

Institute of Physics  
Higher Education Group

## What School Leavers Will Know

Technical Meeting  
Leicester, 13 May 2009

There are changes in arrangements for school and college physics syllabi across the UK, and this meeting aimed to update colleagues on what this will mean for the sets of skills and knowledge that we can expect in our entrant student in years to come. Derek Raine organized the meeting with assistance from John Williams and Bruce Sinclair. The meeting attracted 28 attendees. The speakers' slides and audio commentaries will be made available to UK HE physics departments and online at <http://www.open.ac.uk/picet/>.

We were pleased to have a good range of speakers representing different aspects of the issue.

The Teachers' Perspective was given by Helen Pollard (Oakham School and IoP Network Coordinator for the East Midlands) talking about the International Baccalaureate and Gillian Chang (teacher in Oxford) on the results of the current A-level programmes. David Hayton (King Henry VIII School) gave an interpretation of the pupil perspective of the current physics A-levels.

After lunch John Miller (OCR) gave a useful overview of the changes coming in with the revised A level syllabi, and Bob Kibble (Edinburgh University) described the evolving situation with Scottish qualifications. Malcolm Carr-West (Higher Education Academy) told us about the development of the Engineering Diploma that has now started being taught, and Derek Raine gave a preview of the Science Diploma, which may be relevant to entrants to University in 2014.

All the speakers spoke of changes that were designed to improve the learning of physics through making courses link more strongly to the wider world, and attempting to reduce the amount of "plug and chug" assessment items.

### **International Baccalaureate**

Helen suggested that this was a qualification that was gaining in popularity, and which gave pupils a wider perspective than A levels. It was also perceived as being more demanding to get the top grades than A levels. Gareth Jones noted that in his study of first year students at Imperial College those who were well qualified at IB on average out-performed A-level qualified students. The amount of physics and maths contained in an IB qualification can be chosen by schools and pupils. The Higher Level course in physics was described as a thorough, rigorous, and wonderful treatment. One quarter of the work is internally assessed, with the only examinations being at the end of the two years. 25% of the teaching time is intended to be on practical work, which includes experiment design. The Higher Maths unit contains no mechanics. The demanding nature of the qualification may lead to less time for diversions into topics of particular local interest, but had the advantage of at least 1.5 times more physics coverage than some A-level courses. There was still substantial mathematics in the physics section, though calculus can be avoided entirely.

<http://www.ibo.org/diploma/curriculum/>

### Current A-levels

Gillian had looked at comments from current pupils about A-level physics. She presented these to the meeting after commenting that the average A-level physics pupil was a great person to work with.

*“This is boring”* – some topics have been covered multiple times in a spiral curriculum, with electrical circuits being given as one spectacular example.

*“GCSE to A-level is a big jump”* – this was illustrated by some GCSE exam questions where students were very strongly led to put numbers into a partially identified equation. In contrast, A-level exam questions tend to require much more problem solving.

*“This is stupid”* – if quantum theory and particle physics are examined in the January of AS then they are done before the pupils have a proper understanding of Newton’s laws and waves, which causes problems.

*“I thought I’d hate it, but it’s really good”* – aspects of astrophysics at GCSE can be particularly well received, and telescopes and resolution go down particularly well at A level. Gillian commented that the thermal physics option is popular at her school.

*“What can we learn about ... (boys) relativity and quantum mechanics (girls) useful stuff?”*

*“You’ve made maths make sense”* – many pupils like seeing maths in action.

*“Is there a course like this at University”* – some pupils would like to hear more (possibly from external speakers) on philosophy and history of science.

David had given his good students studying A2 physics and maths some probing questions from Derek Raine. These had promoted good discussions and his pupils had enjoyed doing them. Pupils found it relatively difficult taking concepts that they were familiar with in one context and using them in another. They were taken aback with multiple choice questions with more than one possible correct answer and did not consider all the possibilities. Buoyancy ideas have disappeared from the syllabus and the students had to work from first principles. David invited university staff to visit his (or possibly other) schools to see how much the pupil learning experience had changed since many university teaching staff were there. In discussion he noted that some 60-80% of each of the physics A-levels consists of common core material. Although there are modular exams that can be taken multiple times, there is an element of synoptic examination at the end of the A-level course.

The QCA specifications to which all boards work are on page 15 to 17 of [http://www.qca.org.uk/libraryAssets/media/qca-06-2864\\_science.pdf](http://www.qca.org.uk/libraryAssets/media/qca-06-2864_science.pdf)

### A-level Changes

John started his presentation with comments on revisions at GCSE. As well as the compulsory single combined science GCSE there are now additional science GCSEs and an entitlement to do GCSEs in each of the individual sciences for appropriate students. These all contain an element of “how science works” including a critical approach to data, appreciation of ethical issues and an understanding of risk. The new A-levels were set in motion by the Tomlinson report in 2002 followed by QCA statements in 2006. The new specifications are now being taught, though again there are variations in style and content between exam boards and between different offerings of one exam board. The new A-levels now have two written exams and 20% of course work in each year. The physics A-levels change as follows:-

- AQA A is not much changed in content
- AQA B physics in context is a new approach, stimulated by the Salters Horners A level examined by Edexcel
- EdExcel has one specification but may be taught in a context based (Salters Horners) or traditional format
- OCR A traditional syllabus has little change in content
- OCR B Advancing Physics has been tweaked a little to include a critical approach to measurement, and also relativity in the second year.
- CCEA and WJEC have little change in content

There is little change overall in what is studied by the end of the course, but there is more development of material due to the changes at GCSE. A significant change is the specific inclusion of “stretch and challenge” elements in the A2 examinations to allow exam boards to determine which students should be awarded an A\*

grade. These will not be separate questions, but will be embedded within the mainstream questions to test the best. In particular, some questions will be less atomistic, requiring the candidates to work out their own steps through a problem, and there will be aspects of extended writing and extended use of algebra. A\* grades overall need an aggregate grade of at least A, and a UMS (Uniform Mark Scale) score of at least 90% of the grades in the A2 assessments. There is currently no limit to the number of resits allowed on unit exams. Universities should be able to get a breakdown of unit marks if they wish. John's view was that there was not going to be a large change in the content of the maths A-levels.

For a list of the relatively small changes between the previous and revised OCR Advancing Physics arrangements please see

[www.ocr.org.uk/Data/publications/support\\_materials/A\\_Level\\_Physics\\_B\\_SM\\_What\\_Has\\_Changed.pdf](http://www.ocr.org.uk/Data/publications/support_materials/A_Level_Physics_B_SM_What_Has_Changed.pdf)

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### **Scottish Qualifications**

Bob commented that there were both similarities and differences between the Scottish system and elsewhere in the UK. Each school in Scotland has at least one physics-qualified teacher; there is only one exam board available for state schools in Scotland, and the number of schools is sufficiently modest that an annual physics teacher meeting can be held at which all schools can be represented. Formulae sheets are now used in the Scottish exams, though with no explanation of symbols given. The Scottish Advanced Highers are broadly equivalent to A2, Scottish Highers to AS, and Standard Grade to GCSEs. The newer Intermediate 1 and 2 qualifications are used in some schools by some or all pupils either side of Standard Grade.

There are major changes pre-Standard Grade with the introduction in Scotland of a "Curriculum for Excellence". The Highers course has been repackaged into more contemporary-sounding physics units, and a similar course of action is planned for Advanced Higher. Current outcomes at Advanced Higher result in pupils being well versed in standard techniques, differentiation is widely used, uncertainties are treated well, and rotational mechanics is strong. Pupils are generally less well versed in modern physics and have not had so much experience in discussion answers. There has been concern at the amount of mathematically-based "problem solving" in existing examinations, so the new Highers exams will contain more in the way of text-based analysis and explanation.

<http://www.sqa.org.uk/sqa>

### **Engineering Diploma**

There are a 17 Diplomas being developed 14 of which are keyed to major areas of the British economy. The aim of the Diplomas is to teach a broad range of topics, but to do so in the context of the subject of the Diploma. In the Manufacturing and Product Design diploma for example history, might be taught through costume-design while in the Engineering Diploma it could be through the lives of great engineers. The hope is that more students than currently will see the reason for studying a range of topics if they are linked in well to their chosen Diploma topic. All Diplomas are to be delivered by a consortium of schools, colleges, and companies. There is some concern that this may lead to a low take-up in the independent sector. Diplomas will come with a transcript showing the units taken and grades received within them. The Advanced Diploma is the level most that will be offered as an entry qualification for HE, and is intended to be equivalent to 3.5 A Levels, being worth 420 UCAS points. The Advanced Engineering Diploma is currently being taken by some 150 pupils. It has been developed with major input from the sector skills councils as well as university engineering departments. For engineering related courses the inclusion of OCR Level 3 Certificate in Mathematics for Engineering in the additional and specialist learning will ensure sufficient knowledge of mathematics. This course has been specifically designed by university academics to meet the needs of engineering degree courses.

<http://www.engineeringdiploma.com/universities.aspx>

### **Science Diploma**

Derek Raine presented this topic, which included information from Tina Overton who has been on the development team. After deciding on a range of Diploma topics in “vocational” areas a Minister had decided to introduce “academic” Diploma topics. The first Science Diploma courses have now been postponed by a year to 2012, and there was speculation that they may not survive if there is a change of government after the next Westminster elections. Derek presented survey results from pupils, teachers, and employers, carried out as part of the research into the diploma, showing what the different groups might want in the qualifications. As currently proposed the science diploma when containing additional specialized learning in physics, would have the equivalent of one physics A level but only the AS part of a maths A-level. As such it looks more like a route into a foundation year of an English university, though it may be possible to take extended maths to bring its maths and physics content up to the equivalent of two A-levels. As with other diplomas there is the intention to have two weeks of work experience, but there is reportedly some concern from employers about finding relevant and worthwhile such experiences.

### **Mechanics in A-level**

Gareth Jones (Imperial College) commented on the outcome of a meeting last year on “Newton’s Mechanics, Who Needs It?”. Attendees were cautioned that in the current maths A-level students may study no mechanics. He encouraged universities to advise potential applicants to study at least AS further maths in order to increase their familiarity with important mechanics. He also expressed some concern about comparisons between current A-levels and continental European qualifications.

### **In the Discussion ...**

The possibility for Universities to influence the GCE curriculum

The need for Further mathematics or some mathematical extension work within the A’level provision for those serious about studying this subject at university

	Old Physics A-level	Revised Physics A-levels	IB	Advanced Higher (with Highers before)	Advanced Engineering Diploma
First year that students will finish programme		2010	No changes	No changes in AH in immediate future, new content and assessment to be introduced 2014.	Summer 2010
Last year that students will finish programme	2009 with resit possible 2010	-	No changes	-	N/A
Significant new features		Assessment structure more uniform across different specifications	Core: (HL, and SL) Energy degradation and Power generation and climate change HL only: Digital technology		Taught in the context of engineering
Magnitude	One A-level	One A-level		One A-level	Three A levels 1,080 guided learning hours
Overview		QCA subject criteria for science specify that Physics A level should contain: Mechanics (vectors, kinematics, dynamics, energy, momentum, circular motion and oscillations) electric circuits (current, DC circuits, emf & p.d., resistance, capacitance) Waves Matter (kinetic theory and internal energy) Quantum and nuclear physics (photons, particles, nuclear decay and nuclear energy) Fields (electric and gravitational fields, B-fields and flux and electromagnetic induction), and that these topics should constitute approximately 60% of the A level.	Physics component contains:-  Core (Standard & Higher) – Physical Measurement, Mechanics, Thermal, Waves, Electricity & Magnetism, Atomic and Nuclear, Digital technology  Additional Higher – takes these topics to greater depth + Quantum/Nuclear, Energy + climate change  Options (choose two in second year)– from Biomedical Physics/History & Development of Physics/Astrophysics/Relativity/Optics	Highers course (one year) precedes Advanced Higher course (one year). Each has unit continuous assessment and end of year exam.  Highers:- Mechanics & Properties of Matter Electricity & Electronics Radiation & Matter  Advanced Higher Mechanics Electrical Phenomena Wave Phenomena Investigation	Physics component contains The engineered world 60 GLH Discovering engineering technology 270 GLH Engineering the future 60 GLH Analytical methods for engineering 150 GLH

Contains project or other major open-ended investigation?		Edexcel and OCR B (Advancing Physics) both contain these	Extended essay – students choose which subject to study.	Investigation in Advanced Higher. Appropriate set of AH and Highers in science can be added to with an “Interdisciplinary Project” worth half an AH to get the Scottish Bacc in Science.	
Contains compulsory work experience?		No	No	No	10 days
Lab work by pupils?		All of them	yes	Yes	Yes
Design of experiments by pupils?		Both Edexcel and OCR B (Advancing Physics)	yes	No	Context based
Delivered as context-based or traditional.	Either route is possible	For Edexcel, either route is possible. AQA B is the only other context-based approach.	Either, but traditional is more likely	Traditional	
Development of questioning attitude?		Surely all of them!	yes		Yes
Amount of Calculus used in Physics?		Used but not required. In all the specifications, the notation and meaning of calculus is required rather than the mathematical techniques	None required	$a = dv/dt$ , $\alpha = d^2\theta/dt^2$	
Amount of Calculus used in associated maths qualification?			HL Approx 1/6 of time devoted to differential and integral calculus		Equivalent to A level although some may be seen as from applied
Modular or end-of programme assessments?	Modular, may retake module assessments.	Modular, may retake module assessments.	End	End of programme exams and interim unit test.	Some of each
% of continuous assessment		Generally 20% centre-based assessment (CCEA is 26%)	24	0	Varies from board to board but Maths for Engineering has none

<b>Example content</b>					
$PV=nRT$	✓	✓	✓	X	✓
$H=mc\Delta T$	✓	✓	✓	In Standard Grade	✓
$E=q/4\pi\epsilon_0 r^2$	✓	✓	✓	✓	✓
Biot Savart law	X	X	X	X	
$a = -kx/m$ , show $x = A\cos(\omega t + \phi)$ is a solution	Only in maths A level but numerical/computational approaches used to support it	Only in maths A level but numerical/computational approaches used to support it	✓	✓	✓
Escape velocity	✓	✓	✓	✓	Not as such
Projectile motion	✓	✓	✓	X	✓
$I=\Sigma mr^2$	AQA A option	AQA A option	X	✓	✓
$U=I\omega^2/2$	AQA A option	AQA A option	X	✓	?
$E=mc^2$	✓	✓	✓	✓	X
De Broglie wavelength	✓	✓	✓	✓	X
Photoelectric effect	✓	✓	✓	In Higher	X
Snell's law	✓	Not in QCA core now	✓	In Higher	X
Thin lens equation	Some	Some	x	x	X
Young's slits	✓	✓	✓	✓	X

Thanks to Helen Pollard, Gillian Chang, David Hayton, John Miller, Bob Kibble, and Malcolm Carr for their inputs to this table.

A-level core content listing at

[http://www.qca.org.uk/libraryAssets/media/qca-06-2864\\_science.pdf](http://www.qca.org.uk/libraryAssets/media/qca-06-2864_science.pdf)

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