow, we issue all PhD students with a new laptop computer, in addition to the high performance computer facilities available in the department.

The Department is committed to the development of high-quality research, and its staff have established reputations in their areas of specialization. Students are encouraged to take part in national and international conferences. The department provides some funding to enable research students to attend international conferences, as well as seminars elsewhere in the UK.

Visit
Your decision on where (or whether) to undertake postgraduate study should be based on the best possible information. This is best achieved by a visit to the Department. This gives you the opportunity to talk to potential supervisors and discuss possible research projects, as well as to see the University and the City of Glasgow. We do not conduct formal interviews, instead we arrange a sequence of informal meetings with individual members of the research staff whose work is in, or related to, your area(s) of interest.

We also arrange for you to talk informally to some of our present research students who can give you the ``customer'' view of the Department and tell you about life as a postgraduate student. The Department will normally be prepared to pay reasonable travel and accommodation expenses within the UK. We shall contact you at an appropriate time to arrange a visit.

Clearly a visit is usually only possible for UK residents (but we will of course welcome all who wish to visit). For overseas students, for whom a visit to the Department is not possible, discussions concerning potential supervisors, areas of research, academic life at Glasgow etc. are carried out by email, fax, and if appropriate, telephone.

Supervision, Support & Training
Each postgraduate student is allocated a supervisor and 2nd supervisor (or in some cases, joint supervisors) who is (are) responsible for giving guidance on the nature of research, the standard expected, and the planning of the research programme. The supervisor(s) will maintain contact with the student through regular (typically weekly) meetings, but will also be available for consultation at other times as the need arises.

The Faculty of Information and Mathematical Sciences Graduate School organises a compulsory training course in generic skills (library, tutoring and demonstrating, intellectual property, presentation, first aid etc.) for new postgraduate students. Other training is provided by the Edinburgh Mathematical Society at the International Centre for Mathematical Studies.

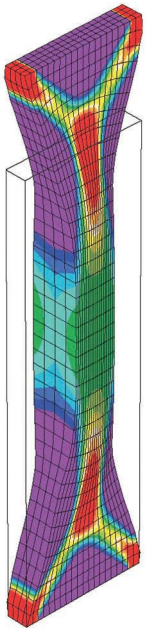
Each research area within the Department has a lively seminar programme involving speakers from throughout the UK (including overseas academics visiting the UK) as well as from the Department. Several research groups also have informal meetings to discuss research in progress and recent developments in their field. Postgraduate students are expected to attend the research seminar(s) relevant to their areas of study. Also, all postgraduate students are required to attend and contribute to the Postgraduate Seminar programme and to give at least one seminar each year. This gives a good opportunity to develop skills in the presentation of material to an audience, building confidence for when this has to be done, for example, at an international conference. Written feedback is provided by members of the audience.

To ensure that students are making satisfactory progress, there is a formal process of monitoring. Postgraduate reviews take place in May of each year. Each postgraduate student is required to prepare a short summary of their work to date. This is looked at by an independent member of the Department with relevant research interests who then has a short informal discussion with the student about his/her work. Between formal reviews, the Directors of Postgraduate Studies are available for students to consult should they have any concerns they feel unable to discuss with their supervisor. Items of general interest to all postgraduate students are dealt with by the Postgraduate Staff Student Committee.

Timing
Most postgraduate students start at the beginning of October, although it is possible to start at any time. You should begin the application process as early as possible to allow time for referee reports to be received and a suitable supervisor(s) to be found. UK and EU students applying to the Department for EPSRC support should bear in mind that an early application is advisable. Overseas students wishing to apply for Scholarships should apply by 31st December in the year prior to entry.

Research Interests

Applied Mathematics



Elasticity
Elasticity theory forms the central core of the subject of solid mechanics, which is a broad fundamental science having applications in a diversity of other areas - for example, engineering structural mechanics, materials science (modelling the mechanical properties of solids such as rubber), geophysics (interpretation of seismic data using elastic wave analysis), non-destructive evaluation of the integrity of materials using elastic waves, modelling the mechanical properties of soft tissue such as arteries so as to understand their mechanical performance and changes with age and disease.

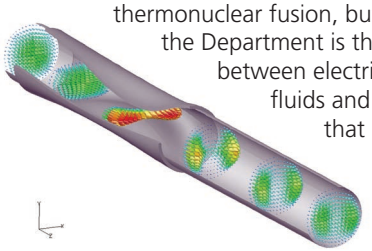
The underlying mathematical theory of elasticity provides a rich framework for the study of such applications and also offers many interesting and challenging mathematical questions in its own right relating to, for example, the governing partial differential equations and the qualitative properties of their solutions.

In the Department of Mathematics there is research in progress on fundamental aspects of the theory of nonlinear elasticity, thermoelasticity and inelasticity, and applications of the theory to, for example, the mechanics of rubberlike solids, the solution of boundary-value problems relevant to vibration isolator structures incorporating rubber components, modelling the mechanical properties of soft biological tissues, damage mechanics, the mechanics of thin-film surface-coated solids and the analysis of waves propagating in pre-stressed materials, membrane theory and bifurcation and stability problems. In addition, there is involvement in the development of computational methods for the solution of boundary-value problems arising in these applications.

Academic staff in the Elasticity group
Dr Ciprian Coman, Dr David Haughton, Dr Kenneth Lindsay, Dr. Xiao Yu Luo, Professor Ray Ogden.

Fluid Dynamics & Magnetohydrodynamics

This the study of the motion of fluids (both liquids and gases) and has a wide range of applications. Examples include: the design of aircraft, weather forecasting, the extraction of oil from porous reservoirs, control of many industrial processes and the understanding of the structure of stars and planets. In many situations, the fluid is controlled by some parameter (such as the Reynolds number) and its behaviour changes as this parameter is increased; mathematically, the solution proceeds through various bifurcations. This is the realm of hydrodynamic stability theory and is a common thread too much of the fluids research in the Department, with applications in such diverse areas as convection in the core of the Earth and the growth of pure crystals for the semiconductor industry. The addition of a magnetic field gives the subject of magnetohydrodynamics or MHD for short. It has applications in industrial processes and controlled thermonuclear fusion, but the main emphasis in the Department is the complex interaction between electrically conducting fluids and magnetic fields that is responsible for the generation of planetary and stellar magnetic fields.

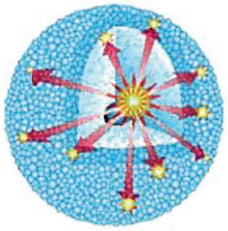


The flow in a thick walled collapsible tube

The work of the MHD group within the Department is primarily motivated by the problem of magnetic field generation in planetary interiors.

Academic staff in Fluid Dynamics & MHD group
Dr Martin Bees, Professor David Fearn, Dr Nicholas Hill, Dr Kenneth Lindsay, Dr Xiao Yu Lu.
A new member of staff to be appointed 06/07.

Mathematical Biology

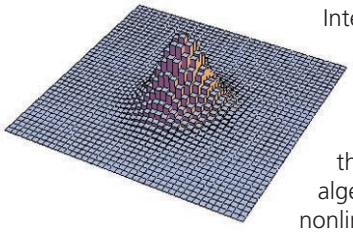


Mathematical Biology is the application of mathematical modelling to solve problems in biology and physiology. It is one of the fastest growing research areas in mathematics and is contributing significantly to our understanding of the biological world and the processes in disease. It also produces new mathematical questions.

A new **Centre for Mathematics Applied to the Life Sciences** has recently been established to promote interdisciplinary research and scholarship in Mathematical Biology. It is a joint centre of the Universities of Glasgow and Strathclyde, under the Synergy agreement.

Academic Staff in the Mathematical Biology group
Dr Martin Bees, Dr Christina Cobbold, Professor Nick Hill, Dr Kenneth Lindsay, Dr Xiao-Yu Luo and Professor Ray Ogden.

Nonlinear Differential Equations



Integrable Systems draws its inspiration from many fields from traditional applied mathematics and mathematical physics through to geometry and algebra. The group studies nonlinear systems of differential equations with the property of being "integrable" or exactly solvable. Specific research interests include:

- bilinear methods and exact solutions;
- Darboux transformations and integrable discrete systems;
- Hamiltonian systems, Lie symmetry theory;
- algebraic and geometric aspects;
- integrable systems relating to Frobenius manifolds and systems of hydrodynamic type.

They interface with the other research groups in the department, particularly the Geometry and Algebra groups.

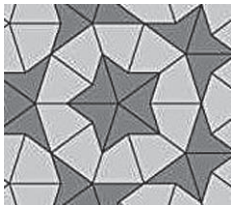
This group organise a regular conference series under the acronym ISLAND see: http://www.maths.gla.ac.uk/island/ for more information.

Their website http://www.maths.gla.ac.uk/research/groups/nldes/#students provides more detailed information on the above topics. In addition it include details of past and present research students and suggested research topics for prospective students, links to the literature and other sites of immediate interest.

Academic Staff in the Nonlinear Differential Equations Group
Dr. Chris Athorne, Dr. Misha Feigin, Dr. Claire Gilson, Dr. Jon Nimmo and Dr. Ian Strachan

Pure Mathematics

Algebra



There is a large and active algebra research group at Glasgow, one of the largest algebra groups in the UK.

Over the last 25 years, worldwide research trends in algebra have increasingly emphasised the subject's connections with, and applications to, other areas of mathematics and science. As examples one can cite geometry, topology, Lie theory, theoretical computing science and integrable systems. This development is very apparent in the research in algebra carried on at Glasgow. Algebra research here splits into two main themes - **group theory** and **ring and modules and representation theory**. In addition, research is carried out in semigroup theory. There is a very strong (and continuing) tradition of post-graduate research in algebra at Glasgow. Details of recent and current Ph.D. students in algebra can be found on our website: http://www.maths.gla.ac.uk/research/groups/algebra/algresstud.htm

The entire algebra group at Glasgow meets together at the Departmental Algebra Seminar, held weekly during term time (usually on Wednesdays at 4 p.m.). As well as the members of the algebra group (including students and visitors) the seminar is often attended by members of other research groups in the department - those having a high level of interaction with algebra are the **nonlinear differential equations, geometry and topology** and **number theory** groups. We also run a number of **working seminars and postgraduate courses**.

The Edinburgh Mathematical Society and the London Mathematical Society provide support for **Scottish Algebra Day**, an annual meeting of algebraists (and others) in Scotland. The London Mathematical Society also support the meetings of the **ARTIN** which usually meets four times a year, once at each of its centres Edinburgh, Glasgow, Lancaster and York. In addition, we have strong links with Australia, Belgium, Brazil, Denmark, France, Germany, India, Israel, Poland, Romania, Spain, Taiwan, the U.S.A. and Vietnam. Recently the group has been supported by the Engineering and Physical Sciences Research council, the European Union and NATO.

Group Theory

Research in group theory at the University of Glasgow is currently centred in three fields: Professor Peter Kropholler carries out research on cohomology of groups; Dr Alec Mason on the **modular group and related groups**; and Professor Steve Pride on geometric and **combinatorial group theory**. These research areas have extensive connections with other research fields, both within mathematics and beyond. For example, research on cohomology of groups includes the study of group actions on cell complexes, leading to applications to important modern conjectures in K-theory, to the study of Poincare duality groups, having close connections with 3-manifold theory, and to complete cohomology, which has links with both homotopy theory and with abstract algebra. Research on the modular group is closely linked to number theory and to hyperbolic geometry, while geometric and combinatorial group theory developed in tandem with topology and still has strong links with that subject, but has also increasingly developed connections with theoretical computing science.

Rings and Modules and Representation Theory

Research in rings and modules and representation theory at the University of Glasgow is currently centred in two fields - Professor Patrick Smith carries out research in module theory; and Professor Ken Brown work on noncommutative noetherian rings and representation theory. A great deal of the work on noncommutative noetherian rings is focussed on its connections with other

research fields, particularly the representation theory of Lie algebras and quantum groups. This leads to interactions with many other areas, including algebraic geometry, algebraic topology, representations of groups, and mathematical physics.

Academic Staff in the Algebra Group
Professor Ken Brown, Dr Alastair Craw, Professor Peter Kropholler, Dr Alec Mason, Professor Steve Pride, Professor Patrick Smith and Dr Catharina Stroppel.

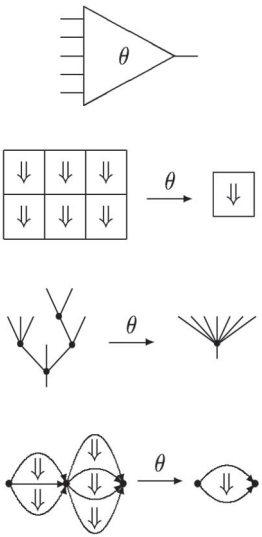
Analysis

Functional Analysis
This area of analysis concerns itself with the interplay between algebraic and topological structures, and provides essential tools for treating such topics as harmonic analysis, ergodic theory, differential equations and integral equations. Central themes are Banach Spaces, Banach Algebras, Operator Theory, Operator Algebras and Spectral Theory. Individual members of the Department are active in the areas of: Numerical Range and Hermitian Elements; Group and Semigroup Algebras; Entire Functions; Operator Algebras and their connections with Topology, K-Theory, Differential Geometry and Physics.

Nonlinear Analysis
This provides the theoretical setting for applications to nonlinear problems, especially those related to differential equations. The tools are a mixture of analytical and topological such as topological degree, fixed point index theory, finite dimensional approximations, variational methods and critical point theory. The main interest in this Department is in constructive solvability methods using the first three tools mentioned.

Academic Staff in Analysis group
Dr M J Crabb, Dr S Pott, Dr A S Wassermann , Prof J R L Webb, Dr L. Wisewell.

Category Theory



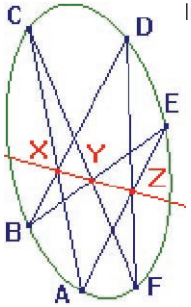
Category theory looks at mathematics on a large scale: objects and the relations between them, in the abstract. The aim is to strip away inessential details and get to the essence of things. By doing this one finds fundamental concepts - "category" and "functor" being well-known examples - that are very general and therefore invite comparisons between apparently unrelated parts of mathematics. Put another way, if you screw up your eyes then you can sometimes see the similarity between objects that you had previously thought quite different.

Much of modern mathematics is, literally, near-unthinkable without the organizing principles of category theory. This is especially true of algebraic geometry, topology, homological algebra, logic, and theoretical computer science, and increasingly many parts of the mathematical sciences (physics, particularly) are finding categorical ways of thinking to be useful.

Academic Staff in Category Theory group
Dr Tom Leinster, Dr Richard Steiner.

Geometry & Algebraic Topology

Geometry and Algebraic Topology play major rôles throughout Mathematics and its applications, with geometric and topological ideas often being indispensable.



In many respects, the latter half of the 20th Century has been a golden age of Geometry and Topology, with spectacular advances in the study of manifolds (particularly in dimension 4), Global Analysis including Index Theory, complex manifolds and Algebraic Geometry, including its applications in Number Theory. Increasingly, strong connections with integrable system theory and global aspects of differential equations as well as the remarkable two-way flow of ideas between Geometry and Theoretical Physics are dominating developments.

Algebraic Topology has developed important machinery such as cohomology theories including ordinary cohomology, K-theory, cobordism and elliptic cohomology. These are often of use in geometric situations, as well as within Algebraic Topology itself which tends to study much less `rigid' geometric situations than Geometers do. There have also been significant interactions with many areas of Algebra, and indeed much of Algebraic Topology can be viewed as `applied algebra' as well as being a major source of innovative algebraic ideas.

Academic Staff
Geometry: Dr Chris Athorne, Professor Kenneth A Brown, Dr A. Craw, Dr Misha Feigin, Professor Peter Kropholler, Dr Ian Strachan Dr Catharina Stroppel, Dr Misha Verbitsky and New Professor to commence 06/07.

Algebraic Topology: Dr Andrew J Baker , Prof Peter H Kropholler, Prof. Stephen J Pride and Dr Richard J Steiner.

Number Theory & Combinatorics

Both number theory and combinatorics are part of what is called discrete mathematics, which has important applications in computer science and information technology, as well as an intrinsic elegance and fascination for mathematicians, professionals and amateurs alike.

Number theory originated as the study of the structure and properties of the ordinary integers, but nowadays has expanded into the study of analogous properties of other (possibly non-commutative) rings. The methods employed are sometimes algebraic (e.g. group theory, ring theory and field theory, especially Galois theory), sometimes analytic (e.g. complex variable theory, Fourier analysis), sometimes geometric (e.g. algebraic geometry of curves and higher-dimensional varieties, Diophantine geometry), and sometimes combinatorial (e.g. graph theory, generating functions). Current topics of interest in the Department include: modular forms and functions; elliptic curves, abelian varieties and Drinfel'd modules; zeta and L-functions; analytical treatment of arithmetical functions, and applications of sieve methods; classfield theory; algebraic function fields over finite fields (including applications to coding theory and IT); finite fields themselves; probabilistic number theory; Galois groups of special families of polynomials.

In combinatorics one is usually concerned with a finite set with some additional structure (e.g. a projective geometry, a graph or a block-design), and seeks to relate it to some already-known set of the same kind, or perhaps to show that certain structures can (or cannot) be imposed on a given set. Another type of question is the enumeration of particular kinds of structures (e.g. how many connected graphs are there on n vertices?). Current topics of interest in the department include: combinatorial design theory; automorphism groups of graphs and designs; Hadamard matrices and symmetric designs and their classification; applications of combinatorics to computer graphics.

Academic Staff in Number Theory & Combinatorics Group
Dr I. Anderson, Dr A.J. Baker , Professor S.D. Cohen, Dr M.K.N. Nair, Dr W.W. Stothers, Dr L. Wisewell.

Postgraduate Courses

Research Courses

Doctor of Philosophy

A minimum period of 3 years full time study, or of duration by arrangement for part time study. Study takes place under the direction of a member of staff (supervisor) whose work is in the area of research interest of the student. It is possible to do a Ph.D. in Mathematics combined with another subject. (e.g. Maths/Music, Maths/Medicine, Maths/Economics); this may require two or more supervisors.

Content
A significant original contribution to the chosen area of research culminating in the writing and submission of a thesis in English.

Prerequisite
A first or upper second class UK degree, or overseas equivalent, in a suitable discipline, normally mathematics.

Assessment
By thesis consisting substantially of original mathematics to be assessed by an internal and an external examiner. The thesis must normally be defended in an oral examination.

Master of Science

The Department offers a MSc (by research) only. This is between 1 and 2 years for full time study or between 2 and 3 years for part time study under the direction of a member of staff (supervisor).

Content
The award of the degree is based on a thesis on a topic chosen in collaboration with a supervisor. The thesis may be a record of original research, a critical review of existing knowledge or a mixture of both.

Prerequisite
A first or upper second class UK degree, or overseas equivalent, in a suitable discipline, normally mathematics.

Assessment
By thesis assessed by an internal and an external examiner. The thesis does not normally require an oral defense.

Funding your Studies

Engineering and Physical Sciences Research Council (EPSRC) is the primary source of funding for postgraduate research in Mathematics in the UK. EPSRC studentships pay fees and maintenance for UK nationals. Other EU nationals are eligible for fees only.

University & Faculty Postgraduate Scholarships
University Postgraduate Scholarships are open to all and, in particular, allow very highly qualified candidates from overseas (who are ineligible for an EPSRC award) to compete with UK and EU nationals for financial assistance to fund their postgraduate studies.

The Faculty of Information and Mathematical Sciences (FIMS) Graduate School awards up to three postgraduate scholarships annually which pay a maintenance award comparable with an EPSRC studentship plus fees at the rate for home students. Students from the UK and the EU pay fees at the home rate. Students from elsewhere (referred to as `overseas' students) pay a higher fee.
(see p24 of University Prospectus for fees and financial

matters.) Full overseas fees may also be covered in exceptional cases. Applicants should apply by 31st December of each year if they wish to be considered for the Scholarship Competition for the following year.

Overseas Research Scholarship
The difference between home and overseas fees can be met by an ORS award. It is emphasised that overseas students need to apply for both a Postgraduate Scholarship and an ORS award to fully fund their studies. Inevitably the competition for Postgraduate Scholarships is severe, but over the past few years, at least one Mathematics candidate has been successful each year. Our postgraduate web pages advertise the closing dates for applications, which is usually January of each year.

Further sources of funding
Further sources of funding in Mathematics are listed on the Graduate School webpage see: http://www.gla.ac.uk/faculties/ims/postgraduatefunding.htm. (We mention, in particular, a Carnegie Scholarship as a possible source of funding for highly qualified students in Scotland.)

Supplemental Earnings
All postgraduate students in the Department have the opportunity to undertake tutorial work with first and second year undergraduates. Typical annual earnings are £500. There may also be opportunities to help staff with paid exam invigilation.

Application Procedure

Initial Enquiries
That fact you are reading this booklet probably means that you have already taken the first step of contacting the Department.

The Glasgow Postgraduate Prospectus details the formal application procedure. The application material includes an application form and two referee report forms. This material can also be downloaded in electronic form from or alternatively, it can be mailed to you.

Please refer to our website for further information on the application procedure. The individual research interests of academic staff members are listed on our webpage, feel free to contact a member of staff to discuss their research field.

If you require further information about Postgraduate Studies in Mathematics please do not hesitate to contact us via the following methods.

By Post: The Director of Postgraduate Studies, Department of Mathematics, 15 University Gardens, GLASGOW G12 8QW.

Telephone: +44 (0) 141 330 5176
Fax : +44 (0) 141 330 4111
Email : postgrad@maths.gla.ac.uk

Website: http://www.maths.gla.ac.uk/postgrad/

We look forward to receiving your application.

Notes