NQ NATIONAL QUALIFICATIONS Review

SCOTTISH QUALIFICATIONS AUTHORITY

National Qualifications Review Report

Physics

Subject Review: Physics

1 Subject summary

Summary of courses

Intermediate 1	Physics
Intermediate 2	Physics
Higher	Physics
Advanced Higher	Physics

Recommendations

Recommendations which can be implemented this session (2001-2002)

1. 20 hour Units in Advanced Higher, Intermediate 2, Intermediate 1 and Access 3
The 20-hour Units should be retained at all levels (see section 2.1). SQA should continue to monitor feedback on this issue, particularly in relation to Intermediate 1.

Recommendations which can be implemented for next session (starting August 2002)

2. Outcome 3 — all units at Intermediate 1 – Advanced Higher (excluding Advanced Higher *Investigation* Unit)
Reduce the volume of internal assessment evidence required for assessment of Outcome 3 in Physics courses at Intermediate 1 to Advanced Higher.

At Intermediate 2 to Advanced Higher level, this will be achieved by requiring candidates to produce one piece of evidence for Outcome 3, in each science Course at a particular level, then using it for Outcome 3 in all the Units of the Course. This will replace the existing requirement to produce distinct pieces of evidence for Outcome 3. This change will require some minor changes to the units, as currently the Outcomes and Evidence Requirements make reference to the context of the Unit.

At Intermediate 1 level the approach outlined above will apply to Outcome 3 of the Units *Practical Electricity*, *Sound and Music*, and *Movement.* A different approach to Outcome 3 is used in the other three Units of the Course. SQA will investigate how to reduce the volume of assessment for Outcome 3 of these units. Recommendations from the investigation will be implemented as soon as is practicable for centres and SQA.

3. Assessment load in Advanced Higher: 2·5 hour examination, Investigation Report of up to 2000 words, and 20 minute Visiting Examiner interview
The Examination and Investigation Report should be retained, but the 20-minute interview with a Visiting Examiner should be dropped. Assessment guidelines and Grade Descriptions for the Investigation Report should be revised to reflect this. (See section 2.4. Sections 2.5 and 2.6 also refer to this issue.)

Mid-long term recommendations

There are no mid-long term issues to be addressed.

2 Course report

2.1 Structure of Courses

Component Units

Acc 3 Physics

- Telecommunications (20 hours)
- Practical Electricity (20 hours)
- Radiations (20 hours)
- Sound and Music (20 hours)
- Movement (20 hours)
- Electronics (20 hours)

Int 1 Physics

- Telecommunications (20 hours)
- Practical Electricity (20 hours)
- Radiations (20 hours)
- Sound and Music (20 hours)
- Movement (20 hours)
- Electronics (20 hours)

Int 2 Physics

- Mechanics and Heat (40 hours)
- Electricity and Electronics (40 hours)
- Waves and Optics (20 hours)
- Radioactivity (20 hours)

Higher Physics

- Mechanics and Properties of matter (40 hours)
- Electricity and Electronics (40 hours)
- Radiation and Matter (40 hours)

Advanced Higher Physics

- Mechanics (40 hours)
- Electrical Phenomena (40 hours)
- Wave Phenomena (20 hours)
- Physics Investigation (20 hours)

Uptake in 2001(figures for 2000 are in brackets)

Int 1 Physics	158 (74)
Int 2 Physics	1 989 (1 603)
Higher Physics	10 143 (9 572)
Advanced Higher Physics	1 051

Do the Courses meet the design criteria (1-7)?

No — there are 20-hour Units at Access 3, Intermediate 1, Intermediate 2 and Advanced Higher.

Issues and recommendations

1. Issue: 20 hour Units in Advanced Higher, Intermediate 2, Intermediate 1

Advanced Higher

The original consultation document for AH proposed 3 x 40-hour mandatory Units and the removal of the Project. This proposal did not receive wide support from centres or end-users. The inclusion of a 20 hour Investigation in AH Biology, Chemistry and Physics was a compromise developed in response to the consultations findings in the sciences as a whole.

The 20-hour Wave Phenomena Unit was developed to complete the 120 hours of the Course. The NAB tests for the Unit are marked out of 20, and last 30 minutes; the tests for the 40-hour Units are marked out of 30 and last 45 minutes. There have been no adverse comments on the impact of the 20-hour Units at Advanced Higher.

Intermediate 2

The 20-hour Units at Intermediate 2 were included to ensure that there was sufficient breadth of content in this Course. The content of these Units could not be merged into a single coherent Unit.

The NAB tests for the 20-hour Units are marked out of 20 and last 25 minutes; the tests for the 40-hour Units are marked out of 40 and last 45 minutes. There have been no adverse comments on the impact of the 20-hour Units at Intermediate 2.

Intermediate 1

This Course is applications-based and is made up entirely of 20-hour Units. This ensures that candidates are not required to study the same topic for an extended period, and that the topics deal with real-world applications of Physics. These decisions are based on the success of the applications-based Standard Grade Physics – it was thought that a Course of this type would attract and retain the interest of candidates studying at this level. The NAB tests for all Units are marked out of 20 and last 25 minutes. The uptake of Intermediate 1 Physics is comparatively low, so there has not been a large volume of feedback on this Course, but the feedback that has been received has been positive.

The use of 20-hour Units in Physics Courses is justified from a breadth of provision and content orientation/divide perspective. A move towards 40-hour Units would create unnatural blocks of unrelated content.

Recommendation: 20 hour Units in Advanced Higher, Intermediate 2, Intermediate 1

The 20-hour Units should be retained at all levels. SQA should continue to monitor feedback on this issue, particularly in relation to Intermediate 1.

2.2 Assessment rationale

Internal assessment

Unit assessments assess all Outcomes and PCs at the minimum standard required for a pass, but do not address any of the additional requirements of the Course. Unit assessment takes place immediately after completion of learning and teaching, and recognises achievement in a straightforward, familiar context. Unit assessments have been designed to be accessible.

Unit assessment includes assessment of practical work. Practical work is essential in providing a context for the development of important scientific problem-solving and practical skills, and underpins the development of knowledge and understanding. It is vital that candidates actively participate in experimental work and have opportunities to manipulate experimental data generated first-hand.

The emphasis is on the development and assessment of analytical and evaluative skills, with a particular focus on report writing. This is intended to match what goes on in the scientific workplace, and should also contribute to raised attainment in the external examination.

External assessment

The external Course examination samples across all of the Unit Outcomes, and achievement is graded on the basis of cut-off scores.

External assessment goes beyond internal assessment in focusing on integration and application of knowledge and understanding, and problem-solving and practical abilities, in the content/contexts of the component Units. The Units are sampled equally in the examination, which includes familiar contexts as well as contexts which are less familiar and more complex than in the Unit assessments. While there are no compulsory practicals, there are questions in the examination on practical work in contexts less familiar to candidates.

Relationship between internal and external assessment

The examination is designed to produce evidence against the Grade Descriptions. While similar questions to those that appear in the NABs may be used in the exam, they are testing the candidate's long-term recall and understanding (grade C). Achievement at grade C goes beyond the sum of achievement in each of the component Units because of the integration of skills and knowledge required. Candidates' responses to NABs alone cannot provide valid evidence of attainment against the Grade Descriptions.

Achievement is graded on the basis of threshold scores. Every Course examination has clearly-defined design parameters that are detailed in the Course specification. The design parameters ensure that variation in the standard of papers from year to year is minimised.

For each Course, there are clear relationships between the design parameters for Unit tests and the design parameters for Course examinations. These ensure that there is clear differentiation between the requirements of the Units and the Course.

Estimates and appeals

Valid evidence for an Estimate could be generated through the use of a summative assessment instrument, such as a prelim-type examination based on work for at least **two** component Units which emulates as far as possible, the standard, security and format of the external examination.

Evidence collected for an Assessment Appeal should cover the content of **all** component Units. The evidence gathered for the Estimate should be combined with other evidence gathered towards the end of the Course for the remaining component Unit.

A high-scoring performance in a NAB, covering the content not assessed in the prelim, would lend weight to an Appeal for a grade C award. For Appeals for grade A, additional Course questions covering content not assessed in the prelim, and providing evidence of attainment against the Grade Description for the grade A award, should be included in the submission. Evidence produced from NABs alone (because of the lack of headroom for grade A) will not be sufficiently compelling for appeals for an A Grade.

Appendix 1 summarises the total assessment load for each Course.

Does the assessment approach meet assessment criterion 8?

Yes

Issues and recommendations

None

2.3 Internal assessment of Units

Description of the overall approach to internal assessment

A common approach was taken to internal assessment in the sciences, building on the experiences of Standard Grade. All Physics Units (other than the AH Physics *Investigation* Unit) that are components of Courses have three Outcomes:

- Outcome 1 – knowledge and understanding
- Outcome 2 – problem solving
- Outcome 3 – practical abilities

Outcomes 1 and 2 are assessed by a holistic end-of-Unit test. Each Unit has clearly-defined design parameters that are detailed in every NAB for that Unit.

Outcome 3 is assessed by a report on an experiment in which the candidate has been involved or based on information that has been collected by the candidate. Each candidate must complete a report individually. There is a widely accepted structure to a scientific report, which comprises of a number of different aspects, all of which must be present — these are defined by the Performance Criteria for Outcome 3. The Outcome is achieved when there is evidence for each PC in the report. This is not a separate assessment event, but part of the on-going learning and teaching process. Supportive criticism of the report (and re-drafting in the light of this) is encouraged as part of this process and to produce evidence for assessment. Re-drafting should focus on the Performance Criteria concerned.

Access 3 Units have two Outcomes. Outcome 1 is assessed by a holistic end-of-Unit test that has clearly-defined design parameters. Outcome 2 involves the submission of one completed report of an experiment in which the candidate has been involved or based on information that has been collected by the candidate.

AH Physics *Investigation* Unit

This Unit has two Outcomes, which are assessed through a lab record (log/diary) which gives brief summaries of the planning stage and records the collection and analysis of data.

A formal report of this activity contributes to the external assessment of the Course (see next section).

Note on comparability with other Courses in the same broad subject area

The approach taken in Physics is broadly similar to that taken in the others sciences. There are minor differences in Outcome 3 — Biology (Int 1), Physics (Int 1) and Chemistry (Int 1 – H) all use structured reports — and these have structured questions to help candidates to frame their report. Biology (Int 2-AH), Physics (Int 2-AH) and Chemistry (AH) require candidates to write a report without such support.

Does the internal assessment of the Units meet assessment criterion 9?

No, especially with reference to Outcome 3.

Issues and recommendations

There has been some concern about the time taken up by the assessment of Outcome 3. In September 2000, centres were informed that the completion of the report and subsequent re-drafting of the report could be completed outwith class time, provided the teacher/lecturer took measures to ensure the authenticity of the work produced. This clarification has led to significant improvements in this area, although a few comments submitted to the review have indicated that this move has not been popular with all teachers.

Examining teams and Assessment Panels tend to feel that difficulties with Outcome 3 stem from the fact that many teachers/ lecturers have been too demanding in terms of the amount of detail required, and in re-drafting requirements — much of the workload stems from re-assessment rather than assessment. Some centres have thought, incorrectly, that a report that did not initially meet all of the PCs had to be completely re-written- in fact, only those parts which do not meet the PCs need to be re-drafted or modified. Other centres have required candidates to correct every minor imperfection before they have judged the report to be satisfactory. This could be addressed by staff development and exemplification of standards.

It should be noted that over-assessment in Outcome 3 generated the greatest amount of comment from stakeholders making submissions to the NQ Review across the sciences. In Physics, it was the single biggest issue. However, there was no clear consensus on what action should be taken.

Recommendation: Outcome 3 — all Units at Intermediate 1- Advanced Higher (excluding Advanced Higher *Investigation* Unit)

Reduce the volume of internal assessment evidence required for assessment of Outcome 3 in Physics courses at Intermediate 1 to Advanced Higher.

At Intermediate 2 to Advanced Higher level this will be achieved by requiring candidates to produce one piece of evidence for Outcome 3 in each science Course at a particular level, then using it for Outcome 3 in all of the Units of the Course. This will replace the existing requirement to produce distinct pieces of evidence for Outcome 3. This change will require some minor changes to the Units, as currently the Outcomes and Evidence Requirements make reference to the context of the Unit.

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2.4 External assessment of the Courses

Description of the overall approach to external assessment

Each Physics Course is assessed by a single question paper with the following duration:

Intermediate 1	1 ½ hour paper worth	84 marks
Intermediate 2	2 hour paper worth	100 marks
Higher	2 ½ hour paper worth	90 marks
Advanced Higher	2 ½ hour paper worth	100 marks

Structure of question papers:

Int 1:

- an undefined number of multiple choice questions each worth 1 mark.
- structured questions to bring the total to 84 marks

Int 2:

- Section A has 20 multiple choice questions.
- Section B has structured questions worth 80 marks

Higher:

- Section A has 20 multiple choice questions.
- Section B has structured questions worth 70 marks

The question papers for Intermediate 1 to Higher sample across all Units of the Course, and are designed to generate evidence against the appropriate Grade Descriptions.

Advanced Higher Course assessment

For Advanced Higher, the examination paper is made up of structured questions worth 100 marks. The Question Paper samples across the three content-based Units, and is designed to generate evidence against the AH Grade Descriptions.

In addition, candidates are required to complete the 20-hour Unit *Physics Investigation*. For internal/Unit assessment, candidates are required to keep a record of the investigation (in a lab notebook or daybook) with respect to the planning and collection of experimental data. For external assessment, candidates are required to write up a formal report (of about 2000 words). This is sent to a Visiting Examiner, who

marks it and carries out an interview at the candidate's centre. 25 marks are available for the external assessment of the *Investigation* Report: three marks are awarded by the presenting centre for the candidate's ability to manage resources; four marks are awarded for the candidate's performance in the interview; up to four further marks can be awarded against the other assessment categories on the basis of the candidate providing additional evidence during the interview that was not present in the report. In total, then, the VE can award up to eight marks which cannot be awarded by alternative means.

The mark for the Investigation (out of 25) is added to the mark achieved in the Course exam (out of 100) to arrive at the total mark for Course assessment.

Note on comparability with other Courses in the same broad subject area

The sciences have adopted a similar approach, in that the exam at each level is the same length. The structure of the papers varies across the sciences.

Use of an interview with a Visiting Examiner as an additional means of assessing and quality assuring the Advanced Higher Investigation is unique to the sciences. Most Advanced Highers include assessment of an investigation or dissertation, with no use of Visiting Examining. Advanced Higher Technological Studies and both Mathematics Advanced Highers only have one external assessment component (an examination question paper of 3 hours duration).

At Higher, Physics has a very slight negative (ie more difficult) National Rating, and is very well placed in the broad grouping of 'technological subjects': Technological Studies, Mathematics, Information Systems and Computing.

Does the external assessment of the Courses meet assessment criterion 10?

Yes, at Int 1 – H
No, at AH — the external assessment load is:

Examination - 2 hours 30 minutes
Investigation report - 2000 words
Interview with Visiting Examiner - 20 minutes

Issues and recommendations

Issue: Assessment load in Advanced Higher - 2·5 hour examination, Investigation Report of up to 2000 words and 20 minute Visiting Examiner Interview

Evidence for some of the grade descriptions is generated from the Investigation Report. The Investigation allows candidates to carry out an open-ended piece of practical work for which they have sole responsibility — a reflection of the way real scientists work.

The investigation draws on all previously-acquired practical skills and knowledge and understanding of the subject; in a sense, it is a culmination of all of the scientific education that has gone before. The report can be used effectively to discriminate between candidates not only in relation to their production of an extended piece of scientific writing but also their understanding of the underlying science, and their application of theory and principles.

A Visiting Examiner assesses the report, and carries out a 20-minute interview with each candidate. While there are strong arguments for retaining both an examination and an investigation, the use of visiting examining can be questioned in terms of:

- possible candidate stress, and additional workload
- additional workload for the teacher/lecturer in preparing the candidate and helping to organise the Visiting Examination
- additional workload for the SQA Co-ordinator
- administrative burden for SQA

- potential for errors in data (see section 2.6, below)

It is important to note the marks allocation for this component:

- Total marks for the investigation- 25 (total for Course 125)
- Centre awards up to 3 marks
- Interview — up to 4 marks, with an additional 4 marks available to supplement marks for report
- Report — 18 marks

In summer 2001, SQA commissioned a consultant to produce a report based on quantitative and qualitative analysis of the effect of the interview on the marks given for the Investigation Report in Advanced Higher Biology, Chemistry and Physics in diet 2001. This report suggests that removing the interview from the assessment procedure would improve validity, reliability and cost-effectiveness in the assessment of the Investigation Report.

The report recommended that the interview be removed and the marks be allocated elsewhere in the report — one option would be to allocate marks for the quality of the context of the subject of the investigation.

Recommendation: Assessment load in Advanced Higher — 2·5 Hour Examination, Investigation Report of up to 2000 Words and 20 minute Visiting Examiner Interview

The Examination and Investigation Report should be retained, but the 20-minute interview with a Visiting Examiner should be dropped. Assessment guidelines and Grade Descriptions for the Investigation Report should be revised to reflect this.

2.5 Quality Assurance

Description of the overall approach to quality assurance

Quality Assurance of Physics Examinations

SQA's standard setting, vetting and marking procedures apply. Attendance at markers' meetings is mandatory.

Quality Assurance of *Investigation* Report at Advanced Higher

Allocation of Visiting Examiners (VEs) to centres cannot be done within SQA's Awards Processing System and is carried out manually. Centres send reports direct to their named VE who contacts the centre to arrange an appropriate time for carrying out the interviews.

Do the quality assurance arrangements for the Courses meet criterion 11?

Yes, Int 1 - H
No, at AH - the use Visiting Examining for the AH Investigation is neither effective nor efficient, since it requires a huge amount of manual administration by SQA and centre staff.

Issues and recommendations

Advanced Higher Investigation – visiting examining

In terms of its effectiveness and efficiency as a quality assurance mechanism, the independent report on Visiting Examining has found that is it no more effective than standard marking and marker check procedures.

2.6 Administration

Issues and Recommendations

Advanced Higher Investigation – administration of visiting examining

The organisation of Visiting Examining for AH is complex and labour intensive as the procedure is not standard and cannot be processed on SQA's computerised Awards Processing System. As a result, it is difficult to track data, and this increases the risk of data errors and/or loss.

Staff in centres have to fill in a special 'AH 5 supplement' form on which they enter centre details, Visiting Examiner numbers, candidate names in alphabetical order of surnames, (dates of birth if required to distinguish between two or more candidates with the same name), the titles of the candidates' Investigation Reports, and marks out of 3 for assessment category (g) 'Management of resources'. Centre staff send the completed top copies together with the Investigation Reports directly to the Visiting Examiner(s). A third copy is sent to SQA.

Visiting Examiners have to complete the forms 'AH 5 Supplement' when they have completed the visiting examining process, by entering marks for assessment categories (a) to (f), adding the centre marks for assessment category (g), and noting the total mark out of 25 for each candidate. The Visiting Examiners are then required to return the Investigation Reports, together with the top copy of the AH 5 Supplement form to SQA. The VEs retain one copy until the end of July as a contingency against the loss of the reports and/or other copies of the form.

SQA staff have to manually transfer marks to a form which can be used by data processing bureaux — this has the potential for introducing data errors. As there are no links between APS and allocations of centres and candidates to Visiting Examiners, normal procedures cannot apply to Marker Check and Finalisation. These procedures are only possible as the result of massive manual intervention of SQA staff and examiners.

SQA will take steps to reduce the administration associated with Visiting Examining in session 2001-2002.

3 Summary of review process and issues raised

Who	Mechanism	Feedback received
Subject specialists	Comments received by post and e-mail. Implementation evidence - research report on Visiting Examination for AH Investigation	86 responses by 5 November 2001. A full summary and collation of these comments will be made available separately. Main recommendations are outlined in the report.
SQA co-ordinators	SQA SAMs and CRMs	No issues raised
Principal Assessors and Senior Moderators	As detailed under subject specialists	Feed back incorporated into recommendations
Units within SQA	Internal views sought - especially Assessment Moderation Unit	Issues raised about manageability of the Visiting Examining at AH in terms of cost effectiveness and added value
Candidates and parents	SPTC survey	No issues raised
Other surveys and reports	MORI January 2001 SFEU/Higher Still May 2001	Teachers of Sciences (80%) are more inclined to maintain that students are not prepared for the external exam. Science teachers (72%) are more inclined to feel that the implementation of internal assessments has not worked One college commented that science Courses have additional demands in practical assessments and the need for 3 assessments in this area. Makes evening class provision more time-consuming. Many students in this market are unwilling to devote more than one day a week to class-based study.

Appendix 1 – approximate total assessment loads

Physics, Int 1
Test 25 min/ practical around 35 minutes per Unit x 6 = 6 hours
External Assessment = 1 hour 30 minute examination
Total = 7 hour 30 minute

Physics, Int 2
Unit tests 2 x 45 & 2 x 25 minutes/ practical 2 x approximately 1 hour & 2 x 45 minutes = 5 hours 50 minutes
External Assessment = 2 hours examination
Total = 7 hour 50 minutes

Physics, H
Unit tests 3 x 45 minute/ practical 3 x 1 hour = 5 hours 15 minutes
External Assessment = 2 hours 30 minutes examination
Total = 7 hours 45 minutes

Physics, AH
Unit tests 2 x 45 & 1 x 30 minutes/ practical 3 x 1 hour + around 1 hour lab daybook for Investigation Unit - ongoing= 6 hours

2000 word report
20 minute interview
2 hours 30 minutes exam
Total: 11 hours 20 minutes + investigative work + 2000 word report