Qualifications and Curriculum Authority

Review of standards in physics

GCSE 1997 and 2002; A level 1996 and 2001

2005

QCA order ref: QCA/05/1574

Contents

Introduction

The Qualifications and Curriculum Authority (QCA) conducted enquiries into standards over time in GCSE physics in 1997 and in A level physics in 1996. The results were published in reports that are available on the QCA website (www.qca.org.uk). The key issues identified by the enquiries were considered as part of work on this review.

By reviewing GCSE and A level syllabuses at the same time, this study also provided the opportunity to consider the issue of progression between GCSE and A level.

Between them, the GCSE syllabuses in this study attracted about 80 per cent of the 46,000 candidates who took GCSE physics in 2002. The A level syllabuses included in this review attracted about 60 per cent of the 30,000 candidates who took A level physics in 2001.

GCSE physics 1997–2002

Key issues identified in 1977/1997 review of standards

This period saw the development of national criteria for physics in 1985 and the introduction of GCSE examinations in 1988. The national curriculum for science was introduced in 1991, which led to new syllabuses for physics for first examination in 1995. The review identified several key issues affecting standards in 16+ examinations in this period.

- A change in assessment objectives that saw a reduction in the proportion of marks given for recall. There was an increased emphasis on understanding and application and, in particular, the assessment of practical skills was introduced.
- In some awarding bodies there was an increase in the breadth of coverage, but this was at the expense of the depth of treatment of some topics.
- The style of question papers changed significantly over this period. In 1977 candidates were expected to choose a small number of questions from a range of questions that all required long written answers. By 1997 there was a shift towards more and shorter questions and a reduction in choice. Syllabus coverage in the examinations was improving as a result. However it was felt that syllabus coverage was still inadequate, due to broad syllabus content and a relatively short examining time.

The review found that between 1977 and 1997 there was an increase in the demand of GCSE physics examinations. However changes made towards the end of this 20-year period, in particular a shift back towards an emphasis on recall and a reduction in overall examining time, had begun to reduce demand in some awarding bodies.

Examination demand

The key changes to GCSE physics examinations between 1997 and 2002 were:

- a reduction from three tiers of entry to two
- changes to the national curriculum, which in turn led to a revised physics core.

Other factors that had a significant impact on GCSE physics were an updating of the extension subject material and changes to the national criteria for science coursework.

Materials available
Reviewers considered the syllabus documents, examiners' reports and question papers with associated mark schemes from each of the awarding bodies in 1997 and 2002. Details of the syllabuses included in the review are given in appendix A.

Assessment objectives
There were only minor changes to the assessment objectives between 1997 and 2002. In 2002 there was often an explicit requirement to assess the skills of communication and evaluation, which was not present in 1997. AQA and Edexcel specified 15 per cent for these skills in 2002.

Syllabus content
A conspicuous change between the two years was the increased clarity with which the syllabus content was specified. In 2002 the syllabuses were presented in a user-friendly format for teachers. For example the Edexcel syllabus in 1997 specified content using national curriculum statements of attainment, as well as 'required knowledge and understanding', 'associated process skills' and 'suggested activities'. In 2002 this was simplified so that the syllabus merely specified learning objectives and possible teaching activities. The quality of information to support teachers also improved. For example CCEA included appendices suggesting where key skills, applications of information and communication technology (ICT) and environmental issues could be addressed.

In most awarding bodies the breadth of syllabus content decreased between 1997 and 2002. In 1997 most syllabuses included a section on weather and atmosphere, as well as a geology topic covering plate tectonics and rock types. These topics, which were part of the Sc3 scheme of work, were significantly reduced in 2002. Other topics such as the use of bi-stable circuits, interference of waves and polarisation were removed. Some of the more mathematical topics, such as lens calculations (AQA and WJEC), U-values (CCEA) and thermal expansion (AQA) were also taken out of the syllabuses. These changes largely affected the higher tier of entry. However in 2002 challenging topics such as circular motion and momentum were retained and some new, rather abstract topics like particle physics, mass-energy equivalence and evidence for the 'big bang theory' were introduced. There was also an increased emphasis on modern applications, such as the uses of ultrasound and the medical uses of the electromagnetic spectrum.

Reviewers felt that overall these changes had the effect of reducing demand slightly at the higher tier in 2002. However this was a desirable change since the 1997 syllabuses contained too much material. The 1997 syllabuses were seen as too broad to be examined adequately.

The content of the foundation tier was broader in 2002 than in 1997. This was largely due to the changes in tiering arrangements. In 1997 there were three tiers of entry: foundation, intermediate and higher. This was reduced to two, foundation and higher, in 2002. In 1997 the foundation tier was targeted at grades D and below. The link to national curriculum statements of attainment meant that the syllabus for foundation students corresponded approximately to statements at level 7 and below. This led to a limited syllabus. In 2002 the foundation tier was targeted at grade C and below. There was no direct link to national curriculum statements of attainment and much of the key stage 3 content had been removed. As a result candidates were faced with a wider and more demanding range of topics. This increased demand at the foundation tier. This was also felt to be a desirable change.

Scheme of assessment
The assessment scheme was similar for all awarding bodies in both years. In 1997 and in 2002 25 per cent of the assessment was for internally marked, externally moderated coursework. In addition to this, all candidates took either one or two written papers.

In 1997 the variation of examining time across the awarding bodies was large enough to lead to differences in demand between awarding bodies. The total examination time for foundation tier candidates varied from 1½ to 2½ hours. For higher tier candidates the time varied between 2¼ and 3 hours.

In 2002 the variation was less at foundation level, where the total examining time varied between 2 and 2½ hours. The general increase in examining time at foundation tier allowed for better coverage of the syllabus content than in 1997.

However at higher tier the variation in examining time across awarding bodies increased in 2002. AQA was the only awarding body to reduce the examining time at this tier, by 15 minutes. As a result syllabus coverage in the examination was less thorough than for other syllabuses. AQA examined candidates for the shortest time, $2^1/_4$ hours, while the total time for CCEA candidates was $3^1/_2$ hours.

Table 1: scheme of assessment

Awarding body	**AQA**			**CCEA**			**Edexcel**			**OCR**			**WJEC**		
Tiers	**FT**	**IT**	**HT**	**FT**	**IT**	**HT**	**FT**	**IT**	**HT**	**FT**	**IT**	**HT**	**FT**	**IT**	**HT**
1997 no. of papers	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
2002 no. of papers	1		1	2		2	2		2	2		2	1		1
1997 time/mins	90	120	150	60+90 = 150	60+90 = 150	90+90 = 180	90+60 =150	90+60 =150	90+60 =150	90	120	135	90	120	150
2002 time/mins	120		135	75+75 =150		105+105 = 210	90+60 =150		90+60 =150	90+45 =135		105+60 =165	120		150

Key: FT: Foundation Tier
IT: Intermediate Tier
HT Higher Tier

Options and extension

There were no optional routes in any of the syllabuses in either year, except for the choice of entry tier. None of the examination papers had optional questions; the only variation in assessment between candidates for any awarding body was in the choice of their coursework topic.

There was a change in the assessment weighting of the ‘extra’ physics material, for example the extension over and above that required by GCSE double science. In 1997 the assessment weighting of the physics core was 60 per cent, the weighting of the extension material was 15 per cent and coursework was 25 per cent. By 2002 the weightings had changed to core 50 per cent, extension 25 per cent and coursework 25 per cent. The 2002 weightings were judged to be a fairer reflection of the extent of the extension material, which represents an extra one-third of a GCSE.

Question papers

There were only minor changes in demand and style of question papers between 1997 and 2002.

By 2002 most awarding bodies included an explicit assessment objective to assess communication and application or evaluation. In the AQA examination this was reflected by the introduction of comprehension-style questions. For example the use of a newspaper article allowed evaluation of scientific information in a ‘real life’ situation. This change gave more able candidates greater opportunity to demonstrate their understanding.

The reduction in the number of tiers of entry meant that less able candidates had to cope with a wider range of tasks, and more extended reading and writing than in 1997. For some awarding bodies, CCEA and Edexcel for example, the level of language required of foundation candidates was high. Insufficient time was allowed for these candidates to read the paper. In 1997 there was too much assessment of recall for foundation tier candidates, but a better balance between the examination of recall, understanding and application had been achieved by 2002, thus redressing concerns about the 1997 examination in the previous report.

In 2002 the examination papers covered the assessment objectives well. The papers had improved in clarity and presentation. Question papers, as well as individual questions, had an appropriate incline of difficulty. These factors meant that question papers were more accessible than in 1997. Some awarding bodies (OCR for example) examined the physics extension material in a separate paper. This was helpful to schools in preparing candidates for the examination.

Tiering

The reduction in the number of tiers of entry had a significant impact on the least able candidates. In 1997 these candidates were entered for an examination that was aimed at grades D–G, whereas in 2002 the foundation tier examination was targeted at up to grade C. In 2002 foundation candidates were exposed to a wider range of question styles, which placed increased demands on their language skills, as well as their ability in physics. There was a reduction in syllabus content between 1997 and 2002, but this had more impact on the higher tier. Generally foundation candidates faced a wider syllabus in 2002. In some awarding bodies, AQA for example, there were only minor differences in content between the higher and foundation tier syllabuses. Differentiation between the tiers was achieved largely through the demand of the question papers.

Coursework

There were major changes to the common coursework criteria for science. In 1997 there were three assessment strands, each with a 10-point scale. To reach the higher levels candidates were required to predict the effect of two independent variables and to use more than one experimental technique. The assessment had to be done in the context of a whole investigation. It was challenging, even for the most able students, to achieve the higher levels. The assessment scheme was awkward for teachers to implement and variations in the marks for similar quality work seen at the script review suggest that it was difficult to standardise marking.

In 2002 these criteria had been replaced by a more straightforward assessment scheme. Students were required to investigate only one variable and the requirement for an additional experimental technique was dropped. The skill of evaluation was introduced as a separate strand. It was no longer necessary to always assess each skill in the context of a whole investigation. This made it easier for teachers to carry out more assessments and to reward achievement appropriately.

These changes had the overall effect of reducing discrimination and demand, especially at the higher tier. This change was felt to be appropriate since it had been excessively difficult, even for the most able students, to gain high marks under the earlier version.

In practice the actual demand of coursework tasks depended on the context. The limited range of coursework tasks seen in the candidates' work disappointed the reviewers. The majority of coursework submissions were drawn from two or three standard investigations, for example investigations relating to the electrical resistance of a metal wire. Because many students carried out the same coursework task there were fewer opportunities for original ideas or creative thinking.

Considering that there were common criteria for the assessment of coursework, and common standardisation procedures, there was still a surprising variation in coursework marks between awarding bodies, with Edexcel marks being lower than those of the other awarding bodies.

Summary

Reviewers considered that the demands of the examination as a whole changed little between 1997 and 2002. Some factors acted to reduce demand and this was seen as a positive change. The main changes were:

- the simplification of the coursework criteria
- a reduction in syllabus content in most awarding bodies.

There were also factors that acted to increase demand. The main ones were:

- a reduced emphasis on recall in 2002
- the introduction of more abstract concepts in the 2002 syllabuses
- the reduction in the number of tiers of entry (increased demand for foundation tier candidates only).

In the judgement of the reviewers, the overall effect of these changes was a marginal decrease in demand in 2002 at the higher tier, when compared with 1997. However the reduction in the number of tiers increased demand at the lower end of the ability range.

A level physics 1996–2001

Key issues identified in 1996 review of standards

The report identified an increasing emphasis on the applications of physics, partly through optional topics such as medical physics. There was also a trend towards including more modern topics, such as particle physics. A less mathematical treatment was becoming common; the need to use calculus was either removed or reduced. Although differences between awarding bodies were identified, these were not large. There was no clear trend in standards over time.

Examination demand

The main changes to A level physics examinations between 1996 and 2001 were:

- an increase in the entry for modular syllabuses
- a reduction in the range of assessment tasks, with increased use of more structured questions.

Materials available

Reviewers considered the syllabus documents, question papers and associated mark schemes and examiners' reports from each of the awarding bodies in 1996 and 2001. Details of the syllabuses included in the review are given in appendix A.

Assessment objectives

Assessment objectives remained virtually the same in 1996 and 2001. Some awarding bodies introduced an additional objective to assess communication. For example AQA required that candidates should be able to 'present ideas and arguments clearly and logically, using spelling, punctuation and grammar with a degree of accuracy'. OCR varied the assessment weighting ascribed to 'knowledge and understanding', and to 'application'. More emphasis was placed on coursework by WJEC. These changes were minor and had no discernible effect on demand.

Syllabus content

For most awarding bodies there were only minor changes in content between the two years. Modular schemes became more common, with some awarding bodies offering a wider range of optional modules. For example in 2001 AQA candidates could choose three optional modules, representing half of their A level course. These optional modules covered a wider range of physics concepts than was available in the linear examination of 1996. Optional modules tended to increase the emphasis on the applications of physics, typically in such areas as medical physics, physics of materials, applied physics (including thermodynamics and rotational dynamics) and astronomy. These modules included demanding subject material, such as black body radiation, ferromagnetic behaviour and nuclear forces and stability. The inclusion of challenging ideas in these optional modules, such as special relativity in the AQA module 'Turning points', tended to increase demand slightly in 2001.

In general small reductions to the core syllabus were more than compensated for by an increase in the breadth of optional material. For example OCR removed measurement techniques and changes of state from the core, but added considerable breadth and depth to all the optional modules, for instance special relativity was added to the cosmology module.

The variation in syllabus content between different awarding bodies was larger than any changes over time. In 2001 WJEC introduced a modular scheme, but the physics content was largely unchanged. This syllabus had a distinctly mathematical emphasis when compared to other awarding bodies. The WJEC syllabus required candidates to recall more derivations and to use calculus notation. The CCEA syllabus changed only slightly between the two years. For example consideration of LCR circuits was omitted in favour of thermodynamics and some material drawn from medical physics. This represented an increase in relevant applications of physics, but had no significant impact on demand.

Scheme of assessment

The review team considered the largest entry syllabus from each awarding body. In 1996 the majority of these were linear syllabuses with terminal examinations. By 2001 the majority were modular syllabuses, generally examined at intervals throughout the course.

Table 2: comparison of total examining times

Awarding body	1996	2001
AQA	Paper 1: 3hrs Paper 2: 3hrs Practical exam: 3hrs or coursework **Total* 6hrs**	6 x $1^1/_2$hr module tests. Each module contributes 16.7 per cent of total* assessment. Three per cent of each module is a coursework investigation. **Total* 9hrs**
CCEA	Paper 1: $1^1/_2$hrs Paper 2: 2hrs Paper 3: $2^1/_2$hrs Practical 2hrs **Total* 6hrs**	4 x written module papers 4 x $1^1/_2$hrs 6hrs Practical 2hrs **Total* 6hrs**
Edexcel	4 x 1hr 20min module papers Synoptic paper 2hrs Practical $2^1/_2$hrs **Total* 7hrs 20mins**	4 x 1hr 20min module papers Synoptic paper 2hrs Practical $2^1/_2$hrs **Total* 7hrs 20mins**
OCR	Paper 1: 1hr Paper 2: 1hr 45mins Paper 3: 2hrs 30mins Practical 3hrs or coursework **Total* 5hrs 15mins**	4 x $1^1/_2$hr module papers Practical 3hrs or coursework **Total* 6hrs**
WJEC	Paper 1: $2^1/_2$hrs Paper 2: $2^1/_2$hrs Paper 3: $1^3/_4$hrs Coursework **Total* 6hrs 45mins**	4 x 1hr 20min module papers Synoptic paper 1hr 40mins Coursework **Total* 7hrs**

*The total examining times do not include the assessment of practical work, so that a comparison can be made between syllabuses whether they offer a practical examination or coursework.

The movement towards modular syllabuses tended to increase the total examining time, most significantly in the AQA syllabus from six hours to nine hours. The variation between awarding bodies persisted, ranging from six hours total examining time (CCEA, OCR) to nine hours (AQA) in 2001.

The modular examination system enabled students to concentrate on part of the syllabus for any one examination, and to resit the examination if necessary. There were no limits on the number of resits allowed in 2001. The similar design of each module exam meant that candidates were able to develop their examination technique as they progressed through the course. These changes tended to increase accessibility.

Options

There was a wide variation between awarding bodies in the provision of optional routes through the syllabuses. CCEA and the WJEC syllabuses had no optional routes in 1996, or in 2001, despite moving to a modular scheme. At the other end of the scale, OCR offered a complex range of optional routes. In 2001 OCR candidates were required to study three compulsory modules that covered the prescribed physics core. Candidates then chose two modules from eight alternatives, including instrumentation electronics or scientific communication. In addition to this, candidates had a choice of three modes of practical assessment: a teacher assessment of experimental skills, an extended investigation, which could be work-related, or a practical examination. Even when certain restrictions are taken into account, and discounting the effect of the alternative practical examination, there were 81 different routes through this syllabus. There was a further choice of question within each of the module papers.

With such a complex set of pathways, it was difficult to be sure about the parity of demand across options. Some of the options appeared to make different demands in terms of content, for example physics of transport had eight subsections and took up three sides in the syllabus; cosmology had 20 subsections and occupied five sides. Optional questions did not always test equivalent skills, for example in OCR paper 4830 one question used approximation to test analysis and problem-solving, whereas the alternative question used Rutherford scattering and largely tested recall.

With such a wide variation between awarding bodies it was difficult to evaluate the effect of options on the demand of the examination. However reviewers felt that the wide range of content covered by the modular schemes made them more demanding overall than the equivalent linear schemes.

Question papers

One effect of the introduction of modular examinations was to reduce the variety of assessment techniques. In the 1996 linear papers there was a wider variety of question paper styles than was apparent in the 2001 module papers. For example in 1996 OCR used an objective test (multiple-choice) paper, a paper with structured questions and a comprehension/data-analysis question, and a paper with longer questions. In 2001 these had been replaced by four module tests of similar design, each incorporating compulsory short answers and a choice of long-answer questions.

None of the awarding bodies used objective tests (multiple-choice questions) in the syllabuses considered from 2001. Structured questions requiring short answers dominated with fewer long-answer, free-response questions than in 1996. Reviewers considered that these changes in style had eased demand slightly in 2001, though the coverage of the syllabus and of the assessment objectives was satisfactory.

Two awarding bodies, Edexcel and WJEC, included a synoptic paper as part of their modular schemes in 2001. Both of these used a comprehension exercise and questions, which drew upon material from across the syllabus. These papers increased the demand of these examinations.

The presentation of examination papers improved between 1997 and 2001, with better use of diagrams and other stimulus material. Mark schemes varied across awarding bodies. Some provided general marking instructions that dealt with the mechanics of marking calculations and gave guidance on marking policy regarding significant figures and units. There were often no clear instructions on marks for use of language.

Coursework and assessment of practical skills

A much wider variation in the assessment of practical skills was seen at A level than at GCSE. Awarding bodies offered either coursework or a practical examination and the assessment weighting varied between syllabuses. (See table 2 below). The number of activities varied widely: OCR demanded at least two assessments of each skill, whereas WJEC required that candidates be assessed on at least five occasions. The assessment criteria also varied widely between awarding bodies. For example OCR placed equal emphasis on the skills of planning, implementing and concluding, whereas WJEC placed more emphasis on analysing and concluding. Some awarding bodies, AQA and OCR, included communications skills in their assessment criteria.

Variations between awarding bodies were much greater than any changes over time.

Table 3: comparison of the assessment of practical skills

	1996	**2001**
AQA	18% practical examination or coursework	18% coursework; one practical investigation per module, so nominally six pieces of work. Though some investigations could be used for more than one module
CCEA	13% practical examination comprising four short exercises	20% practical examination. Three short practical exercises and a design exercise
Edexcel	20% practical examination. No specific weightings for separate skills	20% practical examination. No specific weightings for separate skills
OCR	16% practical examination	16.7% practical examination ***or*** continuous assessment of practical skills ***or*** extended investigation (work-related)
WJEC	15% coursework. An assessment of planning, implementing and concluding. Each skill to be assessed on five occasions	20% coursework. An assessment of planning, implementing and concluding. Each skill to be assessed on five occasions

Summary

The main change in A level examinations over the period 1996–2001 was the move towards modular syllabuses. This had the effect of:

- broadening the range of material covered by any A level syllabus
- increasing the range of physics applications considered
- decreasing the variety in the style of question papers
- increasing the number of options available to candidates
- allowing candidates to resit parts of the qualification as necessary.

Overall reviewers judged that these changes did not lead to any significant changes in demand.

There were differences between awarding bodies, both in the content of the syllabuses and in the style of assessment. These differences did not lead to any significant variations in demand, except for the WJEC, which was felt to be more demanding than other syllabuses largely due to its mathematical emphasis.

Relationship between GCSE and A level physics

The GCSE physics core, in 1997 and in 2002, was a good preparation for A level. At GCSE students studied aspects of electricity, such as simple electrostatics, circuits, current and voltage relationships and electrical power. These were useful preparation for A level where the progression to the study of electric fields, Kirchoff's laws and resistivity was apparent. The study of domestic electricity was also useful preparation as it applied ideas that were used again at A level.

The GCSE treatment of mechanics was also good preparation. Descriptive questions about force and acceleration were developed more quantitatively at A level. Some concepts, like density and pressure, were sometimes not directly quoted in A level syllabuses but were required knowledge and were therefore essential at GCSE.

Seismic waves were discussed at GCSE and did not re-appear at A level. This was a useful way of broadening the subject at GCSE, by discussing an application that was not repeated at a higher level. The study of refraction also showed clear progression, with descriptive work at GCSE forming the basis for Snell's law at A level. Similarly the topics on atomic physics and electromagnetism were important and suitable preparation for A level.

Some parts of the GCSE core were seen as being largely irrelevant to A level physics. The geology topics, more common in 1997 than in 2002, which covered rock types and plate tectonics were seen as providing little help for the future A level student. Similarly the topics on atmosphere and weather were unhelpful. The study of electronic components such as the capacitor, transistor and logic gates were given such cursory treatment at GCSE as to be of little help at A level.

The extension material added by each awarding body often included a more mathematical approach. The study of topics such as the equations of motion and calculations involving specific heat capacity were helpful in giving students more opportunity to work quantitatively.

The change to a quantitative approach was often the most significant change for students starting an A level course and the opportunity to develop numerical skills was beneficial.

Extension topics which promoted enthusiasm for physics, without encroaching too much on A level syllabuses, were welcomed by reviewers. For example space physics was seen as a topic that could be motivating at GCSE and which was not part of the A level core.

The practical skills developed at GCSE were an excellent preparation for A level work, but there was no clear progression between the assessment of practical skills at the two levels. The GCSE criteria placed more emphasis on higher order skills such as planning and evaluating than the A level criteria did. For example the GCSE criteria stressed the importance of scientific knowledge and understanding, particularly when identifying key variables and planning an investigation. The criteria at A level placed more emphasis on practical skills, such as allowing for zero errors and recording results to an appropriate number of significant figures. GCSE practical assessment in 2002 had a separate strand covering evaluation, whereas A level assessment placed less emphasis on this.

Standards of performance at GCSE and A level

Materials available

Reviewers considered candidates’ work from all the awarding bodies in 1997 and 2002 (GCSE) and in 1996 and 2001 (A level). At A level, scripts from candidates at the A/B and E/N borderlines were considered. There were no scripts from the WJEC at grade E at A level.

At GCSE, scripts from candidates at the A/B, C/D and F/U borderlines were considered. The C/D borderline was considered at higher and at foundation level. At the GCSE grade F boundary, only scripts from AQA and Edexcel were considered. Full details of the materials used are provided in appendix B.

Performance descriptors

Reviewers were asked to identify key features of candidate performance in 2002, based on the work seen at each of the key grades. Performance descriptors for each grade boundary were drawn up, focusing on the assessment objectives, as well as allowing for additional features of performance. The performance descriptors can be found in appendices C and D.

Performance at the GCSE grade A boundary

Candidates at this level were generally able to show a broad knowledge and understanding across the full range of the syllabus. They were able to give quite full explanations of physical processes, such as convection, and could deal satisfactorily with some of the more abstract concepts, such as electromagnetic induction. Within each awarding body the performance in 1997 and 2002 was broadly similar, except for CCEA, where reviewers felt that candidates in 2002 showed a better understanding across a wider range of contexts and were more successful at completing calculations

In 2002, differences between awarding bodies were small, although WJEC candidates produced work that particularly impressed the reviewers with the fluency of their scientific explanations. WJEC candidates also dealt particularly well with the mathematical demands of the mechanics topic.

Performance at the GCSE grade C boundary

Candidates at this level showed a good recall of factual information from across the syllabus but showed only a limited ability to apply this knowledge. For example they could define the half-life of a radioisotope, but were unlikely to use the definition to solve a problem correctly. Candidates showed a good understanding of more concrete concepts, but found explanations of abstract ideas, such as the operation of a transformer, very difficult. Comparisons over time showed that standards were similar in 1997 and 2002, although grade C candidates from the intermediate tier in 1997 were able to show greater understanding and stronger numerical skills than grade C candidates from the foundation tier in 2002.

In 2002 the standard of candidates' work from different awarding bodies was broadly comparable, although reviewers felt that CCEA foundation candidates showed a weaker performance across the syllabus, demonstrating a poor understanding of some basic concepts like work and energy.

It was noted that the level of knowledge and understanding shown by candidates in their coursework was often significantly better than that demonstrated in their examination performance. Indeed in some cases in 2002 there was little difference between the attainment of a grade A candidate and a grade C candidate in their GCSE coursework.

Performance at the GCSE grade F boundary

Candidates at this level showed a fair performance in experimental skills and could often plan and carry out simple experiments successfully. They found it difficult to explain their experimental ideas using scientific knowledge. These candidates also found evaluating their results difficult. Although candidates at grade F could deal with some simple equations, to calculate speed, for example they were generally unable to manipulate a formula so as to change the subject of the equation.

Standards were broadly comparable across awarding bodies, although reviewers felt that standards shown by AQA candidates at this grade showed some improvements between 1997 and 2002 and were generally higher than in the other awarding bodies considered. AQA candidates in 2002 showed greater understanding of concepts such as radioactivity and electricity. These changes could be due to the changes in tiering between 1997 and 2002 that exposed grade F candidates to a broader syllabus.

At grade F it was also apparent that the level of knowledge and understanding shown in coursework was usually better than that demonstrated in examination performance.

Performance at the GCE A level grade A boundary

Candidates from all awarding bodies showed a wide range of knowledge at this level. This was particularly the case in 2001, where reviewers saw an improved ability to apply physics knowledge and understanding to real-life situations. In 2001 AQA candidates showed a good level of understanding of quantum physics and WJEC candidates demonstrated a good grasp of some of the more abstract topics, such as the photoelectric effect. Candidates in 2001 were given more opportunity to demonstrate positive achievement by the increased structure of questions. For some awarding bodies, in particular OCR and WJEC, reviewers considered that candidates showed greater numerical ability in 1996 than in 2001.

In general there were no significant variations in the overall standard of candidates' work between 1996 and 2001, except for Edexcel, where reviewers considered that candidates had achieved a higher standard in 1996, especially in the clarity of their written explanations and in their working shown for calculations.

Performance at the GCE A level grade E boundary
Candidates at this level often showed a good level of knowledge and understanding in some parts of the syllabus, but were unable to demonstrate this across a broad range of topics. The more abstract topics, such as electromagnetic induction, were found to be particularly difficult by candidates at this level. Grade E candidates could often demonstrate their ability in closely structured questions, but found it difficult to organise their written explanations in longer answers that involved an extended prose response. The performance of candidates was very similar in 1996 and 2001, though there were some slight variations between awarding bodies. In 2001 CCEA candidates achieved a higher overall standard than Edexcel at this grade, principally due to the greater mathematical abilities shown.

Summary
At GCSE:
- standards of performance between awarding bodies were broadly comparable at all the grades considered
- there were no clear trends over time at the grade A and C boundaries
- there was some evidence to suggest that performance was stronger at grade F in 2002, when compared to 1997. This was thought to be due to the changes in tiering arrangements.

At GCE A level:
- standards of performance between awarding bodies were broadly comparable at all the grades considered
- there were no clear trends across time.

Appendix A: specifications used in the syllabus review

GCSE

Year	Awarding body and specification code				
	AQA	CCEA	Edexcel	OCR	WJEC
1997	1181	G76	1046	1782	020001/2
2002	1181	G76	1046	1782	020001/2

AS/A level

Year	Awarding body and specification code				
	AQA	CCEA	Edexcel	OCR	WJEC
1996	4183	A76	9541	9244	032/632
2001	4183	A76	9541	9536	032/632

Appendix B: number of scripts reviewed

GCSE 1997/2002

	AQA		CCEA		Edexcel		OCR		WJEC	
	97	02	97	02	97	02	97	02	97	02
A	4	8	4	8	4	8	4	8	4	8
C (Higher tier)	4	8	4	8	4	8	-	8	-	8
C (Foundation tier)	4	8	4	4	4	8	4	8	4	8
F	4	8	-	-	4	4	-	-	-	4

GCE A level 1996/2001

	AQA		CCEA		Edexcel		OCR		WJEC	
	96	01	96	01	96	01	96	01	96	01
A	4	8	4	8	4	8	4	8	4	8
E	4	8	4	4	4	8	4	8	-	-

Appendix C: GCSE performance descriptors

Key features of 2002 candidate performance at grade A

Assessment objective 1: Carry out experimental and investigative work in which they plan procedures, use precise and systematic ways of making measurements and observations, analyse and evaluate evidence, and relate this to scientific knowledge and understanding.
Candidates at this level could normally: • show clarity of purpose when planning an investigation by using appropriate and relevant scientific knowledge and understanding to produce a clearly structured plan. They could give reasons to support their choice of method • make careful and reliable observations and record their results using significant figures consistently • undertake some quantitative analysis of results, dealing confidently with direct proportion and attempting, sometimes successfully, to deal with relationships of the form $y = x^2$ or $y = {}^1/_x$ • evaluate the reliability of their results, but could not fully evaluate the procedure used. They often suggested improvements to the method but found it difficult to justify these changes • identify anomalies, and could sometimes account for them. Candidates at this level sometimes drew on material from beyond the GCSE specification, perhaps using A level textbooks or the internet as sources of information. They often found it difficult to apply this material in an appropriate way.
Assessment objective 2: Recall, understand, use and apply the scientific knowledge set out in the syllabus.
Candidates at this level could normally: • use physical ideas and principles to explain more abstract concepts, such as convection or electromagnetic induction • use conventional symbolic representations for physical situations, such as the use of simple free body diagrams to describe the forces acting on a system • demonstrate a broad knowledge and recall information from across the full range of the specification • apply their understanding confidently in familiar situations but often struggled to do so when faced with a novel situation.
Assessment objective 3: Communicate scientific observations, ideas and arguments using a range of scientific and technical vocabulary and appropriate scientific and mathematical conventions.
Candidates at this level could normally: • recall the appropriate formula and rearrange it as necessary, though they may have needed a carefully structured question to lead them through a two- or three-stage calculation • use a wide scientific vocabulary with precision, for example when explaining electromagnetic effects such as the operation of a transformer • handle numerical data confidently, using units consistently and accurately • use a number of points to marshal an argument.
Assessment objective 4: Evaluate relevant scientific information and make informed judgements from it.
Candidates at this level could normally: • identify the factors affecting the choice of an energy source for generating electricity and make reasoned comparisons between alternatives • develop a balanced argument drawing on a range of data and make a judgement supported by evidence, usually using scientific evidence rather than general knowledge.

Key features of 2002 candidate performance at grade C

Assessment objective 1: Carry out experimental and investigative work in which they plan procedures, use precise and systematic ways of making measurements and observations, analyse and evaluate evidence, and relate this to scientific knowledge and understanding.
Candidates at this level could normally: • plan an investigation in which they control the appropriate variables, though they could not always identify the key variables in a given situation • identify suitable safety procedures • use scientific knowledge and understanding to support predictions, though these were rarely quantitative • tabulate results, repeating and usually averaging, their results that usually included the correct units • plot suitable graphs with a best fit straight line, or smooth curve, attempted as appropriate. They could recognise anomalous results but were rarely able to explain them • recognise proportionality, though the term ‘correlated’ was often used • make comments on procedure and sometimes suggested simple improvements to the method.
Assessment objective 2: Recall, understand, use and apply the scientific knowledge set out in the syllabus.
Candidates at this level could normally: • recall factual information well from across the syllabus, but had a limited ability to apply this knowledge. For example they could define the half-life of a radioactive isotope but were unlikely to use the definition to answer a question correctly • demonstrate a good understanding of concrete concepts, for example they could describe the solar system, or complete ray diagrams to explain reflection and refraction of light. They were less likely to be able to explain abstract ideas like electromagnetic induction. Although candidates could describe most of the safety features of the three-pin electric plug, they were unlikely to be able to explain the combined operation of the earth and fuse.
Assessment objective 3: Communicate scientific observations, ideas and arguments using a range of scientific and technical vocabulary and appropriate scientific and mathematical conventions.
Candidates at this level could normally: • recall simple formula, substitute numerical values and evaluate the expression correctly, though they found the manipulation of equations difficult • use the correct scientific vocabulary for some ideas but struggled with more complex ideas, for example some candidates wrote about ‘magnetic charges’ or the potential difference ‘through a circuit’ • use the correct unit for common quantities, like mass or velocity • draw simple electrical circuits correctly, using the appropriate symbols.
Assessment objective 4: Evaluate relevant scientific information and make informed judgements from it.
Candidates at this level could normally: • read information from a table or graph accurately • discuss alternatives, for example in the choice of energy sources for generating electricity, but their reasons were not always based on scientific knowledge and understanding.

Key features of 2002 candidate performance at grade F

Assessment objective 1: Carry out experimental and investigative work in which they plan procedures, use precise and systematic ways of making measurements and observations, analyse and evaluate evidence, and relate this to scientific knowledge and understanding.
Candidates at this level could normally: • plan a simple experiment and describe the method, including a diagram of the experimental apparatus to be used • show some awareness of the need for a fair test, though the plan was unlikely to be linked to valid or appropriate scientific knowledge and understanding • accurately plot a graph of experimental results but were unlikely to be able to construct best fit lines • carry out a simple experiment and record and tabulate a set of results, though these were often recorded with no regard to the correct use of significant figures and units were often omitted • make a simple comment on the trend of the results, but were unlikely to understand the notion of proportionality • write only an incomplete report, failing to include an evaluation of the experiment, and often confusing an evaluation with the conclusion.
Assessment objective 2: Recall, understand, use and apply the scientific knowledge set out in the syllabus.
Candidates at this level could normally: • recall simple equations, such as speed = distance/time • recall some physics terminology and could complete sentences, typically selecting the correct term from a list of alternatives • show an understanding of some concrete issues, for example identifying electrical hazards in the wiring of a three-pin plug. However little understanding was shown of more abstract quantities such as force or potential difference.
Assessment objective 3: Communicate scientific observations, ideas and arguments using a range of scientific and technical vocabulary and appropriate scientific and mathematical conventions.
Candidates at this level could normally: • begin explanations, though they often relied on general knowledge rather than physics principles in their answers. For example candidates could discuss renewable and non-renewable electricity generation in general terms but were unlikely to mention the conservation of energy • substitute numerical values into given formula correctly and evaluate an answer. For example they could calculate the average speed from the formula speed = distance/time. However candidates found it difficult to change the subject of an equation.
Assessment objective 4: Evaluate relevant scientific information and make informed judgements from it.
Candidates at this level could normally: • read data correctly from a table and draw simple implications from it • make only subjective evaluations, based on a personal view, rather than evaluating data in an objective way.

Appendix D: A level performance descriptors

Key features of 2001 candidate performance at grade A

Assessment objective 1: To show a knowledge and understanding of facts, theories or generalisations, classifications, conventions, terminology, techniques, concepts and principles.
Candidates at this level could normally: • show a good recall of facts and theory, and could sustain this across the examination paper • demonstrate a wide understanding of physical concepts, including abstract ideas such as wave-particle duality • select the correct formula and apply it correctly to numerical problems • perform calculations correctly, including those involving exponential or logarithmic forms • show a good grasp of mechanics, though two-dimensional motion was less well understood • show a knowledge of a range of practical techniques and could apply them to a variety of experimental situations • use scientific vocabulary in an appropriate fashion.
Assessment objective 2: To show a knowledge and understanding of the social, economic, environmental and technological applications of science.
Although there were limited opportunities, candidates were aware of a range of examples. Candidates were more often tested on technological applications and they showed good knowledge and understanding in this area.
Assessment objective 3: To describe and interpret scientific information presented in a variety of forms and to translate such information from one form to another.
Candidates at this level could normally: • interpret graphical information accurately and manipulate formulae so as to apply the equation of a straight line. They could use more complex graphical forms, such as inverse-square and exponential relationships • use information from text, graphs, tables and diagrams in the solution of problems.
Assessment objective 4: To explain familiar phenomena in terms of relevant theories, models, laws and principles.
Candidates at this level could normally: • use microscopic models to explain macroscopic behaviour, for example they could explain electrical conduction in metals by discussion of the motion of electrons, or gas pressure by using the kinetic theory • explain abstract concepts well. Their explanations were usually succinct and well structured.
Others
• Practical work was often very competently carried out. Candidates took accurate measurements and recorded them clearly. Experimental results were processed appropriately and the analysis was accurate. • ICT skills were rarely demonstrated, even in coursework.

Key features of 2001 candidate performance at grade E

Assessment objective 1: To show a knowledge and understanding of facts, theories or generalisations, classifications, conventions, terminology, techniques, concepts and principles.
Candidates at this level could normally: • demonstrate understanding in some areas, but were not consistent across the examination paper. Areas of weakness were often in specific areas of the syllabus, often the more abstract ideas such as electrical fields, E.M. **[Q? electromagnetic?]** induction or the photoelectric effect • recall some definitions, but were unlikely to be able to discuss any of the assumptions underlying the theory, for example the ideal gas assumptions made in kinetic theory • use base units well, but were likely to make mistakes with derived units or in conversions, for example from mm^3 to m^3 • carry out some calculations well, and could begin more complex calculations but often had difficulties in algebraic manipulation.
Assessment objective 2: To show a knowledge and understanding of the social, economic, environmental and technological applications of science.
There were limited opportunities for candidates to demonstrate competence in this area. Candidates were able to describe technological applications well, though any comparison of relative merits tended to be limited to general terms, such as ‘polluting’ or ‘expensive’. Candidates could recall specific applications from the syllabus but found it difficult to apply their physics knowledge to novel applications.
Assessment objective 3: To describe and interpret scientific information presented in a variety of forms and to translate such information from one form to another.
Candidates at this level could normally: • construct graphs from experimental data and could often calculate the gradient, though they often found it difficult to make inferences from this information • construct diagrams to represent physical situations, for example circuit or free body diagrams, though errors were often made • carry out practical work and collect appropriate results, but were unlikely to be able to evaluate their work • begin to make simple estimates of error, but were unlikely to have carried out any analysis of uncertainty.
Assessment objective 4: To explain familiar phenomena in terms of relevant theories, models, laws and principles.
Candidates at this level could normally: • begin to explain physical phenomena, but would often omit important points so that the explanation was incomplete • show some understanding of the relevant theories, but would often be unable to organise their written answer coherently • explain some phenomena, especially in highly structured questions. However they were less likely to be successful in explanations relating to abstract concepts, or where the answer required extended prose.
Others
Candidates were often weak at designing experiments to test specific questions.

Appendix E: list of reviewers

Review team	
Coordinator	Dave Kelly
Syllabus reviewers	Bryan Berry Timothy Fearn Neil Jaques Graham Jones Averil Macdonald Ken Price John Skevington
Script reviewers	Pauline Anning William Beales Patrick Carson David Homer Laurie Mansfield Christopher Mee John Richards Christopher Sherry Brian Turner John Warrender