Institute of **Physics**

THE HIGHER EDUCATION GROUP

NEWSLETTER No 6 • May 2008

A Welcome Note

Greetings to all members of the *Higher Education Group*, and to others interested in Higher Education Physics who have found this newsletter on the web or in a staff common room, etc. Our group exists to provide a forum for discussion of issues and exchange of ideas relevant to staff and students in higher education, and we welcome new members to help us in this direction. The Group has strong links into the *Institute of Physics*, obviously, but also to the *Physical Sciences Centre of the Higher Education Academy,* with whom we share similar aims. We recognise that different Higher Education Institutions are going to remain to some extent in competition with each other, but there is a great deal that we can do collectively. We can promote the many good things going on and being developed across our sector, and share ideas and techniques to the benefit of students and staff alike. We are pleased to have gained a healthy number of new members in recent months, but would like to recruit more of the many people in Higher Education in the UK for whom our activities must be of relevance. Once you have read the newsletter, please might you pass it on to an interested colleague?

Our October meeting on *e-learning* attracted a good-sized audience, and was considered very successful. The December meeting on *soft condensed matter* had a similar attendance. Several people went away considering the possible introduction of more on this topic to their degree programmes. The slides used in the meeting are now posted on the Group's website. In February we were pleased to see members of both the *Education Group* and the *Higher Education Group* at our meeting looking at *engaging students in their physics studies*, at both school and university level.

The next meeting, which is on May 14 in Edinburgh, looks in particular at the *experience of entrant physics students*. This meeting is held in collaboration with the *Physical Sciences Centre of the Higher Education Academy.* We are pleased to showcase a number of speakers who have demonstrated success in their areas. Topics to be covered included the use of clickers to engage students in large lecture classes, problem-based-learning, first year projects, innovative labs, and PDP, all within physics. In addition, we are pleased to have input on mathematics support, and the conclusions from a study across Scotland looking at the first year experience and how it may be enhanced. Details of this and other meetings are on the Group's website that is accessible via the Institute of Physics core pages. Meetings under discussion for the coming year include "Mathematics for physics graduates", *"Vision for Optics and Photonics Teaching", "Improving the student experience in teaching labs and projects", and "What will new school leavers know?".*

The Group's *AGM* was held in November, where a number of changes were, as expected, made to the committee. *Eamonn Cunningham* stepped down as secretary to the Group, and we wish here to pay tribute to his input to the work of the Group over several years. Fortunately he remains on the committee. We thank all the retiring members for their contributions, and welcome several new faces onto the committee.

We look forward to meeting you at one of our forthcoming meetings.

Bruce Sinclair
(University of St Andrews), HEG Secretary

Raymond C Jones
(University of Birmingham), HEG Chair

Online training for a new stream of Physics Teachers

A new initiative encourages people with a Physics degree to train to become physics teachers while still in work. *πCETL (Physics Innovations Centre for Excellence in Teaching and Learning)*, Leicester University has provided a physics content module for the online course.

The *iTeach* programme, a joint venture between Christchurch College, Canterbury, and Hibernia College, Dublin, offers *Post-Graduate Certificates in Education* via distance learning. Leicester's involvement has provided a twenty-unit module for "rusty" physics graduates to refresh their knowledge and, most importantly, to develop their ability to see physics as the key to solving interesting, relevant problems. The course consists of online lectures and voice-conferenced tutorials. Instead of opting for a didactic approach of serial content delivery, the Leicester team of authors have used their experience of *Problem-Based Learning* to structure the course around real-world scenarios. Students see how complex problems pose the need for theoretical solutions, and, initially follow through how the problem can be broken down, simplified, and investigated. Having watched guided examples, students can then practice and discuss further questions, all the while picking up useful experience of communicating the importance and relevance of physics in preparation for the classroom.

By basing the course around complex problems instead of a traditional topic-by-topic approach, the module also aims to influence the way the trainee teachers think about delivering physics. The πCETL team, led by *Professor Derek Raine*, believes that being able to learn online using this investigative approach will encourage physics graduates who are currently in non-physics careers to become confident, enthusiastic, and communicative physics teachers.

Sarah Symons
(πCETL, University of Leicester)

Items for the Newsletter

The Newsletter aims to provide a platform for the exchange of news, information, activities and ideas between those active in the Higher Education and those who have an active interest in the subject. The Newsletter is published twice per year. This is the sixth edition covering the period between October 2007 and May 2008. If you would like to make a contribution (news, activities, conference reports, articles, diary dates, letters, book reviews, etc.) to the seventh edition of the Newsletter, please send it to the Newsletter Editor:

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The Bologna Process

The *Bologna Process (BP)*, an intergovernmental initiative, was set up in June 1999 with the aim of creating a *European Higher Education Area* (EHEA) by 2010 and promoting the European system of higher education worldwide. The broad objectives of the process are:

- to remove the obstacles to student mobility across Europe;
- to enhance the attractiveness of European higher education worldwide;
- to establish a common structure of higher education systems across Europe;
- for this common structure to be based on three main cycles: Bachelors, Masters and Doctoral level qualifications.

The process originally established six action lines, which has now grown to ten, to implement the objectives. Progress is ratified by a *Ministerial Summit (MS)* held every 2 years with these summits being supported by two groups: The *Bologna Follow-Up Group* (BFUG) and the *BP Board*, both organised and administered by the *Bologna Secretariat*, which is run by the hosts of the next ministerial meeting. The number of signatories has grown from 29 to 46 countries.

The UK system of HE differs greatly from systems in most of the rest of Europe. In the UK we have no national degrees, no automated requirement for external accreditation (very common in the rest of Europe). Degrees in the UK are awarded by autonomous institutions. The *Academic Infrastructure*, regulated by the *Quality Assurance Agency* (QAA), is a set of external reference points to manage the standards and quality of UK HE. The view of the QAA is that these are reference points, to be used as a starting point for intelligent engagement within institutions, thereby supporting a diverse range of appropriate programmes. The importance of ever-changing external contexts is relevant to developments in HE. These include: student demographics, modes of delivery and study, collaboration, the skills agenda (the business-facing university) and future funding. The European context has a greater emphasis on mobility within HE which requires a more transparent mechanism for comparing qualifications across Europe. The 10 BP action lines are formulated, by necessity, in very general terms to facilitate participation from diverse countries with very different approaches to education. Agreement would not possible with too much detail or a prescriptive approach. The BP is a dynamic one which will continue to change and develop. The establishment of the *EHEA* in 2010 is not an endpoint but a significant stage in a much longer process. The current BFUG programme involves work in: *employability; global setting); mobility; life long learning; grants and funding portability; data collection; recognition of qualifications*. The BP does not have overarching legislation; sanctions; policemen or inspectors. There is a requirement to register national *QAAs* which will be subject to periodic review. Within the BP framework there is no homogeneity; no rules on years per programme (except that 1st cycle qualifications must have a 3 year minimum period). The BP is intended to be characterised by comparability, mutual recognition and compatibility rather than legislation and standardisation.

The *EHEA Quality Framework* (EHEA-QF) is the overarching framework within the BP. Only national qualifications frameworks are required to articulate with the EHEA-QF. In the UK the QAA have stated that this is a matter for them which they have in hand and that this is not to be implemented at institutional level. As a step in this process the QAA is undertaking a review of the *Framework for HE Qualifications* (FHEQ) for England, Wales and N. Ireland. Scotland has its own framework – *the Scottish Credit and Qualifications Framework* (SCQF) reflecting the different periods of study in Scottish HE institutions. The SCQF has already been successfully self-certified against the EHEA-QF. *Bill Rammell, as Minister of State for HE* has asked that the QAA put forward the FHEQ for similar self-certification at the next available opportunity later in 2008. When this is completed both the SCQF and the FHEQ will be appropriately mapped onto the EHEA-QF as required within the BP.

The issue of credit within the BP has been discussed at considerable length. The 2003 MS called for the *European Credit Transfer System* (ECTS) to be adopted within the BP. The ECTS was introduced by the EC in 1989 to facilitate transfer of credit between institutions. Originally conceived as a credit transfer system it has been recognised that the ECTS tool requires further development to enable it to function as an effective credit accumulation system. The 2007 MS called for the EC to undertake a full review of the ECTS framework. The EHEA-QF specifies credit ranges for different qualifications within the BP framework. *First cycle (Bachelors)* qualifications typically include 180-240 ECTS credits, *second cycle (Masters)* qualifications typically include 90-120 ECTS credits, credit for *third cycle (Doctoral)* qualifications is not specified. There is, as yet, no final agreement on the EC review of ECTS. The ECTS user guide will be revised to a large extent as a result of UK lobbying. At present many hold the view that the EC has an overly prescriptive legislative framework for ECTS. Given that the ECTS framework has been adopted by the BP it is appropriate to review it to ensure it is consistent with the aims and approach of the BP. The *European University Association* has produced a statement indicating that education institutions wish to take ownership of ECTS away from the EC and make further developments. The statement also commented on inappropriate prescriptions within current legislation. The EC response to this is not known at this time. One example of current EC legislation with respect to ECTS is that it is not possible to accumulate more than 75 ECTS in a calendar year. This effectively prevents a 1 year Masters programme within the BP. In the UK the situation on credit is varied. Universal credit frameworks exist for N. Ireland, Wales and Scotland. Many institutions in England use credit for transferring between programmes or institutions, and some use ECTS for transfers within Europe. *The Steering Group on Measuring and Recording Student Achievement chaired by Prof Burgess, VC of Leicester University*, has recommended a credit system for England. A consultation on this is currently being conducted by the QAA. The UK credit systems are compatible with ECTS. Guidance on the articulation between UK credits and ECTS is difficult at present as both are either in flux or awaiting final development. The Annex in the Burgess report relates ECTS to credit as currently used in the UK. Broadly UK credit is compatible with ECTS but ECTS has an overemphasis on workload. In countries where BP has been dealt with by legislation, at the national level, there is a strong demand for something easy to count i.e. workload or hours of study. The UK approach is to emphasise *learning outcome* (based primarily on student achievement). The latter has proved difficult to present in much of Europe. Administrative staff working in government ministries generally has little interest in, or detailed understanding of, learning outcomes. The ongoing review of ECTS was recently described at a recent UK QAA meeting as probably not going far enough in response to strong lobbying from the UK. The eventual outcome of this review is not known but it is hoped that it will enable ECTS to become a proper credit transfer and accumulation system which would truly address the BP objectives. There are a range of differing views of quality across Europe. There are widely held views that achievement of learning outcomes are pre-determined or substantially influenced by other factors such as length of periods of study or the highest level academic qualification of the teaching staff. These other factors can be measured more easily and readily use as a proxy for the achievement of learning outcomes. These types of metrics are favoured by Ministries of Education in many countries and serve as metrics to measure successful completion of academic programmes. Learning outcomes are not recognised or currently welcomed in most of Europe. There is a vigorous ongoing discussion over the pre-eminence of learning outcomes versus length of period of study. In many countries those engaging with the BP are civil servants in government ministries and not the academic community. There is a very different view of the academic issues in these cases.

A recent review undertaken for the *Universities UK Europe Unit* looked at the national legislative frameworks in four countries (*France, Germany, Netherlands and Bulgaria*). In each of these countries the duration of 1st and 2nd cycle programmes is defined by law in FTE terms, the year length defined by law, ECTS per year defined by law, and the annual workload is defined by law in Germany and Netherlands. This also showed that there exists considerable variation in the length of Masters' programmes. Currently Germany has 1, 1.5 and 2 year programmes; Netherlands has 1 year humanities, and 2 year science and engineering programmes. France has 2 years but other second cycle qualifications are possible. Different approaches to Masters' programmes also appear in different countries. Research oriented or application oriented Masters must be offered by law in Germany. The Netherlands has research masters and standard masters. France has full masters over 2 years delivered over 2 separate stages. Any student with a correct subject background has the right of entry into the first stage. The second stage has selective admission with very tight limits on numbers. The first stage is a viable stopping off point and is marketed as an "intermediate" degree. The review concluded that there is enormous diversity with: no single model; no required "Bologna" approach, with no obligation to change existing programmes.

When the BP was initiated in 1999 the UK, in contrast to many European countries, had a two cycle (Bachelors plus Masters) systems. Many countries had to undertake substantial revisions in their HE system which, in many cases, was achieved by national legislation. From the UK perspective it is often difficult to appreciate the substantial changes which have occurred in many Bologna countries. One of the strengths of the UK system is *institutional autonomy* allowing a wide range of educational provision to be developed. This has resulted in a very different response to the BP in the UK. Many countries have taken a rigid legislative approach in their response. The BP was originally conceived as an intergovernmental process recognising that this would be the only way to achieve the objectives. A prescriptive approach would be too rigid. It is worth noting that the original European Treaty does not give legislative competence in the area of HE. However the role of the EC in the BP has grown considerably. The EC now has the status of full member alongside the 46 member countries. The adoption of the ECTS tool as a mechanism for recording credit has also given the EC significant influence in the BP. The EHEA will come into being in 2010. In the longer term many of the objectives of the BP will be realised. There are further changes to consider in the UK, one of the most pressing for Physics is the future of the *Integrated Masters*. The eventual fate of this qualification will depend on the development of a national system of credit in the UK and the outcome of the EC review of ECTS. The debate over Masters level qualifications has focussed primarily on the length of the period of study. However as has been shown above the UK has been representing this issue as one of student achievement more correctly measured through learning outcomes. The language of "3+2" or "4+1" representing periods of study is widely used across Europe but may ultimately be unhelpful in presenting the UK position. The real test of the success of the BP will be the extent to which UK qualifications are recognised in practice across Europe by individual institutions. There is a growing view that the one year Masters programme as offered in the UK has many competitive advantages. There is also a growing group who view this with interest across Europe. Ultimately it may well be the cost effectiveness of programme which will determine those that continue in the longer term, which is a process not controlled by any Bologna factors. Employability beyond the UK does require consideration of the requirements of national jurisdictions and although the BP is not prescriptive with regard to this some national legislative frameworks are. Ultimately the real benefit of the BP has been as a stimulus to discuss a range of issues which have forced us to question why we approach HE in the UK the way we do. Whatever your view of the purpose of HE in the UK it is essential that it continues to be viewed as attractive, high quality and competitive by potential applicants outside the UK. It is also very important that UK graduates are regarded as well qualified across Europe and beyond. In this regard the UK must continue to engage with the BP.

Bibliography

1. UUK Europe Unit section on Bologna process http://www.europeunit.ac.uk/bologna_process

2. Bologna Ministerial Summit, London May 2007, http://www.dfes.gov.uk/londonbologna/

3. http://www.dfes.gov.uk/londonbologna/uploads/documents/6909-BolognaProcessST.pdf

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Physical Sciences Question Bank

Aims

The aim of the *question bank* is to facilitate the sharing of questions, and to promote the use of formative assessments. The use of automatically marked electronic assessments can save staff time, as can the sharing of such questions instead of using only those you have prepared yourself. The creation of questions with feedback truly designed to help student learning can be a complex task, and so the gains from sharing these types of question can be even greater. We wish to promote the use of all such questions in ways that help students learn. The way the question bank interface is implemented is aimed at making it easy for academics to find sets of suitable questions and to download them in a form suitable for their local virtual learning environment or assessment system.

Features

Questions from the bank can be used with *WebCT, Blackboard, Moodle* and *SToMP* or they can be downloaded as *Rich Text* (.rtf) files for printing. In this case, the answers and feedback are contained in "*hidden*" text, that can be displayed or hidden on screen or when printing, as desired. Questions can also be downloaded in an *xml form* suitable for import into *Questionmark Perception or Respondus*. All the questions in the bank have marks ascribed for correct responses, and so they are all appropriate for summative use. Most of the questions also have feedback and are thus potentially suitable for formative use, although for questions to be most successful in helping students learn, the way the questions are used has to be tailored to the style of the feedback.

Content

Questions received so far have come from publicly funded projects at *Ulster, Hull, Bath, Edinburgh, Southampton and Surrey*. We have received over 3000 questions from these sources, of which about *500 Chemistry* and over *300 Physics* questions have been processed and are incorporated. More will follow as time permits. The processing of the questions involves converting to a common format, *reviewing*, editing, adding metadata and converting to the required formats for the target systems. Much of this is automated, but each question has to be dealt with individually for at least the review, editing and metadata stages. Where necessary, reviewing is mainly concerned with improvements to feedback. *Editing* deals with such things as the elimination of site specific or presentation specific detail and the style of the feedback (e.g. including 'yes' or 'no'). *Metadata* is added as the questions are imported into the database and some of the most crucial metadata is that used to support the browsing and searching functions of the user interface. The questions contributed so far have, by a very large majority, been of the *multiple choice style (MCQs)*, with the next most frequent being multiple selection and text entry.

The user interface requires users to select a *target system* (e.g. a VLE) before questions can be identified for download. Only questions available for the chosen target system are displayed in the lists, and for WebCT, Blackboard and Moodle only multiple choice, multiple selection and pair matching questions are currently being supported. One of the problems with other question styles is the lack of conformity between the systems in the way these questions are handled, particularly as regards answer conditions, marks and feedback. If you would like to find out more about these issues, a paper that was prepared by this project but was assimilated into a wider discussion by the *JISC CETIS*, is available at:

http://wiki.cetis.ac.uk/Assessment_item_banks:_an_academic_perspective

It is intended that the question bank will be populated with an increasing number of questions over time, and that new features will be introduced to make it easier to find and use the questions. There will be a need to learn how the bank is used and what colleagues want, before doing much work on such enhancements. For example, once downloaded, would you want to stick with the same selection of questions in subsequent years, using your assessment system's archive to store them, or would you return to the bank to create a completely new set of questions, or would you want to choose a new set based upon the previous year's selection but with minor revisions?

Access

The question bank is freely available to all academics working in the *UK HE or FE sectors*, and can be reached from the *Physical Sciences web site*. Under "*projects*" select "*JISC/DEL:E-Learning Projects*" where you will find a link to the "*Question bank project*". The question bank itself can be reached from "*Question Bank*" link at the bottom of the page. At the moment, the interface only works properly in *Internet Explorer 6 or 7*, but it is soon to be available for *Mozilla* browers such as *Firefox*, as well. The site is password protected and you should email either the Physical Sciences Centre at **psc@hull.ac.uk** or Dick Bacon at **r.bacon@surrey.ac.uk** for details.

Dick Bacon
(University of Surrey)

Soft Condensed Matter Physics, 12th December 20

Each year the *HEG* has organised a meeting addressed at some particular area of physics which might, in some sense, be novel or which might have strong claims for inclusion in the undergraduate physics curriculum. This year it was the turn of *Soft Condensed Matter Physics (SCMP)* to stake its claim for a place in the curriculum. Most Physics Departments routinely offer modules in conventional Condensed Matter Physics (CMP) and the question must be asked whether this is always the most appropriate material for a modern undergraduate course – with its emphasis on *Bragg Spots, Brillouin Zones, Densities of States* and other topics. Are these really the topics which we should still be teaching our students when the research world has moved on to the study of *polymerised material* and *biological systems* - properties of which may be more familiar to students than will the properties of crystalline materials. In this meeting five experts discussed material on SCM which has been introduced into the undergraduate programme in their own Universities.

Athene Donald from *Cambridge*, in a challenging overview of the topic, began with two important quotations. The first, from the *The EPSRC International Review of Physics (2005)* said *'….it is the perception of the Panel that there are quite a few physics departments where students get little, if any, exposure to modern SCMP. This is regrettable, because SCMP has deep links with many other areas of science, whilst the theoretical concepts and experimental techniques of this field are of direct relevance for biophysics. In addition, SCMP has many industrial applications.'* and a second quotation came from an article by *Ray Goldstein* from the March 2005 issue of *Physics Today* and entitled *Teaching Biological Physics* which included the paragraph: *'Many physics departments teach a collection of undergraduate courses whose outlines are similar to the menu of 30 years ago, despite the fact that the research interests of physics faculty have changed dramatically. The curriculum must change. In particular, we believe that biological physics must become a mainstream course in all physics departments, offered as regularly as, for examples, courses on solid-state or high-energy physics.'*

The general tenor of these quotations ran through the remainder of the day's meeting. The meeting was reminded that the kinds of materials of interest to Soft Matter Physicists were everyday substances such as soap, paint, yoghurt, liquid crystals and putty and that they would be very familiar to any student. Their typical length scales were intermediate between those of typical atomic and macroscopic length scales and were usually described as being *mesoscopic*. and their energy scales were of the order of k_B T at room temperatures so that fluctuations were very important and timescales were often of the order of seconds at room temperatures. In including such material in an undergraduate programme it was probably better to start by looking at the content of introductory *Properties of Matter* and *Statistical Mechanics(SM)* courses rather than at conventional CMP courses and introducing the ideas of SM into these as illustrative examples. Familiar substances such as inks could be used as illustrative examples because in many ways they were model hard sphere fluids. The links between polymers and the random walk were well known and could be introduced at an early stage. She felt that in many ways (with apologies to the Plasma Physics community) liquid crystals could be thought of a as a fourth and very important state of matter. Important experimental techniques such as neutron scattering and X ray scattering could be well illustrated by their use in studying glasses and amorphous materials.

Mark Geoghegan (Sheffield) discussed and contrasted a conventional approach to teaching CMP (with its emphasis on the crystalline state and the electron theory of solids) to teaching SCM. In the latter, understanding of intermolecular forces was still needed but ideas drawn from thermodynamics on phase separation could be well illustrated by examples from SM and where knowledge about industrially important wealth generating products such as *hydrogels* (used in wound bandages) could be married to fundamental ideas in SM. Liquid crystals also gave an important platform for illustrating ideas such as *chirality* and *viscoelasticity* gave an important illustration of the importance of timescales in understanding the macroscopic behaviour of materials. He pointed out that a second year *Thermal Physics* module was an ideal place to introduce many of these ideas in the context of teaching both statistical physics and thermodynamics. He also provoked comment by asking those present to examine their consciences and ask how much outdated material was still included in their own University programmes. He urged those present to look particularly at the content of their lab modules, their electronics modules (which he felt need no longer be considered an crucial part of a physics degree programme) and their computer programming.

Tom McLeish (Leeds) in a typically thought provoking, yet entertaining, talk argued that 10^9 could be regarded as the first really important large number since on that scale everything appeared more or less spherical whereas the first really significant small number was probably 10^{-9} since on that scale Brownian motion becomes clearly manifest. He pointed out that in a typical second year introductory module on *SM* it was just as possible to illustrate the basic techniques of statistical mechanics by modelling a macromolecule as a random walk (under constant tension) as an alternative to discussing the more usual spin _ paramagnet in a constant magnetic field. Ideas such adiabatic demagnetisation could be introduced by talking about the temperature changes which occur in a piece of rubber when it is alternatively stretched and contracted - these ideas are very easy to demonstrate to a class of students and are likely to be more accessible and real to a group of students familiar with the properties of rubber bands rather than the behaviour of spin systems at very low temperatures. Simple ideas about liquid crystals could be introduced in a year 3 SM module and followed up in the fourth year with a more detailed treatment of aspects of *Biological physics*.

Emyr MacDonald (Cardiff) described an interesting module taught at Cardiff on *Large Molecules and Life* which introduced the physical concepts relevant to understanding macromolecules and which related successfully to other undergraduate modules in areas such as thermal physics. He emphasised, as had previous speakers, that the module required an understanding of some conventional and important material on molecular interactions and bonding and also well illustrated many ideas on mixing and segregation which were common in many thermal physics modules. The fact that much of the bonding was weak and covalent implied that many bonds must be considered in looking at biological molecules. Roughly 14 lectures were devoted to formal teaching of the relevant background material and the remaining was devoted to a reading project in which students had to learn to extract the relevant physical ideas from papers and articles which often had a high biological content - of which physics students would only have a limited background knowledge. In answer to questions he believed that most students got a great deal out of the module and that he was able to bring them to a level where they could function effectively on a reading project.

The final speaker was *Mark Warner* whose talk effectively pulled together many of the threads spun by previous speakers. He himself had a particular interest in *Liquid Crystals and Rubbers* and illustrated a number of the points he made with some effective demonstrations. He had in the past taught such material at advanced undergraduate level and many of the ideas he described offered a significant intellectual challenge for students. The order parameter needed to describe liquid crystal ordering was inherently tensorial in character and provided a welcome alternative to *General Relativity* as a place where tensors might be introduced and used in a non trivial way in an undergraduate course. The theory of liquid crystals required a different Free Energy from that used in more conventional magnetic systems because it was the geometry of the problem which determined its thermal physics. He also discussed the inherently nonlinear continuum mechanics of such systems where considerable ingenuity was needed to picture the geometry being described by the mathematics. The talk concluded with a description of rubber elasticity in which he emphasised, as had previous speakers, the importance of understanding the properties of a simple random walk in order to appreciate that the free energy describing rubber elasticity is entropy dominated and that there were fascinating problems to be looked at related to shape and distortion.

The meeting concluded with a discussion between the panel and audience. One common theme had emerged from all speakers and that was the need to introduce many of the ideas very early in an undergraduate programme via a *Properties of Matter* module in which illustrations could be just as easily drawn from Soft Matter as from other more conventional areas of Physics. Fundamental to an elementary presentation was an understanding of the random walk and its place in simple models of macromolecules. Likewise even before specialism began, a second year *Thermal or Statistical Physics* course could draw on Soft Condensed Matter physics as a rich source of illustrative examples – different from those usually used. There was much scope in the third and fourth years for a stand alone specialist module in SM and the range of topics discussed by the different speakers demonstrated how varied such

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an module might be and how it might also act as a platform for introducing more conventional but important techniques (such as X-ray or neutron scattering) just as well as could conventional *CMPs*. The speakers offered a convincing case for making the changes needed to introduce these ideas into most physics courses. However it was recognised that a serious impediment to drawing non specialists into such teaching was the absence of what was described as a *Kittel* of soft matter – a single textbook to which non specialists might refer, read and from which they might select material. Absence of such a book was likely to prove a significant obstacle to colleagues who might wish to take up the challenge of teaching in a less familiar area. There were questions about whether the material would in fact require too sophisticated an understanding of Statistical Physics and Thermodynamics for the average undergraduate and also whether (in abandoning teaching for example ideas about a density of states) genuinely important physics such as the T^3 phonon contribution to the specific heat of a solid might be lost. The point was made strongly that if changes were to occur to the undergraduate programmes then it was vital for the SCM Community to engage in a dialogue with the groups such as *The Institute of Physics's* accreditation committee which should be made fully aware of the importance of the topic and of the comments of the *EPSRC International Review of UK Physics*. It had proved to be an exciting and challenging meeting which produced many thought provoking ideas.

Raymund C.Jones
(The University of Birmingham

Research-Teaching Linkages in the Physical Sciences

What does the title of this piece meant to you? What are *'Research-Teaching Linkages'* and why should we be concerned about them? Arguably these are the two primary functions of a University – *the creation and dissemination of knowledge;* but how do they relate to each other? Are they in benign co-existence, or antipathy and competition? Should they be better integrated and if so what is in it for us and our students by doing so? And how does this relate to the changing nature of the student cohort who arrives at University to study towards Physics degrees? We are no longer in the business of just educating the minority who will become the next generation of ourselves, but rather must aim to enable all students who study our subject to think about science like a scientist.

Most people would probably equate research-teaching linkages to *learning about research,* via exposure to advanced topics of a staff member's research interest in lecture courses. Some may also include the aspects of a student curriculum that are targeted towards *learning to do research;* the skills and experience developed in practical work and the final year research project experience. But what about *learning through research;* applying the skills and enquiring approach to learning all through the undergraduate programme? And finally, there is *research-informed teaching* in which an academic becomes involved in research into the way in which his or her subject is taught, with a process of deliberate and systematic enquiry into teaching and learning in the discipline.

We have recently completed a project funded by *QAA* Scotland in the **Physical Sciences** looking at some of these issues as part of the *Enhancement Theme* on *'Research-Teaching Linkages: Enhancing Graduate Attributes'*. The project ran throughout 2007, and surveyed the landscape across Physics and Chemistry departments in Scotland, with the aim of finding out what is currently being done across this part of the sector to foster these links, and to present some of the practices we have unearthed in an informative and digestible manner. We have found a rich array of practice, across the breadth of the curriculum from first to final years, across many different institutions and course/subject areas. These have been prepared as a series of over 25 case studies and snapshots of practice, that provide a clear and concise description of the activities and their applicability outwith the courses they were originally implemented in. Examples include redesigned lab work towards more open-ended and less recipe-like activities; experimental tutorials, linking theory and practice in the discipline; workshop-style tutorials to foster both subject and also more generic graduate skills; project and placement skills training prior to this major part of the curriculum, together with a survey of graduates to find out what they considered to be the most important attributes they took away from their time as undergraduates. Our final report is currently being peer-reviewed for publication and will be published in the Autumn. In the meantime, there are more details of the project and its aims, including case study tasters, available online.

http://www.enhancementthemes.ac.uk/themes/ResearchTeaching/default.asp

http://physci.rtl.googlepages.com/

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A Review of the Student Learning Experience in Physics and Astronomy

The Higher Education Academy Physical Sciences Centre is undertaking a **Review** of the student learning experience in physics and astronomy this year. The review will produce a report which provides a snap shot picture of the student learning experience from entry into Higher Education to graduation.

We consider this to be a very timely development for the physics and astronomy especially with the national HEFCE focus on physics as a subject of strategic importance. The increasing need to maintain levels of student recruitment and retention has led to an increase in the level of curriculum development activity and the design of innovative programmes. The level of this activity is likely to increase with the impact of the *HEFCE-funded IOP Stimulating Physics project.* Consequently, there is a need to understand how physics and astronomy are currently taught in Universities and whether innovative teaching and assessment is being "rolled out" from where it has been developed and whether the needs of industry and government agenda are being addressed.

This review will provide academics, curriculum planners, professional bodies and HEIs with an accurate view of academic practice in departments, the trends in the nature of undergraduates entering our courses and in their chosen field of employment. We will attempt to identify trends in pedagogies, identify the main teaching, learning and assessment methodologies being employed and pinpoint good practice in order to raise the quality of the student experience in physics and astronomy across the UK.

The *Review* is being carried out over a 18-month period from March 2007 to September 2008 and are being be steered by a panel of key stakeholders which includes the IOP. The Review Panel is Chaired by *Bob Lambourne* of the *Open University* and *IOP Higher Education Group*. The other members are drawn from academia, employers, professional and other bodies with some cross-disciplinary representation. The review process is being ably supported by a part time Consultant, *Mike Edmunds* from *Cardiff University,* who is an experienced astronomer and someone who is well versed in the IOP accreditation requirements and procedures.

The data for the review is being gathered by staff and student questionnaires and questionnaires and interviews with *Directors of Teaching*. Quantitative data will be gathered from sources such as *HESA* and the *NSS* results. For the Review to be successful and to provide the whole academic physics and astronomy academic community with useful information we are relying on cooperation and collaboration from ordinary academics in University departments. We hope that you have already completed a questionnaire and encouraged your students to do so. A final opportunity to do so will be made available after the Easter break. If you would like any further information about the Review please contact Mike Edmunds at **mike.edmunds@astro.cf.ac.uk** or the Centre at **psc@hull.ac.uk.**

Tina Overton
(Director, Higher Education Academy Physical Sciences Centre)

Physics Education Research for Minimalists

It is a widely acknowledged fact that adults do not read instruction manuals. Instead they assume that with a little bit of trial and error their extensive experience can be brought to bear on any situation. This is particularly important when academic researchers are called on to do some teaching, since it appears to save a lot of time and effort if one believes that there is no literature out there that might provide any useful guidance. Of course, it does not alter the situation to be told there is in fact a great deal of literature available on educational research in physics. I am reminded of the student faced with a comprehensive reading list for a module who asks what it is that he "really" supposed to read! So this piece is about the little that anyone who teaches physics might want to know about educational research, with apologies to those who know it already.

My first choice is a *Scientific American* article on expertise[1]. It has nothing in it about physics, but it explains why so many staff room conversations end up as wakes on the theme of how stupid students are. Amongst other things, the article describes a well-known experiment in which chess masters and novices were briefly shown various positions on a chess board and then asked to recall them. If the chess pieces were arranged in a way that might realistically represent the state of a game then the masters were vastly superior to the novices in recalling the positions. For chess pieces arranged at random there was much less difference. This shows that experts structure memories differently from novices. The difference has been given the name *"chunking"*: pieces of information, up to a certain limit, that are sufficiently familiar are stored as a whole not as individual components. The standard illustration of this is telephone numbers: one recalls familiar ones as a single unit not as a string of unrelated individual digits. What does this mean for the teaching of physics? Here is an example intended to illustrate how different is the students' perception from that of the expert, while at the same time showing how, with conventional approaches to teaching, the two are operationally indistinguishable.

The following is the students' view of a lecture in which they are making their first acquaintance with the material. Summarising somewhat, the lecture has presented them with the following equations and an exercise to test their *"understanding"*:

$$\circledR\, N = 0 \qquad \propto \circledR\, N = \nu_0 \mathrm{k} \qquad \mathrm{N} = \nu_0 m O \qquad \mathrm{G} = \pi t^2 N$$

Exercise: A long dparmpof of radius $t = 0.02$ m has $m = 10000$ yitmd per metre and a vittrmy $O = 1$ szq. What is the zshmryov goraf N at its centre? What is the gaic G through the dparmpof? ($\nu_0 = 4\,\pi \Leftrightarrow 10^{-7}$). What I've done is to leave the words that would be familiar to students but coded the ones that would be new. Just as in the random arrangement of chess pieces, this degrades the ability of the expert to "chunk" the material and hence to some extent emulates the experience of the novice student. However, the crucial point is that (if we assume the physical units have been given consistently) the exercise can be done by pattern matching: no "understanding" is required here in order to demonstrate an operational facility. For the record the subject matter is *magnetostatics* in a somewhat different, but consistent notation!

The problem has been recognized for some time in the context of *laboratory work* in physics where the operational aspects of setting up the equipment and taking accurate readings can also become completely divorced form any conceptual understanding, for the good reason that attempting both at the same time overloads the student's working memory[2]. Many programmes have now improved on the scripted lab with the introduction of pre- and post- lab exercises.

We have a similar situation with what is now widely referred to as *"the mathematics problem"*. In my view the problem is widely misunderstood. It is not that students do not know this or that technical piece of mathematics: it is that they have not *mastered* mathematics at all. When I mark a calculation I don't read it symbol by symbol: like the chess master I read it as a whole and, if the answer is wrong, I can focus in on where the calculation begins not to look right. Likewise when I face an unfamiliar problem I can draw on a repertoire of examples to find a familiar starting point. These exemplars have to be more than a set of remembered manipulations, but must be conceptualized to make possible a comparison beyond the merely operational. The most important point to my mind is to accept that there is a problem which *"improving"* the traditional lecture does not address. How can we begin to tackle the problem?

One of the conclusions of *Ross's* Scientific American article is that expert chunking requires a great deal of practice. One of our professors of applied mathematics at Leicester tells me that in Moscow he completed over 10 000 exercises as part of his training. I guess that our students fall short by about an order of magnitude. However, the development of physics and mathematics intuition that goes beyond rote learning can be helped appreciating the difference between the way in which knowledge is presented and the manner in which it is constructed, a distinction summarized in the saying that the expert is the person who has made all of the mistakes. So as a second set text I suggest an article on *generative mathematics*[3]. In this paper *Burn* contrasts the formal manner of theorems and proofs in which mathematics is presented, with the way in which such knowledge is discovered. In this approach the student has to unpick the context and thought processes that lead to a theorem or lie behind a proof in order to see why the world works that way. The same is true of physics even if we do not use a formal structure of theorem and proof: one might say that the traditional approach provides the solutions before the student is aware of what the questions are.

In the context of Physics considerable research has gone into how students can be helped to a conceptual understanding by taking them through a step-by-step development of the material, particularly by the *Washington school*[4]. The essential point here is that the structure of the material is the result of properly conducted research into its effectiveness. Students build up their intuition through a series of practical and theoretical exercises that address one issue at a time. It is surprising at first how many individual steps are required to build a conceptual understanding of physics which can connect it to how the world behaves, rather than to how one is required to say it behaves in a physics examination. I am personally not convinced of the underlying assumption that physics can be given such a linear structure. You may not wish to follow the method, but you should take a look to see how many notions we often erroneously take for granted. The important point is that students have to build their own understanding. Paradoxically perhaps, an important approach is through collaboration by means of which students can test their understanding. For an example of the effectiveness, which will also serve to introduce the *standardised methods of testing*, see ref[5].

Many possible approaches to *collaborative learning* have been proposed and implemented. My own interest is in *problem-based learning* because it attempts to replicate the research experience at undergraduate level. This means that we encourage students to behave as professional physicists from the beginning, not as professional students. Implementing PBL in physics is not without its difficulties, but a range of experience is available to show how it can successfully address the issues we have raised[6]. No academic physicist would carry out their research without knowledge of the scholarship of their subject. We seem to be quite content to shape the lives of generations of students on the basis of *"tradition"* or of opinion and whim. Of course, the current status of educational research is not sufficiently advanced to provide a guide book to good teaching, nor perhaps will it ever be so. But nor are its results valueless or its ambitions less than noble. Finally, I hope I have not disappointed anyone who wants a long comprehensive reading list[7].

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Derek Raine
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Engaging Physics Students, 20th February 2008, University of Leicester

This meeting explored ways of generating student engagement in physics across a range of areas. The techniques considered ranged from direct approaches such as student mentoring and the development of more engaging curricula, to indirect methods based on teacher fellows and teacher training. A number of those attending the meeting were also involved in the *IOP's Stimulating Physics (SP) project* which addresses many of the concerns raised at this meeting. Although there was no direct link between this meeting and SP, it was good to see that those involved in the project were so willing to share their detailed insights and experience with the wider membership of the IOP through this meeting of the *HEG*.

There is a strong ethos of engaging physics in the *Leicester Department:* many items relating to astronomy, space research and various branches of physics are prominently displayed in the entrance foyer and in other parts of the building. The meeting took place on the first floor, amidst the recently refurbished and re-equipped labs, computer rooms and meeting areas that facilitate Leicester's innovative *Problem-Based Learning* approach to undergraduate physics.

After some introductory comments from the meeting's principal organizer, *Derek Raine*, the first presentation was by *Tracey Parker*, the *Leicester Department's* outreach officer. She spoke about engaging students through the *IOP Mentoring Scheme*. As the Scheme's mentoring coordinator for the Notts. region, she is responsible for recruiting mentors and mentees, and for monitoring the e-journals that keep them in contact. The mentees are typically school science students in years 9 to 13, while the mentors are enthusiastic undergraduates or science professionals willing to provide encouragement, support and guidance to the mentee but not do their homework! The scheme, operated by the IOP in partnership with the *Brightside Trust*, provides training for the mentors and ensures that all contact is through the *Bright journals* website where each mentee has his or her own e-journal. The Scheme is still in its pilot stage at present, and will be until July 2009, but it already involves 17 mentors and 55 mentees with 9 more mentors awaiting training and 27 mentees waiting to be assigned to mentors. The pilot is going well and the schools involved have been very enthusiastic. You can get some more insight into the scheme by visiting the website: www.bigbangblogs.org which shows some of the magazine style articles and activities that support those involved in the Scheme.

The second presentation, by *Vicky Adrienne*, concerned the *IOP Teacher Fellow Scheme*. To put the Scheme in its proper context she briefly outlined HEFCE's 1.8 million pound SP Project run through the IOP. The Project has two strands, one concerned with stimulating demand, the other with access. The Teacher Fellow Scheme is part of the *access strand* (as is the *ISciences programme* in which Leicester is participating), while e-mentoring, along with industry visits and improved careers advice, belongs to the *demand strand*. Teacher Fellow *Debbie Davis* explained to the meeting that in her case a year-long Fellowship was allowing her to spend 2 days per week at the Bristol University while continuing in her post as physics subject leader at a comprehensive school. An important aim of the Scheme was to facilitate the exchange of information between physics teachers in schools and universities. A Teacher Fellow can provide a university physics department with information about developments in school teaching and pedagogy while gaining insight into modern teaching practices at the university. The hope is that this interchange will enrich the Fellow's background and enable them to give better advice to potential applicants, possibly leading to an improvement in retention. She reported that amongst other positive achievements the Fellowship had reignited her passion for physics and helped her to promote physics university courses.

The ever innovative *Bob Newport* from the *Kent University* spoke about his efforts to use the science in movies and computer games to engage students on *Foundation Programme in Physics*. The programme running since 1993 currently attracts about 25 students per year. These are students without the traditional A-level qualifications, many of them mature, who are well equipped to make the most of free-flowing discussions. He explained the origins of his *'Physics at the Movies'* activities, gave several dramatically illustrated examples, and spoke about the way in which students' scientific writing skills could be improved by requiring them to produce a 2000 word essay about the physics in a movie clip.

The next speaker was *Paul van Kampen* from *Dublin City University* (DCU). He discussed the huge gap between the way science is practiced and the way in which it is taught, and suggested this was one of the reasons why so many found school science boring. Accepting that teachers will generally teach as they were taught, he described the way science teacher education at DCU is organized emphasising features such the strong base of subject content knowledge, the student centred physics education project and the teaching of electromagnetism by the guided enquiry method. It was clear that the programme had been significantly influenced by the findings of the *Physics Education Research Group* at the *Washington University*, and there were plans for further developments inspired by that group. *Sarah Symons* continued the theme by describing Leicester's role in engaging trainee teachers through an on-line course making use of *PBL*. The course is part of a 2 year part-time *PGCE* offered by *iTeach*, a partnership between *Canterbury Christ Church University* in the UK and *Hibernia College* in Ireland that aims to deliver flexible on-line initial teacher training to students across UK. The students taking the course have 200 hours to revise their generally rather rusty knowledge of 1st year physics achieved through the completion of 20 individual study units, each containing an asynchronously studied recorded lecture, a synchronous follow-up tutorial and 8 hours of individual study. Each unit is based on 1 central problem, e.g. the required height of a shot tower or the behaviour of a space tether.

The meeting ended with contributions that examined curricular developments at two different institutions. *Paul van Kampen* returned to talk about the rethinking of the first year labs that had taken place at DCU and *Frances Laughton* described developments in the physics curriculum at *Bath*. *Paul* outlined some of the general findings to emerge from *physics education research* regarding lab work and showed how these applied to the case of DCU. He gave particular emphasis to the value of 30 minute pre-lab discussions to prepare students for the investigations that followed, the need for active student engagement and the avoidance of 'cookbook' approaches to lab work. He also stressed the importance of proper training for the (post-graduate) lab demonstrators and the vital role played by faculty in carrying out the educational research, tutoring the students, marking their work and providing appropriate feedback. *Frances* addressed the problem of developing students' skills in problem solving and self-directed learning in the context of a department with 28 academic staff that specialised in photonics, nanoscience, condensed matter and space and planetary science. The changes described were systematic and wide ranging, but particularly noteworthy was the final year BSc unit built around one big problem that could be approached on the basis of knowledge gained in Years 1 and 2. The problem involved the planning of a space mission and required the students to work in teams (each with their own Moodle page) that individually addressed issues such as propulsion, navigation and communications, electricity generation and target encounter. Each week the teams must resolve a specified challenge, such as identifying an appropriate launch site. He pointed out that students faced with a challenge will now turn first to Google, so it was important to make sure the answer was not immediately available there. Other findings were that the teams should contain no more than 5 students and that it was advantageous to include real problem solving in the preliminary assignments. The students found the challenge stimulating and interesting, good for their team-working skills and worked hard. In short, they were engaged.

Bob Lambourne

(πCETL, The Open University)

"Those who can" teach as well, you know: The role of a University Teacher

Over the last two-three years, the *Physics Departments* at the universities of *Glasgow*, *St Andrews* and *Edinburgh* have begun to appoint academics in *"teaching-only"* posts. These positions go by various names: university teacher, teaching fellow, teaching development officer, but in each case the idea is the same – create a position, or positions, within a Department for people with an active interest in the teaching of Physics and allow them to focus on that interest without asking them to also try and maintain an active Physics-research career, as per a "traditional" university lecturer position.

I was the first *University Teacher* appointed at *Glasgow,* back in September 2005, and in this article I am going to try and give you some idea of what my job entails. I am also, hopefully, going to give you the arguments for why teaching-only positions (whatever name they go by) can greatly benefit Physics departments, as well as the teachers themselves. My work covers active teaching, administrative and supportive roles, and teaching development. The active teaching, totalling roughly twice that of a lecturer, covers lecturing at all levels of undergraduate studies, demonstrating in undergraduate teaching laboratories and running tutorials (both large, whole class groups and smaller groups of 4-5 students). On the administration side of things I act as *Class Co-ordinator* for large first year courses, organise departmental summer schools for university applicants, sit on various departmental and university-wide committees, and so forth. In my supportive role I act as an *Adviser of Studies for Physics and Astronomy* undergraduates and the Department's *International Students Co-ordinator.*

So what of *teaching development?* Now this is where the value of a University Teacher can be best seen. Whilst teaching-only appointments benefit departments because we can relieve some of the teaching load from fellow academics by the simple fact that we teach *more*, we are in a position to devote all our time to not only improving our own teaching, but that of our whole Departments.

Teachers have a real enthusiasm for their teaching, just as traditional lecturers have for their research. We are willing, and able, to invest similar resources into our teaching. Just as researchers travel the length of the world to keep up with the latest developments in their fields, so teachers travel to education-related conferences, meet with colleagues to discuss new innovations in teaching, read the latest education journals and so on. We act as conduits by which the latest teaching methods and innovations can be brought into a Department. We also have the ability to look at the teaching in our Departments from a wider perspective – we are not restricted to our own courses. This enables a more *integrated approach to teaching* to be created. Someone with a teaching-only appointment has the enthusiasm, determination and (perhaps most importantly) the time to put into improving the teaching of Physics in their departments, time which a traditional academic would normally spend in their research lab. In my own work, for example, I have been able to implement wide-ranging changes to our first year undergraduate teaching laboratories. For the first time in many years, there was someone available with the time needed to spend on a complete, ground-up renovation. And the results have been tremendous, with the students rating their experiences in the laboratories far higher than previously. Similarly, another teacher at *Glasgow, Morag Casey*, has driven forward a scheme of active support for our first year students in her role as *Director of Learning Support*. For the first time, the Department has the ability to identify and help students who are showing signs of academic troubles early enough in the academic year that they can be helped within that same year. And in *St Andrews*, teaching fellow *Antje Kohnle* has been responsible, amongst many other projects, for the development of a *formative computer-based assessment system*.

Hopefully it is clear that the existence of such teaching-only appointments within a Physics Department is of great benefit to those Departments. But what of the teachers themselves? Personally, I think the best thing about my teaching-only appointment can be best summed up by a phrase that a fellow teacher at *Glasgow, Ross Galloway*, coined: *"teaching guilt"*. This is the idea that many traditional lecturers would very much like to spend time improving aspects of departmental teaching, but feel they must focus their time on their research. They must maintain their publication records, bring in suitable grants and so forth. They simply do not have the time needed to fully commit to teaching renovations and innovations. As a University Teacher, though, I am specifically charged with the task of dealing with all aspects of teaching, therefore I'm not plagued by "teaching guilt". I derive much satisfaction from being able to dedicate my time to getting my own teaching just right and helping improve the experiences of our undergraduate students throughout their degrees.

What I've tried to do here is give you an idea of what a *University Teacher* is, what they do, and why they are of benefit to their respective departments. I would never suggest that teaching-only appointments should ever replace the traditional lecturer. I do believe, though, that having the two types of academic working side by side greatly benefits department and students alike.

Peter H. Sneddon
(University of Glasgow)

Calendar of Educational Physics Events

8th - 13th June, 2008; Bryant University, Smithfield, Rhode Island , USA; Gordon Research Conference on Physics Research and Education; *Computation and Computer-Based Instruction*. (http://www.grc.org/programs.aspx?year=2008&program=physres)

19th – 23rd July 2008; Edmonton, Alberta, Canada; 133rd National Meeting of the American Association of Physics Teachers (AAPT); *Physics From the Ground Up* (http://www.aapt.org/)

23rd – 24th July 2008; Edmonton, Alberta, Canada; AAPT PER Topical Group; Physics Education Research Conference 2008; *Physics Education Research with Diverse Student Populations*. (http://www.compadre.org/PER/features/NewsDetail.cfm?id=154)

18th – 22nd August 2008; Nicosia, Cyprus; International Group for Research in Physics Teaching and Multimedia in Physics Teaching and Learning; GIREP-MPTL Conference 2008; *Physics Curriculum Design, Development and Validation*. (http://www.ucy.ac.cy/girep2008)

4th - 5th September 2008; University of Edinburgh, Edinburgh, Scotland; Higher Education Academy Physical Science Centre and Physics Innovations Centre for Excellence in Teaching and Learning; *2008 Physics Higher Education Conference (PHEC)*. (http://www.heacademy.ac.uk/physsci/events/detail/phec_2008)

4th - 6th September 2008; Poiana Brasov, Romania; European Physics Education Network (EUPEN) 10th General Forum; *Physics Studies; Global Views, Local Need* (http://www.eupen.ugent.be/)

Early October 2008; Manchester University, Meeting of the IOP Higher Education Group; *Mathematics for Physics Graduates*. http://journals-of-physics.org/activity/groups/subject/hed/index.html)

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