How science works in A-level physics

All of the new GCE physics specifications reprint in an appendix or in some other way the QCA subject criteria relating to “how science works”. Curiously, these were not included in the 2005/2006 QCA consultation, which attracted a huge response from science teachers. Instead they were quietly added in afterwards and, unhelpfully, awarding bodies were given little guidance about their implementation. This has resulted in important differences between AS/A2 physics specifications.

Crudely, “how science works” has the following aspects:

- the nature and limitations of scientific knowledge (hypothesis and prediction, links between data and explanation, modelling, and the role of the scientific community in validating new knowledge);
- scientific enquiry skills (experimental skills, data handling and assessing the quality of data);
- communication (using scientific language, mathematical skills and presenting data);
- applications and implications of science (technological decision making in the context of benefit versus risk and ethics).

Of these, the second and third aspects have conventionally been considered essential to any A-level physics course. Depending on the specification, the first and last aspects are more likely to be innovative.

When deciding which specification to adopt, I suggest that you refer to the above list and consider the following key points:

**The specification**

What “how science works” content statements appear in each assessment unit? In the AQA Physics A specification, for example, these are shown separately in Section 3.7. How clearly are the learning outcomes specified? Will you know what you have to teach?

**The sample assessment material**

Are example “how science works” questions included? What mark weighting do they have? Particular questions in sample examinations can help you to interpret specification requirements. If there are no relevant questions, either the awarding body is paying lip service to an aspect of “how science works” or your students may be caught out on a real examination paper.

**Useful resources**

Two websites, supported by the Institute, can help you to teach “how science works”:

- www.practicalphysics.org has briefings on scientific enquiry, with links to many experiments that can be used to develop experimental and data-handling skills. It provides historical case-studies illustrating the nature of science and it is linked to experiments that students can do.
- www.peep.ac.uk (the Physics and Ethics Education Project) is a relatively new website. This shows how tools for ethical analysis can be used to think about controversial issues in science and society. There is a range of case-studies, made interactive by including student activities.

**Peter Campbell**, Nuffield Curriculum Centre

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**Introduction**

Schools and colleges in England, Wales and Northern Ireland will have to start teaching a new A-level specification from September 2008. If you are still undecided as to whether to stick with what you know or to change, we hope that this supplement might help you with your deliberations. The specifications table contains a summary of the seven new courses from five examination boards, outlining the key features of each (pp2–4). There is a brief description of the topics covered in each unit and information about the internal assessments for units three and six.

In addition, Peter Campbell of the Nuffield Curriculum Centre gives some useful advice about “how science works” in the new specifications and what you might want to look out for (p1). Teachers in institutions where they have already made a decision share the reasons for their choice, commenting frankly on their particular circumstances and the constraints that they are working under.

There is also a little more detail about the AQA Physics B (physics in context) course. Some of the examination boards, in conjunction with publishers, are producing resources in a similar format to those produced for the new GCSEs. While some of these are still in development, those for Advancing Physics and Salters Horners Advanced Physics are in the process of being fully revised, in the light of experience, for the new specifications.

For more details about the individual specifications, and the support and resources on offer, visit the websites of the individual examination boards:

- www.aqa.org.uk
- www.ccea.org.uk
- www.edexcel.org.uk
- www.ocrb.org.uk
- www.wjec.co.uk
- www.york.ac.uk/org/seg/salters/physics
- www.advancingphysics.iop.org
- www.peep.ac.uk

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**Advanced Level Physics Specifications**

**AQA A**
- **Key Features**
  - Momentum; circular motion; electric and magnetic fields;
  - Practical (20 marks); approx two experimental tasks, three short and one long, performed under plan (in advance), carry out an experiment, record measurements, tasks chosen from a selection;
  - Communication: imaging; digitising; refraction; lenses; sampling; quality of measurement (20 marks);
  - PSA (9 marks); ISA (41 marks) – the an experimental task plus data-analysis task performed under plan (in advance), carry out an experiment, record measurements, tasks chosen from a selection;
  - Rectilinear motion; forces; energy and power; fluid flow and waves; interference; diffraction; polarisation; refraction; photons;
- **Unit Titles**
  - PHA5A: Energy and Power;
  - PHA5B: Electromagnetism, Nuclei and Medical Physics;
  - PHA5C: Waves and Particles, Microscopes and Medical Imaging;
  - PHA5D: Processes, Experimentation and Data Analysis;
  - PHB3T, centre-marked route T; practical skills assignment (PSA);
  - PHB3X, centre-marked route X; practical skills verification (PSV – teacher verification);
  - PHA6T, centre-marked route T or PHA6X, externally marked route X.

**AQA B**
- **Context**
  - OCR A
  - AQA A
  - Edexcel and Pearson are also similar to traditional optional element in coursework style.
  - This specification is identical to traditional practical arrangements are as for AQA A.
  - PL4A 2: Practical Techniques.
  - PHB3G: Processes, Experimentation and Data Analysis.
  - PHA6T, centre-marked route T or PHA6X, externally marked route X.
- **Unit Titles**
  - Introduction to Waves;
  - Oscillations and Fields;
  - Waves and Particles, Microscopes and Medical Imaging;
  - Processes, Experimentation and Data Analysis;
  - Practical Skills Assignment (PSA).

**CCEA**
- **Key Features**
  - Momentum; thermal physics; circular motion; SHM; the nucleus; results (20 marks).
  - Approximately 5 questions (60 marks);
  - Approximately 7 structured questions.
- **Unit Titles**
  - Unit G494: Rise and Fall of the Universe.
  - Unit G495: Field and Particle Phenomena and Electricity.
  - Unit G496: Researching Physics.
  - Unit G493: Physics in Practice.
  - Unit G491: Mechanics.
  - Unit G492: Standard Mechanics; simple bulk materials properties and Young's modulus.
  - Unit G490: Waves and Particles, Microscopes and Medical Imaging.
  - Unit G497: Physics from Creation to the Universe.

**WJEC**
- **Key Features**
  - Momentum; circular motion; electric and magnetic fields; Practical (20 marks); approx two experimental tasks, three short and one long, performed under plan (in advance), carry out an experiment, record measurements, tasks chosen from a selection;
  - Communication: imaging; digitising; refraction; lenses; sampling; quality of measurement (20 marks);
  - PSA (9 marks); ISA (41 marks) – the an experimental task plus data-analysis task performed under plan (in advance), carry out an experiment, record measurements, tasks chosen from a selection;
  - Rectilinear motion; forces; energy and power; fluid flow and waves; interference; diffraction; polarisation; refraction; photons;
  - Approximately 5 questions (60 marks);
  - Approximately 5 structured short-answer questions plus data-analysis question.
  - Approximately 5–8 very short questions plus 3–5 long questions.
  - Approximately 7–8 short-answer questions.
  - 5–8 long questions.
  - Approximately 5–8 very short questions plus 3–5 long questions.
  - 5–8 long questions.
- **Unit Titles**
  - Unit 1 Physics on the Sca
  - Unit 2 Waves, Photons and Particles.
  - Unit 3 Exploring Physics.
  - Unit 4 Oscillations and Fields.
  - Unit 5 Physics from Creation to the Universe.
  - Unit 6 Energy under the Microscope.
  - Unit 7 Waves and Particles, Microscopes and Medical Imaging.
  - Unit 8 Processes, Experimentation and Data Analysis.
  - Unit 9 Investigative and Practical Skills in AS Physics.
  - Unit 10 Investigative and Practical Skills in AS Physics.

**OCR B**
- **Key Features**
  - Momentum; thermal physics; circular motion; SHM; the nucleus; results (20 marks).
  - Approximately 5 questions (60 marks);
  - Approximately 7 structured questions.
- **Unit Titles**
  - Unit 1; 120 min; Ext; 15%.
  - Unit 2; 105 min; Ext; 15%.
  - Unit 3; 75 min; Ext; 15%.
  - Unit 4; 90 min; Int; 20%.
  - Unit 5; 75 min; Ext; 15%.
  - Unit 6; 75 min; Ext; 15%.
  - Unit 7; 75 min; Ext; 15%.
  - Unit 8; 75 min; Ext; 15%.
  - Unit 9; 75 min; Ext; 15%.
  - Unit 10; 75 min; Ext; 15%.

**Édouard Peltier**
- **Key Features**
  - Momentum; thermal physics; circular motion; SHM; the nucleus; results (20 marks).
  - Approximately 5 questions (60 marks);
  - Approximately 7 structured questions.
- **Unit Titles**
  - Unit 1: Momentum and Energy in Nature.
  - Unit 2: Electric and Magnetic Fields in Nature.
  - Unit 3: Waves and Interactions in Nature.
  - Unit 5: Thermal Energy in Nature.
  - Unit 7: The Universe in Nature.
A-level specification choices

Edexcel (SHAP) GCE

A decade ago, our girls’ comprehensive was one of the original pilot schools for the Salters Horners Advanced Physics (SHAP) course, so it is true to say that SHAP holds a special place in our hearts. Sentimentality aside, we have decided to stick with it and do SHAP Mk II in the next academic year.

Like most departments, I imagine, we have taken the opportunity to take stock of our course and peruse other offerings, but none blew us away with a fervent wish to leave the SHAP fold. With so much other change afoot in the 11–18 curriculum, the “if it ain’t broke, don’t fix it” mantra is plenty reason for us to stay loyal.

An interesting session at the ASE Annual Conference 2008 held in Liverpool focused on context-led versus more traditional teaching approaches to A-levels, and research evidence about the merits of the different methodologies hasn’t made us want to switch. While the shiny new textbooks will probably be slightly thinner due to the reduction in content, the major change for us is likely to be in assessment. An assessed visit, which our students have always enjoyed, can continue to be part of internal procedures, and the demise of longer, open-ended practical investigative work means relief from the administrative headache of juggling limited resources.

An incoming new head of physics may have other plans about the nature of the A-level physics course we should be offering, but the proof will ultimately come down to student option choices and examination success once on board with our course. Our school’s small but perfectly formed A-level groups have thrived on a Salters Horners diet, and we expect this to continue with Advanced Physics Mk II.

Ian Francis

OCR Physics B

Sherborne School is a boys’ boarding school in Dorset, and we have been teaching OCR Physics B (advancing physics) since its introduction in 2000. The staff and pupils have found it a refreshing change from standard GCSE topics, and the context-led approach has proved popular with the large number of boys who continue to read engineering subjects at university. It has not put off a few students from studying physics at university either.

The course has roots in the former Nuffield A-level physics, and the boys enjoy the coursework investigations in particular, which I am pleased to see remain in the new course. We have had to build up a good stock of equipment for investigations, including Pasco data-logging equipment and a set of laptop computers, which now get excellent use around coursework time in both the lower- and upper-sixth forms. We are fortunate to have a separate project lab, where investigations can be set up and left. In the past we have managed without, but it does make life much easier.

Although we find it a valuable exercise, we have had some concerns about plagiarism in the research coursework, and this has made it a more onerous task to assess and moderate properly. I am pleased to see that it still exists in the new course, albeit in a more concise package that should make it more manageable to mark and much less likely to include large passages quoted directly from the internet.

The resources available on the teacher’s CD-ROM are wide-reaching and provide lots of opportunities to extend the most able through extra reading or extension questions. Pupils did find the original course textbooks rather difficult to revise from, but an “Exam Café” revision CD-ROM is available for the new course, which I am hoping will be the final piece in the puzzle.

Ben Ryder, Sherborne School, Dorset

OCR Physics A

We are a state grammar school for boys with about 35% of our students opting to do A-level physics. We have decided to go with OCR A for the following reasons:

- With more than 70 students a year doing physics, the coursework demands of Advancing Physics or the SHAP physics-based visit would be impractical for us.
- Our students, on the whole, like mathematics and enjoy “traditional” conceptual teaching, so this ruled out a context-led course.
- We have been affected in the past by “guess what the examiner is thinking” questions on other specifications, where particular words or definitions are needed to get the mark but are not specified as vital in the specification or approved textbook.
- Previous experience at another school with OCR examiners has been positive.
- In choosing between AQA A and OCR A, we felt that the material was both more accessible and more able to stretch the most academic students with OCR A.

We were slightly disappointed that this decision means that students won’t get a choice of options but we feel that this is a secondary matter. With regard to coursework we believe that OCR A will be both manageable and rigorous.

Anton Machacek, RGS High Wycombe

I teach at a large sixth-form college on the south coast. We have a significant number of international students for whom context-led courses may be difficult because they come from such varied backgrounds, so we have decided to opt for OCR A. This is a change of examination board, but we were unhappy with some aspects of the coursework administration with our previous board. The type of coursework and its management is a significant issue for us because we have more than 100 students and only two teachers to manage it. We hope that the new course will provide good progression from the new GCSE science courses, in particular with regard to the “how science works” component. With students coming from a variety of different 11–16 schools, it is difficult to tell whether or not a particular choice of specification will enhance the attractiveness of the course.

Glen Thomas, Worthing College
**WJEC**

Reigate Grammar School has made the decision to change its examination structure so that pupils will only sit public exams in year 13. The intention is to free up a lot of teaching time, which we plan to make the most of. WJEC has options at A2 and, with our extra time in the summer of year 12, we are planning to offer two of the options instead of just the mandatory one. This will help students to make more informed choices come the UCAS season.

Part of module five is a “case-study, synoptic in nature, based upon open-source material”. This will encourage teachers to think, throughout the course, about the context in which we teach physics. Furthermore, there is currently no exam board-endorsed textbook. This will allow us to choose one all-purpose reference book that is not confined to the course and will allow pupils to get used to using large books. Extension topics will be accompanied by written material from the examination board.

The course as a whole is very well put together. Topics are not mixed about in different units, leaving teachers to make connections where they are required. It will be possible for pairs of teachers to teach sections of the same module without treading on each others toes.

The only down side is, as a school, we do not have the space or the technician power to teach an A-level specification that does project work, which I feel is best for the pupils. We hope that our future new-build and lab refurbishment will give us that element of choice. However, WJEC has kept a practical examination in which pupils will be expected to do a series of experimental tasks, which we welcome as a department.

As I understand it, the writers of the specification feel that there is very little wrong with the old syllabus and so have tried to change as little as possible. They are a very tight-knit group and continuity with the examiners is fantastic. The quality of care by the physicists at WJEC is of a consistently high standard too.

Alastair McGilchrist, Reigate Grammar School

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**AQA Physics A**

Richmond upon Thames College is a general FE college in Outer London with about 5000 full-time equivalent students in 2007/2008, including 105 AS physics students and 54 A2 physics students.

The department has one full-time and four part-time physics lecturers, two part-time technicians, extensive but ageing practical equipment and interactive whiteboards in each teaching room, but limited access to computers in teaching laboratories.

We already offer AQA Physics A, which we have taught since the Curriculum 2000 reforms. We are graded as “good” by OFSTED and are classed as successful but with room for improvement.

We held a team meeting to discuss the choice of new specifications in December 2007. Points raised included:

- Context-led syllabuses can be more difficult for weaker students.
- Having to learn in a different way would be good if we had more time.
- Stability is important and technicians are already busy, so we’ve chosen the new A2 applied science investigations in physics.
- AQA has papers online.
- We felt that chemistry and biology, which have switched to context-led courses, have had two significant outcomes:
  - A large amount of work, preparation and training, therefore also high monetary cost.
  - Results that dip then recover.
- The decisions were:
  - Keep to the AQA A specification.
  - Consider a context-led syllabus again in two years after resolving existing problems.

In essence, we chose stability over change because our main weaknesses at present don’t relate to the choice of specification. In terms of numbers of students, we already have to turn some away. We are only limited by the number of teaching laboratories but we’re hoping to build a brand-new college in the future.

Jon Clarke, Richmond upon Thames College

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**AQA Physics B**

The Assessment and Qualifications Alliance (AQA) has designed two new GCE physics specifications that will be available for teaching from autumn 2008 onwards.

Physics B (physics in context) is a new development designed for teachers and students who will appreciate an approach to physics that places the subject firmly in a range of different settings. It aims to introduce students to novel and stimulating areas of physics as well as to develop essential knowledge and understanding through context and application.

In developing this specification, the AQA has drawn on varied settings in which physics plays a key role, as well as the many resources available to enhance the teaching of physics at this level.

Both of the AQA specifications are supported by detailed complementary materials, produced in conjunction with Nelson Thornes.

David Baker, senior subject officer, physics and electronics, AQA

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**CCEA**

At Foyle & Londonderry College, we have chosen to continue delivering the Northern Ireland CCEA specification at A-level. It has always provided candidates with a broad experience of the subject and has proved to be a sound foundation for further study and/or a valuable skills-base for many careers. CCEA covers classical and modern physics, encompassing theory and practical applications, such as in medical imaging (AS Unit 2).

Having considered the recent changes, we feel that constructive amendments have been made. Notably, all four written papers are now of 90 minutes duration. Also, the synoptic elements at A2 have been scaled down from substantial, discrete questions to become embedded within questions. Both of these provide more scope for pupils to demonstrate their knowledge, understanding and application of the topics that they have studied. Practical skills will now be examined through teacher-assessed tasks, with no coursework.

There is progression from AS to A2 level, obvious in both the level of difficulty of the material and the demands of the questions. Students may benefit from the modular system, entering for the winter and/or summer series of examinations. In our experience, CCEA quality control is consistently at a very high level, and we have confidence in its marking and awarding procedures.

Sandra O’Connell, Foyle & Londonderry College

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