REPORT on the progress of the MAGIC project 2006-07.

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1. Introduction

The MAGIC (Mathematics Access Grid Instruction and Collaboration) project commenced in October 2006 following the receipt of a grant from the EPSRC via the PHD Taught Course Centre initiative. This project is aimed at sharing postgraduate courses in mathematics using Access Grid technology. The project is led by Prof. Neil Strickland (University of Sheffield) and Prof. Jitesh Gajjar (University of Manchester), and the MAGIC consortium currently has 15 members from the sites as listed in Table 1.

University of Birmingham
Durham University
University of Exeter
Keele University
University of Lancaster
University of Leeds
University of Leicester
University of Liverpool
Loughborough University
University of Manchester
University of Newcastle
University of Nottingham
University of Sheffield
University of Southampton
University of York

Table 1 MAGIC Consortium members

The motivation and background to the project are given in the case for support for the grant submitted to the EPSRC, and reproduced in Appendix 1. The EPSRC call was initiated in part from the need to respond to comments made in the Roberts Review, and the International Review of Mathematics, which noted that PhD students trained in the UK did not have the same depth and breadth of mathematics knowledge as compared to students trained in Europe and the USA. The training that students received in the UK was regarded as being too narrow and specialist. The MAGIC project stems from a collective desire to address some of these shortcomings.

In this report we aim to provide a summary of the progress made in the first year and the steps that we have taken to ensure that the aims and objectives of the project are being met.

1.1 Membership of Consortium

The original bid to EPSRC included as MAGIC consortium partners all 14 universities as listed in Table 1 apart from Exeter University. We had a request from Exeter to join the consortium at a later stage and the Academic Steering Committee (see below) agreed to allow Exeter to join, provided that in the first year they would play a passive role in the sense that they would not be asked to deliver courses. In future years, and subject to receiving a satisfactory statement of intent letter and approval by the Scientific Advisory

Committee, they could be approved as full members. An additional request from East Anglia University to join the consortium was received. They have been asked to wait until the end of year 1 when we would be in a better position to judge whether it would be feasible to include additional members.

1.2 MAGIC Committees

As part of the conditions of the grant imposed by EPSRC, the terms and reference of the two committees, the MAGIC Scientific Advisory Committee (SAC) and the MAGIC Academic Advisory Committee (AAC), were drawn up and following consulation with EPSRC subsequently approved by them. These are given in Appendices 2ab.

1.2.1 MAGIC Scientific Advisory Committee

The members of this committee are:

Prof. Elmer Rees (University of Bristol)
Prof. Saleh Tanveer (Ohio State University)
Prof. Jon Forster (Southampton University)
Dr Robert Leese (Oxford University, Smith Institute)
Mark Bambury (EPSRC)
Prof. Neil Strickland (Sheffield University)
Prof. Jitesh Gajjar (University of Manchester)

It is noted that in forming this committee it was difficult finding a willing person from outside the MAGIC consortium in the area of Statistics and EPSRC (via Anne Farrow) agreed that we could recruit someone from within the consortium for this, and Prof. Jon Forster kindly agreed to help out.

The role of this committee (see terms of reference, Appendix 2a) is essentially strategic and to provide an independent overview and scrutiny of the MAGIC project, and to advise the AAC in matters relating to the progress of the MAGIC consortium in fulfilling its vision.

1.2.2 MAGIC Academic Advisory Committee.

The members of this committee are:

Prof. Sergey Shpectorov	University of Birmingham
Prof. Michael Farber	Durham University
Prof. Peter Ashwin	University of Exeter
Prof. Graham Rogerson	Keele University
Prof. Martin Lindsay	University of Lancaster
Prof. Alastair Rucklidge	University of Leeds
Prof. Jeremy Levesley	University of Leicester
Prof Mary Rees	University of Liverpool
Dr Alexei Bolsinov	Loughborough University
Prof. Jitesh Gajjar	University of Manchester
Prof. Peter Jorgensen	University of Newcastle
Dr Martin Edjvet	University of Nottingham
Prof. Neil Strickland	University of Sheffield
Dr Chris Howls	University of Southampton

Dr Stefan Weigert University of York

The role of this committee (see terms of reference, Appendix 2b) is to oversee the day to day management of the MAGIC consortium and to facilitate the delivery of the programme of courses. This committee is currently chaired by Jitesh Gajjar and its secretary is Mary Rees. The AAC has met twice in May 2007, and November 2007, and minutes of the meetings are available at
http://www.maths.manchester.ac.uk/~gajjar/MAGIC/minutes_of_academic_steering_committee/

2. Overview of the procurement process and installation of equipment.

The procurement and tender process was handled via Sheffield University's procurement department and following the call, five suppliers tendered bids to build the MAGIC facilities by the deadline in March 2007. From these Asysco plc was chosen as the preferred bidder to build access grid nodes at the original 14 sites as listed in the EPSRC case for support. (Exeter is not included in this list). The standard configuration at most sites consists of a rack mounted PC running Insors software and linked to three cameras, three projectors and an interactive whiteboard. Some sites have a drop down screen, and at others a blank wall is used as the projected surface.

The installation of the equipment and nodes commenced in the summer of 2007, much later than initially envisaged. The delays were caused by the prolonged tendering process, and also delays at sites caused primarily by the local estates department in carrying out necessary electrical and other work needed prior to nodes being installed. The delays also meant that we were unable to have a preliminary testing phase as originally planned and mentioned in the case for support.

However, by the start of October most nodes had been built and apart from a few difficulties at the outset, it is noteworthy that we have been able to deliver a more or less complete programme of lecture courses in semester 1 of 2007. The lecture series commenced properly on 15th October. By the end of October 2007 twelve of the nodes were fully operational and in service, and the remaining Newcastle and Lancaster nodes will be ready in Spring 2008. These sites are in the process of having new building facilities built. The Exeter node is also operational. The semester 2 programme of courses is scheduled to commence on 20th January 2008.

The ASC has noted their gratitude to Neil Strickland for his hard work and dedication with the project. Neil has been instrumental in getting technical issues resolved and in setting up the website which has been a tremendous help in facilitating the smooth delivery of the courses.

With the nodes fully installed it has been possible to have 'normal' interactive live lectures with most sites logged in. Lecturers are able to use the equipment to display pdf and other lecture slides at remotes sites. They are also able to deliver lectures using the interactive whiteboards with a Mimio controller attached. The audience at remote sites not only listen to, but can also interrupt and ask questions. The lecturer is able to view the audience from remote sites, and likewise remote sites can view participants from other sites.

There is one facility which has not been possible to set up as yet and this is the ability to record audio and video streams of the lectures for playback at a later stages. There are one or two technical issues which need to be resolved before this can be done.

A facility for registering technical problems with lectures has been added to the MAGIC website and to date the number of technical problems which have occured is very small. Some of the earlier difficulties stemmed from people not too familiar with the use of the equipment, and network issues. Network difficulties caused the cancellation of a few lectures in week 2, but otherwise these problems have not recurred.

3. Academic Aspects

3.1 Website

The MAGIC website
http://www.maths.dept.shef.ac.uk/magic/index.php
gives details of the MAGIC project, courses, information for lecturers, functions as a material repository site, etc. Students from the MAGIC consortium are able to login and register for courses. Lecturers are able to login and view details of students and also deposit lecture notes, lecture slides, assessment material. The site can also be used to email selected students and staff and to make general announcements. The site can also be used as a discussion forum. At some stage the site will be expanded to include online questionnaires for feedback from students and lecturers on lecture courses. When lectures are being broadcast, students/staff are able to record attendance for that lecture. Problems with lectures can also be registered.

3.2 Assessment policies.

In preliminary discussions before the consortium was formed, and also as stated in the EPSRC case for support, it was decided that assessment polices for the MAGIC courses would be left to individual institutions. The main reason for this was it was not possible to construct a uniform policy which all institutions were happy with. Moreover, we did not want to create unnecessary bureaucracy. For these reasons it was decided that assessment of MAGIC courses would be left to the individual institutions to decide and the lecturers for the MAGIC courses would assist in providing material which could be used for assessment, but they would not necessarily be involved in assessing students from other insititutions.

One of the terms and conditions of the grant imposed by EPSRC required all members of the consortium to produce statement of intent letters in which they would state how many hours of lectures their students would take and what the assessment policy of the institution was. A summary of the content of the letters is given in Table 2 (Original copies of the letters are filed with Jitesh Gajjar).

Institution		**Student commitment**	**No of lectures promised by institution**	**Assessment policy**
University of Birmingham		100 hours	4x20 hours	End of year report+oral examination
Durham University		3 courses	2 courses	End of year report,+ attendance register.
University of Exeter		40 hours	1-2 courses	Oral presentation
Keele University		4 courses	2x20 hours	Two courses formally assessed+ progress report
University of Lancaster		80 hours	1x20 hours	End of year report+ review after 18 months
University of Leeds		40 hours	2x20 hours	Formal exam, essay, report+oral exam
University of Leicester		40 hours	40 hours	End of year report and assessment
University of Liverpool		40 hours	40 hours	Report, coursework, oral examination
Loughborough University		100 hours	4x20 hours	Coursework, essays, oral examination
University of Manchester		80-100hours	4x20 hours	End of year report + oral exam.
University of Newcastle		60 hours	1x20 hours	Report+oral examination
University of Nottingham		60-120 hours	80 hours	?viva
University of Sheffield		No formal requirment	1x20	End of year report.
University of Southampton		6 taught courses	5 courses	Formal assessment +oral examination
University of York		80 hours	4x10 hours	Formal progress meeting

Table 2 Summary of assessment policies at partner institutions.

3.3 Academic programme

A call for courses was issued early in the spring of 2007 and 58 course proposals were received and discussed at the ASC meeting in May 2007. At this meeting the principles and criteria for choosing courses were considered and following discussion it was agreed to operate a uniform policy towards course preparation costs. It was agreed that for courses shortlisted that 10 hours of MAGIC lecture preparation would receive £2000 towards preparation costs and for a 20 hour course £4000. In return for receiving the money institutions would be required to deliver a full set of notes and other material for the course which would be deposited on the MAGIC website, lecturers would provide assessment material for use in assessing students, and we would expect courses to be given for 3 years. Lecturers would need to provide a written report no later than 3 months following the end of a course. A sample offer letter for a shortlisted MAGIC course is given in Appendix 3.

The courses chosen by the ASC as shown in Tables 4ab form the basis of the MAGIC programme for 2007-2008. The MAGIC website contains much more detailed information on the various courses, the lecture timetable, lecture notes etc. Outline descriptions of the courses and syllabi for the courses are given in Appendix 4.

MAGIC Course and duration	Name of Course	Pure/Applied	Number registered
MAGIC007 10 hours (Steve Donkin,York)	An introduction to linear algebraic groups	Pure	18
MAGIC008 20 hours (Alexey Bolsinov,Loughborough)	Lie groups and Lie algebras	Pure	39
MAGIC009 10 hours (Harold Simmons,Manchester)	Category Theory	Pure	16
MAGIC011 20 hours (Neil Strickland,Sheffield)	Manifolds and homology	Pure	19
MAGIC012 20 hours (Brita Nucinkis,Southampton)	Cohomology of groups	Pure	25
MAGIC027 10 hours (Peter Giblin,Liverpool)	Curves and Singularities	Pure	10
MAGIC015 20 hours (Jeremy Levesley,Leicester)	Introduction to Numerical Analysis	Applied	41
MAGIC018 10 hours (Alexander Movchan,Liverpool)	Linear Differential Operators in Mathematical Physics	Applied	15
MAGIC019 20 hours (Alexei Piunovskiy,Liverpool)	Markov Decision Processes with Applications	Applied	5
MAGIC020 20 hours (Anatoly Neishtadt,Loughborough)	Dynamical Systems	Applied	16
MAGIC023 10 hours (Marta Mazzocco,Manchester)	Integrable systems	Applied	10
MAGIC024 20 hours (Carsten Gundlach,Southampton)	A geometric view of classical physics	Applied	8
MAGIC025 20 hours (Yibin Fu,Keele)	Continuum Mechanics	Applied	17

Table 4a MAGIC courses in the Autumn semester 2007. The numbers in the fourth column indicate the number of registered students.

MAGIC001 20 hours (Christopher Parker,Birmingham)	Reflection Groups	Pure
MAGIC002 20 hours (Dirk Scheutz,Durham)	Differential topology and Morse theory	Pure
MAGIC003 20 hours (Martin Lindsay,Lancaster)	Introduction to Linear Analysis	Pure
MAGIC004 20 hours (Anand Pillay,Leeds)	Applications of model theory to algebra and geometry	Pure
MAGIC005 10 hours (Andrey Lazarev,Leicester)	Operads and topological conformal field theories	Pure
MAGIC006 10 hours (Ian McIntosh,York)	Compact Riemann Surfaces	Pure
MAGIC010 10 hours (Charles Walkden,Manchester)	Ergodic Theory	Pure
MAGIC037 10 hours (Ivan Fesenko,Nottingham)	Local fields	Pure
MAGIC038 10 hours (Detlev Hoffmann,Nottingham)	The algebraic theory of quadratic forms	Pure
MAGIC028 10 hours (Mary Rees,Liverpool)	Geometric Structures on surfaces and Teichmuller Space	Pure
MAGIC013 20 hours (Roy Mathias,Birmingham)	Matrix Analysis	Applied
MAGIC014 20 hours (Alastair Rucklidge,Leeds)	Hydrodynamic Stability Theory	Applied
MAGIC016 10 hours (Stefan Weigert,York)	An introduction to quantum information	Applied
MAGIC017 10 hours (Ed Corrigan,York)	Solitons in relativistic field theory	Applied
MAGIC021 20 hours (Roger Grimshaw,Loughborough)	Nonlinear Waves	Applied
MAGIC022 20 hours (Jitesh Gajjar,Manchester)	Mathematical Methods	Applied
MAGIC029 20 hours (James Blowey,Durham)	Numerical Analysis and Methods	Applied

Table 4b. MAGIC courses, Spring semester 2007-08.

4. Other MAGIC activites

4.1 Postgraduate student conference.

Part of the budget for the MAGIC project includes an element for holding student conferences. At the ASC meeting in November 2007 it was agreed to pool both the Pure and Applied money together and use it for student conferences covering all subject areas. A call has been issued for potential organisers to bid for money to host a student conference. The details of the call are given in Appendix 5. The deadline for receipt of bids is 20th January and these will be considered by the ASC.

4.2 Research collaborations.

The MAGIC nodes are being used for research and other collaborations between various sites at times when rooms are not being used for MAGIC lectures. It is planned to try and restrict lectures to the period 9.00am-2.00pm where possible. Outside these times people have been encouraged to use the facilities for research interactions with remote sites. Brief details of the other activities for which MAGIC node facilities have been used are given below.

1. Seminar and research interactions between Prof. P Rowley and colleagues in Birmingham.
2. 'Not the Singularities' seminar by Jon Woolf (Univ. of Liverpool) organized by Prof. P Giblin, on 11th Dec. 2007.
3. Liverpool University are running a workshop on 'Complex Dynamics' from 14-18th January 2008 and will be using the MAGIC nodes.
4. Conference to discuss collaborative research on uncertainy of computer models, organized by Jonathan Cunningham (Durham) together with 15 colleagues from Southampton, Warwick, Aston and Sheffield. 5th December, 2007.

5. Budget Matters

Difficulties with new finance administration and accounting at Sheffield University has meant that detailed accounts of finances concerning the installation have proven difficult to obtain. If a budget statement can be extracted it will be presented at the meeting of the SAC, otherwise a verbal report will be presented.

A budget statement for the finances handled by Manchester will be presented at the meeting.

A summary of costs associated with course preparation is given below, but see also minutes of the AAC, May 2007, November 2007.

	Pure	Applied
Budget	87.5K	125K
Allocated for courses in 2007-08	48K	48K
Balance	39.5K	79K

6. Summary

Given that installation of the nodes began from June 2007 onwards, and that a full programme of lectures with 13 courses, and spanning 420 hours, has been delivered without encountering too many technical difficulties, the MAGIC project has so far demonstrated that the technology used is feasible to deliver high quality lectures in all areas of mathematics, and involving upto 15 remotes sites. From this perspective the project so far has been immensely successful. Outstanding technical issues which need addressing include the incorporation of recording and playback of lectures.

Concerning academic issues quality control, including feedback and evaluation of student and lecturer opinion of the courses, remains to be done. Questionnaires have been devised but it has not been possible to incorporate these on the MAGIC website to date, although we expect this facility to be available soon. Informal feedback from students and colleagues has so far been very positive. An area which needs to be monitored includes low attendances at some courses.

The MAGIC courses shortlisted cover many areas of mathematics, but there are obvious gaps in specific subjects areas such as Statistics, Analysis. The future call for courses will concentrate on tackling some of these missing areas and to addressing any problems which emerge from formal feedback and evaluation of courses. A critical review of the programme carried out would aid future selection of courses and future programmes offered. This is where the SAC will be able to help in providing a more independent and critical overview of the MAGIC operation.

APPENDIX 1

The case for support submitted as part of the proposal to EPSRC is reproduced here. This defines the MAGIC vision and states the aims and objectives of the MAGIC project.

MAGIC Mathematics Access Grid Instruction and Collaboration

Most information in this case for support is amplified at the website: aim.shef.ac.uk/magic.

A: Vision

The MAGIC consortium covers 14 universities: Birmingham, Durham, Keele, Lancaster, Leeds, Leicester, Liverpool, Loughborough, Manchester, Newcastle, Nottingham, Sheffield, Southampton and York. Between us, we submitted 375 staff members in pure and applied mathematics at the last RAE, and in recent years we have had about 515 postgraduate research students in mathematical sciences. Both these figures are about 35% of the UK total.

We include internationally leading groups in many areas of mathematics. Both the strength and the breadth of our research activities are amply demonstrated by the bibliographic data displayed at aim.shef.ac.uk/magic/papers.php.

It has been widely recognised that the postgraduate provision in the UK has two main shortcomings. While our PhD students receive excellent specialist training, their access to wider background education is limited, which leaves them with a narrower perspective than they should have. This makes it harder for them to do independent research or to see their work in its proper context, which places them at a disadvantage relative to their natural competitors from the US and other European countries. Secondly, PhD students working in a particular field often do not have the possibility to interact with other students or academics in their area who may be working at other institutions in the UK. The MAGIC consortium arises from our collective desire to address these deficiencies.

Our plan is to share postgraduate courses in mathematics using Access Grid[1] technology for scalable video conferencing. This will be set up so that students anywhere can participate in fully interactive lectures at the time that they are given, or else watch them at a later date, using only a web browser. Access Grid facilities will be set up so that lectures can be given either using pre-prepared electronic material, or by writing on an interactive whiteboard. Students from all venues will be able to see and talk to each other as well as to the lecturer. We have performed initial experiments with various combinations of hardware and software (supported by a £5000 grant from the University of Sheffield), and are continuing to refine our technical framework.

The size of our group will give us access to a very broad range of expertise and a large supply of lecturers. Indeed, this will be by far the most comprehensive set of taught courses ever offered to UK PhD students, and comparable with the programmes provided by leading US universities. We will also be able to offer such a wide range of courses with little impact on teaching loads, so that the programme will be sustainable in the long term. Our structures and technology are designed to allow for flexible and spontaneous teaching. They are also designed to minimise administrative burdens and interference with the established policies and procedures of participating universities, and to eliminate almost all travelling time for students and lecturers.

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[1] Access Grid is a set of resources designed to support distributed collaborative interactions across the internet; see www.agsc.ja.net for further details.

As well as running lecture courses by video conferencing, augmented by a number of presentation and application sharing tools, we will run bi-annual conferences open to all students in the consortium, as well as a number of one-day regional events that will be smaller and more frequent.

The MAGIC consortium will enable collaboration between UK mathematics departments on a scale that is unprecedented. Our lectures will be available to all universities outside the consortium and we intend to work closely with other providers of PhD taught courses, such as the Scottish National network, to share our portfolio and resources.

B: Course Provision

Introduction:
The aim is to create a unique and comprehensive portfolio of courses spanning most areas of pure and applied mathematics, including probability and statistics, in both breadth and depth. The principal delivery mechanism will be lectures and tutorial classes supported via access grid technology. The majority of our proposed budget covers the installation of comprehensive video conferencing equipment. This hardware could be used to deliver many different kinds of courses, of different lengths, aimed at students of different levels, and covering different areas of mathematics. We fully expect that our ideas about how best to use this equipment will evolve over the lifetime of the project. We will give several courses starting in February 2007 and our experience with these will inform the structures that we put in place for the main body of courses starting in October 2007. With that proviso, we expect to follow the plan described below in the first year of full operation of the network. The requirements for the training of students following pure and applied mathematics streams are somewhat different, and for this reason the training programme outlined below differs in detail on certain aspects for the two student cohorts.

Each participating division will offer a number of courses annually commensurate with its size. (Here a 'division' means a department of pure mathematics, applied mathematics or statistics, or a pure or applied section in a unified department.) Typically this will be 20 or 30 hours of lectures per year. Courses will be of either 10 hours or 20 hours duration. For pure options, the 10 hour courses will be designed to give a broad survey of an area of mathematics, designed to widen the perspective of students who are not working directly in the relevant field. The 20 hour courses will be somewhat more specialised and will offer a more complete treatment of their subject matter.

In the training programme for applied mathematics and statistics, to address the requirements of covering both depth and breadth, courses would be grouped as either CORE or NON-CORE. The CORE courses would start from a low level accessible to all students, but will build to cover the breadth of fundamental material that every applied mathematics PhD student is expected to know. The NON-CORE courses will provide in-depth material in specific areas (usually pertinent to a student's area of specialism). In practice it will not be possible to cover every aspect of a topic in detail in the few lectures, and so it is envisaged that CORE modules will be supplemented by a good set of printed notes. The CORE courses will be a minimum of 20 lectures, and the NON-CORE typically 10 lectures. The statistics courses will be a mixture of 10 and 20 lecture courses and augment the training planned under the national bid for statistics. Moreover, the courses here will be available to **all** students and not just a selected few under the national bid.

Each department will make their own rules about what students are required to take (in accordance with the relevant policies of their universities and the background of the students), but we will work on the basis of 100 lecture hours per student. For applied students, the consensus view of a number of the partners is that students will take approximately 60 hours of CORE lectures, and 40 hours of NON-CORE lectures. The courses might all be taken in the first year, or spread over three years. All lectures will automatically be recorded, and the records will be made available on a publicly available website.

Dissemination:
We will publicise our network by announcements in all the relevant newsletters, such as those of the London Mathematical Society, Institute of Mathematics and its Applications, and the Maths, Stats and OR network, and by emails to all the Heads of Department in Mathematical Sciences. We will maintain a website with comprehensive details of courses and timetables. The technology used will allow students **anywhere** (including those not in our consortium) to receive lectures either at the time that they are given or at a later date, using only a web browser. For full participation they will need an Access Grid node; we anticipate that such facilities will become increasingly common even outside of our network. We will not require any selection criteria, as the technology used allows for audiences significantly larger than the whole body of UK PhD students in mathematics.

List of courses:

The list of courses will be finalised by the procedures described in Section D. Here we give an indicative list; further details are available at the MAGIC website. In particular, the bibliographic data at aim.shef.ac.uk/magic/papers_by_course.html shows that for almost all proposed courses, we have several member departments with extensive research activity in the relevant area.

Pure Mathematics: Commutative algebra Lie theory Group theory Representation theory Functional analysis Banach spaces and algebras Fourier analysis Operator theory Measure and integration Advanced complex analysis Manifolds Algebraic topology Homotopy theory Algebraic curves Varieties and schemes Combinatorics Set theory and logic Category theory Algebraic number theory Analytic number theory Elliptic curves Manifolds and Morse theory Teichmuller theory **Applied Mathematics & Statistics:** **Core:** Numerical analysis and methods Applied Analysis Dynamical Systems Mathematical methods Continuum mechanics Mathematical physics	**Applied, non core:** **Fluids:** Boundary layer theory Advanced inviscid flow theory Hydrodynamic stability Theory Turbulence **Solids:** Fracture Non-destructive testing Nonlinear Elasticity **Methods:** Asymptotics Advanced differential equations Waves Wavelets Nonlinear Waves Control and Optimisation **Applications of fluids:** Magnetohydrodynamics Environmental Flows Geophysical Flows Granular and particle-laden flows Astrophysical flows **Modelling & Industrial:** Financial Mathematics Combustion Inverse problems Industrial Modelling	**Biomathematics:** Modelling Basic biology Biofluids Reaction diffusion problems Pattern formation **Numerical Analysis:** Numerical solution of PDES Numerical methods for SDEs Programming Parallel computing Approximation theory **Mathematical Physics:** Black Holes and general relativity Sources of gravitational radiation Advanced electromagnetism Quantum mechanics Statistical mechanics & condensed matter **Probability & Statistics:** Multivariate analysis OR and discrete optimisation Survival analysis Longitudinal data analysis Computation intensive methods Brownian motion Stochastic calculus Markov decision processes Statistical inference Linear and nonlinear regression models

C: Management Strategy

It will be a challenge to manage and coordinate activities between 14 universities across the different subject areas. The coordination of the pure courses will therefore be handled by Sheffield, and the applied and statistics courses by Manchester. A steering committee will be formed for both Pure and Applied courses to oversee the training the programme. To minimize unnecessary administration the infrastructure will be designed to be flexible, and many tasks will be automated, or delegated to partner institutions.

The steering committee:

There will be a steering committee, with one member from each participating university. Approximately half the members will be pure mathematicians, and the other half will be applied mathematicians. For some purposes, the pure half and the applied half will act independently. The remit of the committee will be to oversee the smooth running of the programme, make strategic decisions regarding course portfolio, and assign funds for node construction, course development, and conferences. The committee will meet twice per year by videoconference, but most of their work will happen on a private electronic discussion board. This has the advantage that discussions are automatically archived and arranged in connected threads. We will also provide facilities to record and tally votes online.

The scientific advisory committee:

There will be a scientific advisory committee comprising the lead investigators, and at least three distinguished **external** advisors drawn across the respective subject areas of pure mathematics, applied mathematics and statistics outside the consortium. This committee will meet annually to scrutinise the programme for its scientific quality and merit, to ensure that the consortium's finances are being managed effectively, and to take a more strategic overview of the activities of the network. The committee will meet prior to the start of the MAGIC programme and thence annually.

Flexibility and delegation:

We will concentrate on delivering lectures, and will not attempt to enforce rules about which courses (or how many courses) should be taken. These matters will be left to the policies of individual universities, and the judgement of students and their supervisors (although we will offer some suggestions and guidance for best practice). Assessment policy will also be left to individual institutions. Many will follow the practice common in the US and continental Europe, where students have oral examinations administered by their own departments (who may use the results to decide whether students may progress). Lecturers will be asked to provide some material to assist with this. Other institutions may wish to use more formal assessment, in which case they will be responsible for organising the setting and marking of papers.

Finally, we will be flexible about the format of MAGIC courses. This is especially important as the mode of delivery is new and unfamiliar; we would therefore want to encourage innovative approaches to teaching and learning, but will also value the (highly successful) traditional tried-and-tested methods. Some approaches will work well, others will not, and we will only learn which is which by experimentation. We hope to teach a partial slate of courses starting in February 2007, which will give us valuable experience in advance of the start of the full programme in October 2007.

Automation:

In the start-up phase of the project, we will automate as much administration as possible. We will use Moodle[2] to organise course materials and handle student registration. We will also use Moodle to host a threaded discussion forum for lecturers, which we will use for an annual review of our course portfolio as well as ongoing monitoring of the operation of our programme. Most

[2] Moodle is an open source virtual learning environment, see www.moodle.org.

universities have their own systems to keep track of courses taken by graduate students. Where possible, we will write scripts to (fully or partially) automate the interface between Moodle and these university systems. Our access grid setup will change very little from day to day, so we will also be able to write scripts to automate the starting up of our access grid sessions, the placement of lecture recordings in appropriate places in the MAGIC website, and so on.

MAGIC members in Sheffield, Manchester, and York have already completed various projects of similar technical complexity, such as the AiM online assessment system (aiminfo.net), and various contributions to Moodle. The MAGIC website itself (aim.shef.ac.uk/magic) is itself a showcase for a variety of relevant technologies.

Annual planning:

Around Easter each year the steering committee will decide on a slate of courses to be offered in the following year. We will start by reviewing the previous year's courses, taking into account informal and formal feedback via questionnaires from students and lecturers. Any feedback will be correlated with results of the online questionnaires, and the committee will suggest changes or improvements where appropriate.

Next, each division will be asked to offer topics that they would be prepared to teach. The steering committee will then negotiate with each other and with the offering divisions to select the most appropriate courses from each division. Where appropriate, the committee will also allocate money from MAGIC funds to support the development of any courses that are new. The principles of the negotiation will be as follows. (a) We will aim for a comprehensive collection of courses (forming a broad portfolio as previously endorsed by the scientific advisory committee), without gratuitous overlaps. (b) Where lecturers are willing to invest time in preparation of detailed electronic course material we will provide funds to support that. However, we will also allow space (but not necessarily funding) for more spontaneous courses, especially if they involve new ideas or a fresh approach. (c) We will take account of students' reactions to courses given in previous years, numbers of students studying in various areas, and the research expertise of the offering departments. (d) Our member departments will have various constraints and preferences of their own, and we will do our best to accommodate these. We will budget for some secretarial support during the main negotiation period.

The initial phase:

If we are awarded funding by the EPSRC, we will immediately start negotiating about courses to be given starting in February and October 2007. The procedure will be largely the same as that discussed above. We will also distribute money for building Access Grid nodes. To some extent we will negotiate with equipment suppliers as a consortium, but each department will have their own preferences and constraints, and their own ideas about how their MAGIC room might be used when MAGIC lectures are not taking place. They will also have their own procedures about how installation work should take place. Departments will therefore have to produce their own final plans, and submit a budget to the steering committee. The committee may require changes or additional contributions where necessary to keep within the overall project budget. In the initial phase we will also set up software systems to handle lecture delivery, course administration and so on. These will consist mostly of freely available products such as Moodle, with some commercial videoconferencing software, and some additional code (to be written by us) to make everything work together. We have installed open source project management software, which we will use to monitor the progress of node installations, software integration, and course development work.

D: Quality Control Strategy

We will use Moodle for course management, and we will build in mechanisms to collect student feedback, both through open discussion boards and through online questionnaires distributed at the end of each semester. The steering committee and lecturers will also have a private discussion board on which any issues can be raised. Steering committee members will typically have some departmental role that gives them regular contact with postgraduates, so they should have a good idea of how their students are coping with MAGIC. We will also circulate email to all supervisors and graduate course directors asking for their opinions.

Monitoring and examination of students will be left to their home institutions. All our member universities have systems in place to monitor and support their postgraduate students, and these systems can readily be adapted to cover MAGIC.

All lectures will be recorded and many courses will have online notes, so any interested party will be able to see the contents and approach used. This will also make it easy to share good practice. Many courses will be of interest to some faculty members as well as to postgraduate students, and this will provide another route for informal feedback.

The lead investigators, in their annual report to the scientific advisory committee, will offer an outline summary of the success of the courses offered, and highlight particular situations eliciting strong positive or negative responses.

E: Sustainability Strategy

Our project is intrinsically sustainable. We will spend most of our budget on non-recurrent hardware costs. The hardware will be very useful for research collaboration as well as for postgraduate teaching, so departments will be strongly motivated to maintain it beyond the lifetime of the grant. Most of the remaining money will be spent on developing courses, many of which will have very long shelf lives. Our economies of scale mean that we can offer a very wide range of courses while asking individual member departments to contribute less than an hour of lectures each for each week of term time. They will therefore have access to a broad programme with far less effort than might otherwise have been expended on teaching a very limited set of courses to their own students. This means that our project will develop substantial momentum, which will keep it going long after the grant runs out. In five years, say, we would envisage our model to be adopted at many more universities, especially as Access Grid technology will by then be commonplace and a familiar tool in our teaching and research environment.

F: Evaluation of Impact

Our primary metric will simply be the total number of person-hours spent by students taking MAGIC courses. As our framework is not prescriptive, supervisors will only tell their students to take MAGIC courses if they are seen to be valuable. Attendance figures will therefore be a good measure of the success of the project. We hope to reach 10000 person-hours in 2008/09 and subsequent years. We will set up software to make it as painless as possible to collect and collate this data. Of course we hope to find money to allow our students to study for 3.5 years or more, and this will make them more willing to take courses in their first year; we will monitor this effect.

We will welcome, and indeed encourage, further nodes to join MAGIC after it has started. This will be straightforward, but quite expensive for the incoming department. Any request to join will therefore be a substantial vote of confidence in our model, as will be any plan to set up a separate but similar network. The number of such requests or plans will thus be a useful auxiliary metric.

As explained in Section D, we will regularly gather feedback from students and lecturers about their experiences with MAGIC. This feedback will be another qualitative metric.

We will informally monitor the success of our students in finding postdoctoral positions (but we do not think it will be possible to extract meaningful quantitative information from such an exercise).

G: Justification of Resources

We have budgeted for £40k for each Access Grid node for equipment and installation, which is lower than quoted by vendors (inSORS and Virtalis) in our preliminary discussions with them, but consistent with costs reported by university audio-visual departments who have recently installed such nodes. The maintenance figures were quoted by inSORS, and are in line with existing university experience. The Access Grid facilities are of course central to our whole plan and so each participating university has agreed to contribute £10k towards the cost of their node.

We have budgeted to prepare 850 hours of lectures (in a mix of 10 hour courses and 20 hour courses). We have allowed £2500 on average for each block of 10 hours. This would usually be spent to buy replacement teaching, releasing the time of a lecturer to prepare material for MAGIC. Costs for replacement teaching vary between about £2500 and £5000 for a one semester course, depending on circumstances.

We have asked for £10k for software development. This will be carried out by graduate students under the supervision of the PI, who has extensive experience of software projects. Various such developments in York have been completed in this way in recent years, so they have a supply of qualified students. The amount of code needed is relatively small; most of the work will be done by Moodle and the inSORS grid software, and we will write some scripts to control those components in a convenient way.

Although we will try hard to automate or delegate all administration, the project will necessarily create some additional work for support staff. We have therefore asked for a contribution of £8k per year towards salaries of such staff (to be split between Sheffield and Manchester).

We have asked for £15k per year for meetings. These will be held at different universities around the network. A typical plan would be for a short meeting involving two night's accommodation (at about £50 per night in student residences). Travel costs might also average £50 per student, and we would ask for a £50 contribution from their DTA, so the consortium would pay £100 per EPSRC-funded student. Many talks will be given by the students themselves or by academics from the host institution, for which no additional funding would be required. Speakers from other UK institutions will cost about £200 each. University room charges might be £500. We have about 500 students in the consortium, but we expect that MAGIC participation will be concentrated among the 140 or so first year students (not all of whom are EPSRC funded). Other meeting formats are being considered, but the annual costs are similar.

H: Diagrammatic Plan: See separate sheet.

APPENDIX 2a

MAGIC Scientific Advisory Committee
Terms of Reference

1. Membership

The Scientific Advisory Committee will be composed of:

- The two Principal Investigators (or their nominated representatives) as identified on the EPSRC form for the MAGIC bid.
- Three nominated people from outside the MAGIC consortium drawn from the areas of pure mathematics, applied mathematics and statistics.
- A nominated representative from industry.
- A representative from EPSRC.

The Scientific Advisory committee will be chaired by one of the external nominees but not by the two Principal Investigators (or their nominated representatives). The external nominees will normally be distinguished experts in the respective subject areas.

2. Remit

The role of the Scientific Advisory Committee will be essentially strategic and it will advise the Academic Steering Committee on matters related to the progress of the MAGIC consortium in fulfilling its vision of creating a a unique and comprehensive portfolio of courses spanning most areas of pure and applied mathematics, including probability and statistics, in both breadth and depth. In addition the Scientific Advisory Committee will:

a) Receive reports on MAGIC activities from the MAGIC Academic Steering Committee and review the activities of the MAGIC consortium.
b) Offer advice to the Academic Steering Committee on the strengths or weaknesses of the portfolio of training courses offered by MAGIC, and direct the Academic Steering Committee towards policies to maximise the strengths and mitigate the weaknesses.
c) Scrutinise the financial management of MAGIC activities.
d) Approve the membership of MAGIC consortium partners. In the initial phase of the project, the MAGIC consortium partners as listed in the MAGIC EPSRC case for support, will need to be ratified on behalf of the Scientific Advisory Committee by the EPSRC representative in consultation with the two Principal Investigators.

3. Meetings

The Scientific Advisory Committee will meet at least once a year. The meetings will be minuted and minutes published on the MAGIC consortium website. All member of the committee will have equal voting rights and the Chair will have the casting vote in the event of any split vote.

APPENDIX 2b

MAGIC Academic Steering Committee
Terms of Reference

1. Membership

The Academic Steering committee (ASC) will be composed of the following people:

- One representative from each of the participating MAGIC consortium partner institutions. Here a consortium partner is defined as one of the participating institutions as listed in the MAGIC EPSRC bid documents or as subsequently approved by the Academic Steering Committee and the Scientific Advisory Committee.
- The two bid leaders (Principal Investigators of the MAGIC bid) from the University of Sheffield and University of Manchester.

The committee will be chaired by one of the bid leaders, or their nominated representatives, and the chair will alternate between the two bid leaders, or their nominated representatives, every year. The committee will elect a secretary. The committee will maintain an approximately equal balance of members across the subject areas of pure and applied mathematics. The committee may invite an EPSRC representative and other external observers to the meetings of the ASC.

2. Remit

The main function of the Academic Steering committee will be to oversee the management of the MAGIC consortium to facilitate the delivery of a training programme of taught courses for PhD students in mathematics, and shared between the consortium partners using access grid technology. In particular the committee will be responsible for:

a) Setting up a suitable programme and portfolio of courses across the different subject areas of pure mathematics, applied mathematics and statistics for the training of PhD students in mathematics.
b) Allocating resources for equipment at consortium partner sites.
c) Allocating resources for course preparation and delivery.
d) Allocating resources for student conferences.
e) Maintaining excellence in the teaching standards, academic content, and delivery of MAGIC courses by incorporating feedback from the Scientific Advisory Committee, academic staff, participating students and formal review of courses.
f) Monitoring performance and putting in place mechanisms for a review of all courses delivered through MAGIC.
g) Collection and compilation of suitable data to aid review of MAGIC activities.

The Academic Steering Committee may delegate some of its responsibilities to sub-committees as appropriate. The Academic Steering Committee will submit an annual report on MAGIC activities, via the Chair, to the Scientific Advisory Committee and the EPSRC. The Academic Steering Committee will in allocating resources take due note of any comments from the Scientific Advisory committee, and strive to ensure that resources are utilized effectively for the continued success of MAGIC activities.

3. Meetings

The Academic Steering Committee will meet at least twice a year. The meetings will be minuted and the minutes will be published on the MAGIC consortium web site. Minutes will also be circulated to all members of the Scientific Advisory Committee.

4. Voting rights

Each member of the committee will have equal voting rights and no single partner institution is allowed more than one vote. The Chair of the committee will only vote in the event of a split decision and so will have the casting vote. The committee will be deemed quorate provided 60% of the members are present at a meeting.

APPENDIX 3

Sample offer letter for courses.

APPENDIX 4

Brief descriptions or outline syllabi for autumn 2007 semester courses.

MAGIC007 An introduction to linear algebraic groups.

_An introduction to algebraic groups, going as far Borel\'s Fixed Point Theorem. Affine algebraic varieties, Algebraic groups, Connectedness, Dimension, Varieties in general, Completeness of projective varieties, Borel's fixed point theorem. Applications: the Lie Kolchin Theorem, conjugacy of Borel subgroups.

MAGIC008 Lie groups and Lie algeras.

Lie groups, Lie algebras, classical matrix groups GL(n,R), SO(n), SO(p,q), U(n), Sp(2n,R); exponential map, one-parameter subgroups; actions and basic representation theory, orbits and invariants; nilpotent and solvable Lie groups and Lie algebras, Killing form, simple and semisimpe Lie algebras.

MAGIC009 Category Theory

Categories: basic definitions and examples from algebra, logic, set theory, and topology, plus pointed cases. **Functors:** many examples in the above contexts. **Natural transformations:** further examples as above. **Adjunctions:** theory, plus a detailed discussion of examples such as function set and product in sets, loop and suspension in pointed spaces.

MAGIC011 Manifolds and Homology

Topological manifolds: definition and examples. **Cohomology rings:** basic properties, without construction. Description (without proof) of the cohomology rings of many interesting manifolds. **Cohomology of configuration spaces:** partial proof of stated description. Geometry of balls and spheres. Geometry of Hermitian spaces. Cohomology of balls and spheres. Cohomology of unitary groups. Cohomology of projective spaces.
Vector bundles. Smooth structures and the tangent bundle. The Thom isomorphism theorem. Homotopical classification of vector bundles and line bundles. Cohomology of projective bundles; Chern classes; cohomology of flag manifolds and Grassmannians.
Normal bundles, tubular neighbourhoods, and the Pontrjagin-Thom construction.
Poincaré duality. The universal coefficient theorem. Cohomology of complex hypersurfaces.

MAGIC012 Cohomology of Groups

Introduction to basic concepts ((co)homology of chain complexes, modules over a ring, exactness, pro jectives and injectives, Ext and Tor ...). Cohomology of groups (projective resolutions via topology, Induction, Coinduction, cohomological finiteness conditions, group extensions). If time permits one or more of the following topics: H^2 and group extensions with abelian kernel, cohomological finiteness conditions for soluble groups, virtually torsion free groups, Bredon cohomology.

MAGIC027 Curves and Singularities

Curves, and functions on them. Classification of functions of 1 real variable up to R-equivalence. Regular values of smooth maps, manifolds. Applications. Envelopes of curves and surfaces. Unfoldings of functions of 1 variable. Criteria for versal unfolding.

MAGIC015 An Introduction to Numerical Analysis

Introduction and prerequisites. Description of the ideas to be covered and the assessment activities. Stable and unstable computation, relative and absolute error, floating point computation and round off errors. Finding roots of nonlinear equations. Bisection, secant and Newton's methods. Approximation of functions I. Polynomial interpolation, Lagrange and Newton forms: divided differences. Approximation of function II. Piecewise polynomial approximation. Splines and their generalisations into higher dimensions. Approximation of functions III. Least squares and orthogonal polynomials. Numerical integration. Newton-Cotes and Gauss formulae. Integration of periodic functions. Romburg integration. The Fast Fourier transform. Numerical differentiation and Richardson extrapolation. Solving systems of linear equations I. Gauss elimination, pivoting. Cholesky factorisation. Solving systems of linear equations II. Conditioning and error analysis. Solving systems of linear equations II. Iterative methods: Jacobi, Gauss-Seidel, SOR. Least squares solution and the QR algorithm. Solving partial differential equations I. Finite difference methods for elliptic equations. Solving partial differential equations II. The Galerkin method and finite element methods. Solving partial differential equations III. Parabolic equations, explicit and implicit methhods. The Crank-Nicolson method. Solving ordinary differential equations I. Taylor series methods. Runge-Kutta methods. Solving ordinary differential equations II. Multi-step methods. Higher order differential equations. Solving ordinary differential equations III. Boundary value problems: shooting methods, finite difference methods, collocation. Summarising and finishing course. This lecture also allows some time if other topics take longer than expected.

MAGIC018 Linear Differential Operators in Mathematical Physics

Generalised derivatives: Definition and simple properties of generalised derivatives. Limits and generalised derivatives. **Sobolev spaces:** Definition of Sobolev spaces. Imbedding theorems. Equivalent norms. **Laplace's equation:** Laplace's equation and harmonic functions. Dirichlet and Neumann boundary value problems. Elements of the potential theory. Generalised solutions of differential equations. Singular solutions of Laplace's equation, wave equation and heat conduction equation. Variational method.
Weak Solutions. The energy space. Green's formula. Weak solutions of the Dirichlet and Neumann boundary value problems. Spectral analysis for the Dirichlet and Neumann problems for finite domains. Heat conduction equation. Maximum principle. Uniqueness theorem. Weak solutions. Wave equation. Weak solutions. Wave propagation and the characteristic cone. Cauchy problems for the wave equation and the heat conduction equation.

MAGIC019 Markov Decision Processes with Applications

Introduction: Revision of Probability. **Markov chains:** Definitions. Transition probability, diagrams. Classification of states, limiting behaviour, absorbing and ergodic chains. **Markov Decision Processes:** Finite and infinite horizon, dynamic programming approach. Discounted model and expected average reward. Canonical equations and the linear programming approach. Linear-quadratic regulators. Applications to Reliability, Queues, Inventory etc.

MAGIC020 Dynamical Systems

Linearisation of differential equations and maps. Multipliers, Floquet theory, Krein signature, Lyapunov exponents. Topological classification of hyperbolic equilibria and periodic trajectories. Stable, unstable and center invariant manifolds of equilibria and periodic trajectories. Reduction on center manifold. Normal forms of nonlinear systems near equilibria and periodic trajectories. Bifurcation theory, saddle-node, Poincaré-Andronov-Hopf bifurcation, period doubling, Andronov-Leontovich and Shilnikov bifurcations. Normal forms of Hamiltonian systems and symplectic maps. Perturbation theory for integrable systems, averaging of perturbations, elements of Kolmogorov-Arnold-Moser theory.

MAGIC023 Integrable Systems

Analytical mechanics: Hamiltonian and Lagrangian approach. Rigid body equations. Lie algebras: main definitions of Lie algbera and Lie group. Adjoint and co-adjoint action. Differential manifolds: tangent and cotangent bundle, vector fields, differential forms.

MAGIC024 A Geometrical View of Classical Physics

Differential geometry. Special relativity and Electrodynamics.Thermodynamics. Fluids. General relativity

MAGIC025 Continuum Mechanics

Vector and tensor theory: Vector and tensor algebra, tensor product, eigenvalues and eigenvectors, symmetric, skew-symmetric and orthogonal tensors, polar decompositions, integral theorems. **Kinematics:** The notion of a continuum, configurations and motions, referential and spatial descriptions, deformation and velocity gradients, stretch and rotation, stretching and spin, circulation and vorticity. **Balance laws, field equations and jump conditions:** Mass, momentum, force and torque, theory of stress, equations of motion, energy, jump conditions. **Constitutive equations:** Basic constitutive statement, examples of constitutive equations, observer transformations, reduced constitutive equations, material symmetry, internal constraints, incompressible Newtonian viscous fluids, isotropic elastic materials, viscoelastic materials, rheological models such as Reiner-Rivlin fluid and Bingham fluid. **Advanced formulations:** Elementary continuum thermodynamics, variational formulations, conjugate measures of stress and strain, Hamiltonian formulations. Illustrative problems. **Linear Elasticity:** a cylinder deformed by its own weight, surface wave propagation **Nonlinear Elasticity:** inflation of spherical and cylindrical shells **Fluid Mechanics:** a selection of steady flows bounded by plane boundaries.

Outline syllabi for spring 2008 semester courses.

MAGIC001 Reflection Groups

Let V be a Euclidean space. The finite reflection groups on V play a central role in the study of finite groups and of algebraic groups. We shall begin by classifying all the finite subgroup of the orthogonal group O(V) when V has dimension 2 or 3. For G a finite subgroup of O(V), we then introduce fundamental regions for the action of G on V. Following this we define Coxeter groups as finite groups generated by reflections in O(V) which act effectively on V. To study such subgroups of O(V) we introduce root systems and show that G simply transitively on the positive systems in the root system. In the final chapter, we classify root systems and thus also classify the Coxeter groups. This classification is as usual parameterized by the Coxeter diagrams.

MAGIC002 Differential topology and Morse theory.

The course will describe basic material about smooth manifolds (vector fields, flows, tangent bundle, foliations etc), introduction to Morse theory, various applications.

MAGIC003 Introduction to Linear Analysis

This couse provides an introduction to analysis in infinite dimensions with a minimum of prerequisites. The core of the course concerns operators on a Hilbert space including the continuous functional calculus for bounded selfadjoint operators. There will be an emphasis on positivity and on matrices of operators. The course includes some basic introductory material on Banach spaces and Banach algebras. It also includes some elementary (infinite dimensional) linear algebra that is usually excluded from undergraduate curricula. Here is a very brief list of the many further topics that this course looks forward to. Banach space theory and Banach algebras; C^*-algebras, von Neumann algebras and operator spaces (which may be viewed respectively as noncommutative topology, noncommutative measure theory and `quantised' functional analysis); Hilbert C^*-modules; noncommutative probability (e.g. free probability), the theory of quantum computing, dilation theory;Unbounded Hilbert space operators, one-parameter semigroups and Schrodinger operators. And that is without starting to mention Applied Maths and Statistics applications.

MAGIC004 Applications of Model Theory to Algebra and Geometry

The course will discuss and survey some classical and recent applications of model theoretic techniques to various other areas of mathematics. In addition to introducing basic notions of model theory, the course will also introduce in a soft manner notions from algebraic and diophantine geometry as well as valued fields. As such the course is aimed at the general postgraduate audience. But it would also be essential for students aiming to work in model theory and related subjects. The applications will go from elementary things (Ax's theorem) to more sophisticated ones (definable integration, diophantine geometry over function fields).

MAGIC005 Operads and Topological Field Theories.

We explain the basics of the Feynman path integral formulation of quantum field theory and how it leads to asymptotic expansions of oscillating integrals and Feynman graphs. We then make a connection to pure mathematics via operads, modular operads and related notions. We will see how operads are applied in various problems in geometry and physics, particularly to the study of moduli spaces of Riemann surfaces. Time permitting, we consider such topics as deformation quantization, the Witten conjecture and/or Chern-Simons theory.

MAGIC006 Compact Riemann Surfaces

Riemann surface as a complex manifold (motivated by multi-valued functions); vector fields and differential forms; basics of integration and singular homology for curves on surfaces; the Abel-Jacobi map and Abel's theorem; the Riemann-Roch theorem; (maybe get as far as Weierstrass points).

MAGIC010 Ergodic Theory

Examples of dynamical systems (maps on a circle, the doubling map, shifts of finite type, toral automorphisms, the geodesic flow). Uniform distribution, inc. applications to number theory. Invariant measures and measure-preserving transformations. Ergodicity. Recurrence and ergodic theorems (Poincaré recurrence, Kac's lemma, von Neumann's ergodic theorem, Birkhoff's ergodic theorem). Applications of the ergodic theorem (normality of numbers, the Hopf argument, etc). Mixing. Spectral properties. Entropy and the isomorphism problem. Topological pressure and the variational principle. Thermodynamic formalism and transfer operators. Applications of thermodynamic formalism: (i) Bowen's formula for Hausdorff dimension, (ii) central limit theorems.

MAGIC037 Local Fields

MAGIC038 Algebraic Theory of Quadratic Forms

MAGIC013 Matrix Analysis

Introduction. Matrix products - Standard product, tensor/Kronecker product, Schur product. Decompostions - Schur form, Real Schur form, Jordan form, Singular Value decompositions. Other preliminaries - Schur complement, additive and multiplicative compounds. **Norms -**norms on vector spaces, inequalities relating norms, matrix norms, unitarily invariant norms, numerical radius, perturbation theory for linear systems. **Gerschgorin's Thorem, Non-negative matrices and Perron-Frobenius-** diagonal dominance and Gerschgorin's Theorem, spectrum of stochastic and doubly stochastic matrices, Sinkhorn balancing, Perron-Frobenius Theorem, Matrices realted to non-negative matrices - M-matrix, P-matrix, totally positive matrices. **Spectral Theory for Hermitian matrices-**Orthogonal diagonalisation, Interlacing and Monotonicity of Eigenvalues,Weyl's and the Lidskii-Weilandt inequalities. **Singular values and best approximation problems-** Connection with Hermitian eigenvalue problem, Lidskii-

Weilandt - additive and multiplicative versions, best rank-k approximations, polar factorisation, closest unitary matrix, closest rectangular matrix with orthonormal columns. **Positive definite matrices-**Characterisations ,Schur Product theorem, Determinantal inequalities, semidefinite completions. The Loewner theory. **Perturbation Theory for Eigenvalues and Eigenvectors,** primarily the non-Hermitian case.
Functions of matrices, equivalance of definitions of f(A), approximation of/algorithms for general functions , special methods for particular functions (squareroot, exponential, logarithm, trig. functions).

MAGIC014 Hydrodynamic Stability Theory

Introduction. Derivation of the Navier-Stokes equations. Boundary conditions. Non-dimensionalisation. Additional forces and equations: Coriolis force, buoyancy. Boussinesq approximation. **Basics of stability theory.** Swift-Hohenberg equation as a model. Linear stability. Dispersion relation. Marginal stability curve. Weakly nonlinear theory. Normal form for pitchfork bifurcation. Global stability. **Rayleigh-Benard convection.** Basic state. Linear theory. Normal modes. Marginal stability curve. Weakly nonlinear theory. Modified perturbation theory. Global stability for two-dimensional solutions. Truncation: the Lorenz equations.**Double-diffusive convection.** Rotating convection, plane layer and spherical geometry. Linear theory: real and complex eigenvalues, Takens-Bogdanov point. Taylor-Proudman theorem. Thermosolutal convection. Linear theory: real and complex eigenvalues. Salt fingers. **Instabilities of parallel flows.** Instabilities of invicid shear flows. Linear theory. Squire's theorem. Rayleigh's equation. Plane Couette flow. Rayleigh's inflexion point criterion. Howard's semi-circle theorem. Examples: Kelvin-Helmholtz, bounded shear layer. Role of stratification. Role of viscosity, global stability. Shear flow instabilities of viscous fluids. Orr-Sommerfeld equation. Examples: plane Couette flow, plane Poiseuille flow, pipe flow, Taylor-Couette flow. Problems with normal mode analysis. Pseudo-spectrum and non-normality. Absolute and convective instabilities. Finite domain effects.
Introduction to pattern formation. Stripes, squares and hexagons. Weakly nonlinear theory. Mode interactions. Oscillatory patterns: standing and travelling waves. Long-wave instabilities of patterns: Eckhaus, Benjamin-Feir, etc. **Introduction to the transition to turbulence.** Supercritical vs subcritical bifurcations. Fully developed turbulence. Turbulent cascade. Energy spectrum. Isotropic turbulence. Mean plus fluctuations, Reynolds stress. Closures: eddy viscosity, Subgrid-scale modelling, similarity models.

MAGIC016 An Introduction to Quantum Inofrmation

The aim of this course is to introduce basic ideas of quantum computation and quantum information. To actually process information means to to build a physical device capable of performing the required operations. If one attempts to use microscopic carriers to store and subsequently process information, on is forced to rethink the fundamentals of computation of information. Interestingly, this altered perspective not only imposes restrictions to process information but also opens up new, classically unexpected approaches.

Main paradigms of quantum information theory such as the no-cloning theorem, teleportation, and basic quantum algorithms will be presented. The ideas of doing computations quantum mechanically will be made explicit using quantum circuits.

Entanglement of quantum systems is an important feature which is thought of as a resource to perform tasks in a non-classical way. Hence, the problems of identifying and quantifying entanglement emerge, and some of the currently available tools will be discussed.

MAGIC017 Solitons in Relativistic Field Theory

Standard solitons in two dimensions (one space, one time)- such as those in the sine-Gordon model - will be reviewed along with a selection of their properties. This leads on to a description of the role of the solitons within quantum field theory, especially their scattering and bound states. There are many questions concerning the generalisation to affine Toda field theory and some of these will also be described.

MAGIC021 Nonlinear Waves

Introduction and general overview: Wave motion, linear and nonlinear dispersive waves, canonical nonlinear wave equations, integrability and inverse scattering transform (IST), asymptotic and perturbation methods, solitary waves as homoclinic orbits. **Derivation and basic properties of some important nonlinear wave models:** Korteweg-de Vries (KdV) and related equations (surface water waves, internal waves, ion-acoustic waves in plasmas, etc.). Nonlinear Schrodinger (NLS) equation, and generalizations with applications to modulational instability of periodic wavetrains (optics, water waves, etc.). Resonant interactions of waves (second harmonic generation in optics, general three-wave and four-wave interactions, long-short wave resonance, etc.). Second order models: Boussinesq and sine-Gordon equations and generalizations (Fermi-Pasta-Ulam problem, long longitudinal waves in an elastic rod, Frenkel-Kontorova model, etc.). **Properties of integrable models:** KdV equation (conservation laws, inverse scattering transform (IST), solitons, Hamiltonian structure). NLS equation (IST, bright and dark solitons, breathers, focussing and defocussing). Sine-Gordon equation (Bäcklund transforms, kinks and breathers). **Extension to non-integrable nonlinear wave equations:** Perturbed KdV equation (effects of variable environment and damping). Higher-order KdV equations, and systems (Gardner equation, integrability issues, solitary waves). Coupled NLS systems (integrable cases, solitary waves, etc.). Perturbed sine-Gordon equation (effects of disorder in crystals, kink-impurity interaction, nonlinear impurity modes, resonant interactions with impurities). **Whitham theory and dispersive shock waves:** Whitham's method of slow modulations (nonlnear WKB, averaging of conservation laws, Lagrangian formalism). Decay of an initial discontinuity for the KdV equation: Gurevich-Pitaevskii problem. Generalised hodograph transform and integrability of the Whitham equations. Applications of the Whitham theory: undular bores, dispersive shock waves in plasma, nonlinear optics and Bose-Einstein condensates.

MAGIC022 Mathematical Methods

Advanced differential equations (series solution, estimation of behaviour of solutions). Asymptotic methods (WKB, Steepest descent, Matched expansions). Transform methods. (Laplace, Fourier, Mellin, Hankel). Complex analysis, (Contour integrals, conformal mapping techniques, Cauchy-Hilbert integrals, Wiener-Hopf methods). Special functions (hypergeometric). Green's function methods.

MAGIC028 Geometric structures on Teichmuller spaces.

The hyperbolic plane and hyperbolic geometry Complex and hyperbolic structures on surfaces Covering space theory for manifolds with extra structure Uniformising theorems for simply connected surfaces with complex or hyperbolic structure. Groups of holomorphic bijections. Covering groups of surfaces. More on hyperbolic geometry. Geodesics, perpendiculars, polygons. Hyperbolic structures on pairs of pants and compact surfaces with boundary. Isotopy of loops and homeomorphisms. Ambient isotopy. Mapping class groups. Teichmuller space. Coordinates, topology.

MAGIC029 Numerical Analysis and Methods

Elements of approximation theory, orthogonal polynomials, splines, wavelets. Eigenvalue problems (theory and computational aspects). Modern numerical methods for ODE's (initial value problems, stiff problems). Solution of linear systems (modern iterative methods), computations with sparse matrices.

APPENDIX 5

This appendix contains details of the call for a Postgraduate Student Conference issued in December 2007.

MAGIC Postgraduate Student Conference

Purpose of Meetings: To foster off-line, face-to-face academic interactions between mathematics postgraduate students registered at MAGIC consortium universities.

Structure of Meetings: Organisers are free to devise their own plans for how the meeting will be structured. This may include for example, talks by students and external speakers, workshops, short courses, mini-symposia.

Timing of Meetings: Meetings may be spread over a few days during the vacation periods.

Objectives: Grants of up to £15000 are available for organisers of conferences for postgraduate students in Mathematics.

Eligibility: Applications should be made by the Chair of the organizing committee. The organising committee will normally comprise registered research students in one of the MAGIC consortium universities. The committee should also include at least one academic staff in some advisory capacity. Applications will require a formal letter of support of the host institution.

Criteria: Applications will be judged by the MAGIC Academic Steering Committee (ASC) or a subset of nominated members. Priority will be given to applications which demonstrate that any grant provided will make a significant contribution to the viability and success of the meeting. The ASC expects that the meetings which it supports will be open to all research students in all subject areas of mathematics enrolled in a research degree programme at one of the participating MAGIC consortium universities. Support of larger meetings including other research students is not ruled out, but for such meetings the grant will normally cover only a modest part of the total cost. Potential applicants should avoid suggesting dates for the conference which clash with other significant mathematical meetings in Britain such as the British Mathematical Colloquium or the British Applied Mathematics Colloquium, but if the applicants' institution is hosting such a meeting, they might wish to exploit the presence of international speakers to run a meeting in series.

Please note:

- The grant provided may not be able to fund the full amount asked for.
- Reasonable registration fees of some nominal amount per day should be charged.
- The Committee will give greater preferance to mathematical meetings covering all areas of mathematics, ie pure, applied, statistics and OR and not subject specialist meetings.
- It is expected that the conference will be organized by students for students, although academic staff members may offer guidance on planning and organization.
- Applications will require a letter of support signed by the Head of Department/School.
- Financial management will be done through the host Department/School.

Support here is intended to contribute to travel, accommodation and subsistence costs, but not registration fees, of participants and invited speakers. The application should include the name, institution and area of expertise of the invited speakers for whom funding is requested.

The grant may not be used to cover the cost of secretarial help or publicity- the registration fee may be used in this respect.

Academic and financial reports of the conference are required.

Value of award: The overall upper limit for grants is £15,000. This is normally made up of

- A basic grant which is primarily intended to cover the expenses (not salary) of principal speakers (up to £4000)
- Support for research students, travel and subsistence (£xx)
- Limited other costs.

Grants must be claimed in a specified financial year. Please ensure that you state in your application in which year you intend to claim the grant, bearing in mind that grants should normally be claimed not earlier than 3 months before, and not later than 3 months after, the event for which the grant is made.

The limits mentioned are upper bounds, not standard awards. Grants are made to meet actual expenditure on items in the application, and any surplus must be returned as soon as possible and may not be used for other purposes.

Form of application: Application forms may be downloaded at http://www.ma.man.ac.uk/~gajjar/MAGIC/conferences in RTF or PDF format. Applications should be set out clearly, and typed. They should be self-contained; please do not append substantial documents that contain irrelevant detail or refer to websites for key information. Please send all applications to

Prof. S.M. Rees, Department of Mathematical Sciences, University of Liverpool, Liverpool L69, 7ZL. Email: maryrees@liverpool.ac.uk

Queries regarding applications can be addressed to Jitesh Gajjar, (j.gajjar@manchester.ac.uk) who will be pleased to discuss proposals informally with potential applicants and give advice on the submission of an application.

Checklist: Applicants may like to note the following general checklist used by the Committee when assessing applications:

- Mathematical quality of the proposed meeting.
- Well argued proposal, with a clear statement of the mathematical component.
- Well thought out and cost-effective budget, with the request restricted to allowable costs, and an appropriate and clearly identified balance of funding from other sources and the registration fee.
- The difference made by our grant to the viability and success of a project.
- Likely beneficiaries.
- Sufficient time available for publicity for the event and the means by which it will be publicized.
- Receipt of satisfactory reports on previous grants awarded by MAGIC.

Deadlines and decision timetable: Deadlines for receipt of applications for these meetings is 20th January 2008. Decisions on the application will normally be made within 6 weeks of the deadline.

MAGIC Postgraduate Student Conference

Financial Support for Conferences – Grant Application Form

Before completing this application please refer to the guidelines for applicants.

1. NAMES OF ALL MEMBERS OF THE ORGANISING COMMITTEE.	
2. NAME OF PERSON WITH WHOM CORRESPONDENCE WILL BE MADE. (Please include title) **Address:**	**Email address:** **Telephone number:** **Fax number:**
3. DETAILS OF PROPOSED CONFERENCE **a. Title of the conference:**	
b. Venue:	
c. Starting date for the conference : **d. Finishing date for conference:**	
d. Estimated number of participants:	
4. SUMMARY OF FUNDS REQUESTED.	
On behalf of the organising committee I apply for funds for the proposed conference. The funds will be used in accordance with the guidelines and any unused funds will be returned to the MAGIC sponsors. SIGNATURE: NAME DATE	
The School/Department has examined and supports this application and will provide academic guidance and secretarial assistance in managing any funds in accordance with the guidelines. This should be signed by the Head of Department or their authorised signatory.	

SIGNATURE: **NAME** **DATE**

5. Please give a list of the invited speakers. This should include their name, brief address (ie institution, town and country) and area of expertise. Please indicate any who have provisionally accepted an invitation to attend. |Explain any reasons for choice of speakers.

3. FINANCIAL STATEMENT

A detailed breakdown of the **TOTAL** estimated expenditure together with information of expected income from registration fees, and grants received or applied for, should be given below.

EXPENDITURE

a. Fares for speakers:

b. Subsistence for speakers:
c. Publicity (e.g. printing of circulars, postage, etc.) and hire of rooms: MAGIC will not be able to pay for commercial rates for room hire.
d. Staff costs (e.g. secretarial etc):
e. Social events:
f. Other costs not listed above (such as fares and subsistence for other participants including research students):
Total Expenditure: £
INCOME **g. Registration fee: £**

Total estimated income from fees: £

Please describe what this income will be used for, and in particular how much of it will be used for administrative costs.

h. Grants received:

i. Pending applications:

ANY ADDITIONAL INFORMATION.

MAGIC Postgraduate Student Conference.
Guidelines for applications.

Applications should be submitted using the template provided and should not exceed 3 pages + 1 page letter of support in length. Minimum font size is 10pt.
Please send 1 hard copy (with signatures) and one electronic copy of the proposal to
Prof. S.M. Rees, Department of Mathematical Sciences, University of Liverpool, Liverpool L69 7ZL. Email: maryrees@liverpool.ac.uk
The deadline for this year is 20th January 2008.

Page 1. Please give the following details:

1) Names of members of the organising committee. To be eligible the members of the organising committee will need to be enrolled on research degree programme at one of the MAGIC consortium universities.
2) Give the name and contact details of the person (say Chair of organising committee) with whom all correspondence will be made.
3ab) Give details of the proposed venue for conference. Organisers should have checked availability of the venue for the proposed dates and any costs of hiring the venue before making the application.
3c) Give the provisional dates for the conference. Checks should be made that these do not clash with other major meetings at the proposed dates.
3d) Estimated number of applicants. Some research here may be necessary.
4) From your budget plans how much MAGIC money do you need to make this work. Signatures are required from your Head of School/Department to confirm the readiness of your institution to host the meeting and that the financial administrators in your Dept/School are aware of and have checked the details of your application.

Page 2)

6) Give the names and details of invited speakers including areas of expertise. Please indicate those who have provisionally accepted. Mention briefly why these speakers have been chosen.

Page 2, 3) Financial Statement Expenditure. Please give details of the estimated expenditure and budget under the headings:

6ab) Expenditure for speakers including estimated costs for fares and subsistence for each invited speaker. Some speakers may be able to cover their costs.

6c) Cost of publicity and hire of rooms. It may not be possible to fund rooms at commercial rates.

6c) You need to budget for any IT staff and secretarial costs for help in managing meeting and finances. Finances will normally be handled through your departmental financial administrators, so they will be able to advise you or likely costs. The costs for this can be covered by the registration fee only and any grant awarded may not be used for this purpose.

6e) Estimated costs for travel for social activities, for example conference dinner. Note that EPSRC rules mean that alcohol may not be purchased by this grant. Any purchases of alcohol, e.g., for conference dinners should either be made directly by participants or should be covered by the registration fee.

6f) Estimated costs for travel and subsistence for student participants. Check out typical accommodation costs and budget for a capped contribution (say £50)towards travel costs.

6f) Miscellaneous other costs (fully itemised).

Work out the estimated expenditure from the above items

Financial Statement, Income. Please give details of the estimated income under the following headings.

6g) Registration fee to be charged, and total estimated income from registration fee. Explain what the registration fee will be used for. [For example to cover secretarial costs].

6h) Any grants received. Organisers are free to apply to other learned bodies and other potential sponsors for help with finances. Mention any sums promised.

6i) Any pending applications. Are there any other applications pending for the same meeting, and give an indication of when the decisions for it will be announced.

Please use the free space to add any other information that will help evaluate your proposal.

Letter of Support.

The application should be considered by your School/Department who need to check that the financial details are appropriate. A formal letter signed by the Head of School/Department is required as part of the application. This letter should mention that a) the members of the organising committee are fully registered research students in their institution; b) the School/Department supports the application c) the School/Department will provide the required secretarial assistance in managing the funds; d) the host institution will provide the necessary accommodation and conference facilities.

Additional notes.

Successful applicants will receive a formal letter advising them of the funds allocated and the procedures for obtaining the funds. Funds will not normally be issued more than 3 months earlier or later than the conference start and end dates. A final report will be required not later than 3 months following the end of the conference. This should include a detailed financial statement showing income/expenditure, together with a copy of the conference programme and book of abstracts. It is expected that all sponsors will be fully acknowledged in any publicity material, abstracts and proceedings.