Physics:
Guidance on gathering evidence and providing estimates

Contents

Aims

The aims of this document are:

- to guide and advise teachers and lecturers in gathering evidence and providing estimates for their candidates
- to provide guidance on:
  - what is meant by an estimate
  - how to make estimates fair for all candidates
  - how to improve the predictive value of estimates
- to provide advice on:
  - how to compare evidence for estimates with SQA assessments
  - normal rules used in marking evidence for estimates in physics

What is an estimate?

An estimate is a judgement of a final grade a candidate will achieve in a National Course. It is based on a holistic review of a candidate's performance as indicated by assessment evidence, gathered at a centre level. It is imperative that each estimate is a realistic, evidence-based prediction of a candidate's final attainment in the course assessment.

The challenge for teachers and lecturers is to use their professional judgement to estimate the grade a candidate will achieve in a national course before they sit any course assessment.

Teachers and lecturers are asked to make this estimate by taking account not only of the evidence of the candidate's attainment of the skills, knowledge and understanding of the course, but also of the relative strength and reliability of the predictive value of each piece of evidence.

For example, a prelim exam, covering most of the course, is likely to be a more reliable predictor of a candidate's final grade than an end-of-topic test. It is important to consider the quality of evidence rather than the quantity of evidence when engaging with the estimation process.

The following types of evidence, shown in order of reliability for producing estimates, could be utilised when estimating a candidate's overall attainment in physics.

Prelim or mock exam

A prelim or mock exam is undertaken under the same conditions as the question paper. It should be clearly aligned to the course specification, content and level of demand as exemplified in the specimen question paper and past papers.

Specimen question papers and past papers are in the public domain and can be readily accessed by candidates. If used in their entirety, they do not form valid evidence. However, individual questions from past papers can be incorporated into prelims, mock exams or class tests. Alternatively, centres may devise their own prelims or use commercially produced question papers.

Commercially produced question papers may provide valid evidence for informing estimates. They do not have to be the most recent version. Teachers and lecturers should judge whether any commercially produced question paper meets the demands of the course specification and has an appropriate level of demand.

Top-up exam or an extended test

As prelims or mock exams usually take place before the course is completed, it is important that evidence to support the latter part of the course is generated for consideration in making an estimate. The best way of doing this is through a top-up exam or an extended test. This assessment should sample the knowledge not covered in the prelim or mock exam, as well as skills. It should also sample content from the earlier parts of the course. However, it is important that no questions are repeated between the assessments, as questions should be unseen.

The attainment demonstrated in this top-up exam or extended test should be combined with the attainment demonstrated in the prelim or mock exam, to form a judgement about the estimated grade.

Centres should give greater weight to the prelim or mock exam, however; the judgement should be holistic rather than focussing only on the piece of evidence that gives the best grade.

End-of-topic class tests

End-of-topic class tests should sample the key aspects of the course and be conducted under the same conditions as the question paper. End-of-topic class tests are unlikely to contain sufficient integration, challenge and/or application, but could be used as **supplementary** evidence to support estimates.

Fairness to all candidates

When making estimates, teachers and lecturers should bear in mind any factors that may impact a candidate's access to learning, especially:

- assessment arrangements in place for the final exam, such as reader, scribe, extra time etc
- illness or personal circumstances at the time of the evidence being produced
- caring responsibilities, illness or disability which present a barrier to learning

Teachers and lecturers should also take steps to eliminate any bias from estimates. Implicit bias may originate from stereotypes based on factors such as background, gender, disability, and ethnicity.

Predictive value of evidence

Judgement about a candidate's estimated grade must be grounded in evidence that demonstrates attainment.

In preparing evidence, teachers and lecturers should consider:

- course coverage
- similarity to course assessment
- level of demand

Over reliance on end-of-topic tests as a basis for an estimate is discouraged. By their nature, end-of-topic tests, even those designed to include A-type marks, tend to compartmentalise knowledge and understanding of the course, and are therefore of a lesser demand than course assessment.

A piece of evidence has a high predictive value if a candidate who performs well in the evidence would be reasonably expected to perform equally well in the course assessment.

Some considerations that impact on the predictive value include the following:

Course coverage

If a piece of evidence covers only a small portion of the course content, it is unlikely to be a good predictor for the full course. Evidence does not need to cover the entire course specification, but the more material that is covered, the more reliable the predictive value is likely to be.

Similarity to course assessment

Evidence that is similar to SQA course assessment will have a more reliable predictive value than evidence that differs considerably, in terms of structure, content and the conditions under which the evidence is obtained.

Evidence gathered under less strict conditions, or of a lower demand than SQA course assessment, will have a weaker predictive value.

Level of demand

Evidence gathered should support the estimated grade. The evidence gathered must be set at an appropriate level of demand to be a reliable predictor.

In physics, approximately 30% of course assessment assesses A-grade skills, knowledge and understanding. To be a reliable predictor, evidence should mirror this.

In other words, the most reliable estimate of a candidate's grade will be derived from evidence that matches the external assessment as closely as possible.

In physics, SQA’s question papers are constructed taking account of:

- coverage of the content of the course
- coverage of the skills, knowledge and understanding of the course
- integration of knowledge and skills from across the course
- the level of demand of the question papers as a whole (ie the proportion of A-type marks to C-type marks)

Question paper scaling

The purpose of scaling is to maintain the balance between the assessed skills. Scaling was introduced when half marks were removed, and the ‘standard 2-marker’ became the ‘standard 3-marker’.

Since we are not combining marks from the question paper with marks from an assignment or project, scaling is not necessary at Advanced Higher (AH) level. At Higher (H) and National 5 (N5), however, scaling is needed to maintain the balance between multiple-choice and extended-response questions.

So, at Higher level, there are 25 marks for multiple-choice questions, unscaled, and 130 marks for extended responses, scaled to 95, to give a total of 120.

At National 5, there are 25 marks for multiple-choice questions, unscaled, and 110 marks for extended responses, scaled to 75, to give a total of 100.

Course content

The table below gives an indication of how a physics question paper is balanced for course content.

<table>
<tr><th>AH</th><th colspan="2">Rotational motion and astrophysics</th><th colspan="2">Quanta and waves</th><th colspan="2">Electromagnetism</th><th>Units, prefixes, and uncertainties</th></tr>
<tr><td>100%</td><td colspan="2">~37%</td><td colspan="2">~37%</td><td colspan="2">~18%</td><td>~8%</td></tr>
<tr><td colspan="8"></td></tr>
<tr><th>H</th><th colspan="2">Our dynamic universe</th><th colspan="2">Particles and waves</th><th colspan="2">Electricity</th><th>Units, prefixes, and uncertainties</th></tr>
<tr><td>100%</td><td colspan="2">~37%</td><td colspan="2">~37%</td><td colspan="2">~19%</td><td>~7%</td></tr>
<tr><td colspan="8"></td></tr>
<tr><th>N5</th><th>Dynamics</th><th>Space</th><th>Electricity</th><th>Properties of matter</th><th>Waves</th><th>Radiation</th><th>Units, prefixes, and scientific notation</th></tr>
<tr><td>100%</td><td>~16%</td><td>~16%</td><td>~16%</td><td>~16%</td><td>~16%</td><td>~16%</td><td>~4%</td></tr>
</table>

In a prelim, the marks should be proportional to the topic areas being covered; for example, at National 5, if examining all Dynamics, Space, and Waves content but only half the Radiation content, it would not be appropriate for all these areas to be equally represented in the paper.

There is no requirement for everything within the topic areas to be assessed, but a wide range of sampling across the topic areas should be employed.

Skills assessed

The skills, knowledge and understanding question types are the same for National 5, Higher, and Advanced Higher Physics courses.

There are three knowledge-based skills (K1, K2, and K3) and seven skills relating to scientific inquiry (S1 to S7). For physics question paper assessments, approximately 70% of the marks assess the three knowledge-based skills and 30% of the marks assess the skills of scientific inquiry.

The table below shows the percentage distribution of marks, by skill, across the question papers.

Skills		N5	H	AH
K1	Demonstrating knowledge and understanding of physics by making accurate statements.	6-9%	3-10%	1-6%
K2	Describing information, providing explanations, and integrating knowledge.	16-26%	14-23%	10-24%
K3	Applying knowledge of physics to new situations, interpreting information, and solving problems.	46-61%	40-54%	40-60%
S1	Planning and/or designing experimental/fieldwork investigations to test given hypotheses or illustrate particular effects.	1-6%	1-5%	0-7%
S2	Selecting information from a variety of sources.	0-2%	0-3%	0-2%
S3	Presenting information appropriately in a variety of forms.	1-6%	1-6%	1-6%
S4	Processing information/data (using calculations and units, where appropriate).	4-13%	7-20%	7-19%
S5	Making predictions based on evidence/information.	0-3%	0-5%	0-7%
S6	Drawing conclusions and giving explanations supported by evidence/justification.	3-10%	3-8%	4-10%

S7	Suggesting improvements to experimental procedures.	2-6%	1-4%	1-8%

Some of the skills of scientific inquiry are more naturally assessed as part of the coursework (assignment or project) and are not heavily assessed in the question paper. In the absence of coursework, there is scope to assess these skills in a prelim so long as this does not significantly change the structure or format that candidates may be expecting, based on practice using past papers.

The marks allocated to a single question can be split between knowledge and skills categories to reflect the nature of the question.

Question paper structure

The National 5 Physics question paper has two sections.

Section	Content
1	**Multiple-choice questions totalling 25 marks** This section samples knowledge and understanding from across the course and a selection of skills of scientific inquiry by providing candidates with appropriately challenging five-option multiple-choice questions.
2	**Extended-response questions totalling 110 marks** This section also samples knowledge and understanding from across the course and a selection of skills of scientific inquiry, including two open-ended questions, each worth 3 marks. There may be integration of topic areas and skills from different parts of the course.

Higher Physics has two question papers.

Paper	Content
1	**Multiple-choice questions totalling 25 marks** This paper samples knowledge and understanding from across the course and a selection of skills of scientific inquiry by providing candidates with appropriately challenging five-option multiple-choice questions.
2	**Extended-response questions totalling 130 marks** This paper also samples knowledge and understanding from across the course and a selection of skills of scientific inquiry, including two open-ended questions, each worth 3 marks. There may be integration of topic areas and skills from different parts of the course.

Advanced Higher Physics has a single question paper.

Content
Extended-response questions totalling 155 marks This paper samples knowledge and understanding from across the course and a selection of skills of scientific inquiry, including two open-ended questions, each worth 3 marks. There may be integration of topic areas and skills from different parts of the course.

A-type marks and C-type marks

A-type marks

A maximum of 30% of the marks in course assessment will be 'A'-type marks. These require candidates to demonstrate a consistently high performance in relation to the skills, knowledge and understanding of the course.

Candidates demonstrate this by:

- showing a deeper level of knowledge and understanding
- integrating and applying skills, knowledge and understanding across the course
- displaying problem solving skills in less familiar and more complex contexts
- applying skills of scientific understanding and analytical thinking in complex contexts, or contexts that involve more complex data

The criteria for A-type marks relate to the level of demand of a question rather than the difficulty that candidates may have with a question. In general, questions testing higher order skills such as analysis or evaluation usually have A-type marks associated with them. Questions testing recall, despite candidates often performing poorly in them, do not have associated A-type marks, since recall is not a higher order skill.

Questions with A-type marks may also be evidenced through the approach used for marking. For example, the difference between 'justify' and 'must justify' questions is not in the expected response (the two would be identical) but in how the response is marked.

C-type marks

Questions with C-type marks require candidates to demonstrate successful performance in relation to the skills, knowledge and understanding for the course.

Approximately 70% of marks across the paper should be targeted at C-grade candidates.

It should be noted that there is no intentional targeting of questions for B-grade candidates. The probability is that B-grade candidates would achieve the majority of C-type marks and some of the A-type marks.

Examples of questions with associated A-type marks can be found in ‘Appendix 1’ at the end of this guidance.

Constructing a physics prelim

There is no requirement, or obligation, on centres to construct new assessments on which to base estimates.

However, if using any pre-existing assessments on which to base estimates, centres should consider how closely these mirror SQA-produced question papers. (See the section on ‘Using cut-off scores’).

The following should be considered if constructing a new physics prelim.

- If using past papers as a source, the prelim should be composed of questions drawn from at least **three** past papers and avoid drawing consecutive questions en-bloc from a single past paper.
- If questions from past papers are adapted, or if a centre devises its own questions, or a mix of these, the questions must meet the assessment requirements detailed in the course specification (see Skills Assessed section above).
- Marks should be proportional to the areas being covered. For example, if examining one full topic area but only half the content of another topic area, it would not be appropriate for these areas to be represented equally in the paper.
- Each question assessing knowledge should focus on the mandatory content listed in the course specification and assess only what is listed there. The context of the question, however, may be unfamiliar to candidates.
- Approximately 30% of the marks should be A-type and 70% C-type.
- The prelim should mirror the structure, format, and language of an SQA question paper.
- There should be two open-ended questions.
- Care should be taken not to include questions that are either too short or too long. The number of marks allocated to each question or sub-question should be similar to those allocated in past papers.

Writing questions

To support teachers and lecturers should they wish to write questions for assessments on which to base estimates, some guidance to SQA question writers can be found in Appendix 2 at the end of this guidance.

Marking reliably

Teachers and lecturers should be familiar with the document *'Physics: general marking principles'*.

Close attention should also be paid to the published marking instructions and general marking principles that accompany past papers, as these demonstrate the required marking standard.

Centre-devised marking instructions should follow the same format and standard as those published by SQA. It is good practice to prepare the marking instructions at the same time as the questions are being written. Marking instructions can then be refined in light of candidate responses.

Some common marking issues include:

- substitution of data
- open-ended questions
- calculations with a carry forward
- 'show'-type questions
- 'must justify' and 'justify' questions
- explain questions

Explanations and examples of these issues are included in Appendix 3.

Using cut-off scores

Teachers and lecturers should use the information provided in this guide to check how closely the assessments used to produce evidence for estimates mirror SQA question papers.

The notional cut-off scores for course assessment are:

70% A grade
60% B grade
50% C grade
40% D grade

These notional cut-off marks should **not** be applied unless the assessments used by the centre mirrors an SQA question paper. It **would** be reasonable to use these grades for estimates if the prelim (or other evidence) matches an SQA question paper in terms of course coverage, similarity of question style (skills coverage, duration etc), and level of demand (30% A-type marks).

The cut-off scores should be amended to reflect any differences between centre evidence and SQA question papers.

Such differences may include:

- a prelim being split over a number of sessions rather than a single sitting
- assessments with an insufficient number of A-type marks
- assessments which do not adequately sample the skills, knowledge and understanding of the course
- assessments which do not adequately integrate the skills, knowledge and understanding of the course

In such circumstances, the cut-off scores used should be increased to compensate for the differences.

For example, a centre checks their prelims and decides that they contain 25%, rather than 30% A-type marks. There is a 'first' prelim in a 2-hour single sitting in January, and a 'mop-up' prelim in a 1-hour sitting in May. Overall, the coverage of skills, knowledge and understanding is satisfactory, and the 'mop-up' prelim contains some integration of skills, knowledge and understanding from earlier topics. To account for differences between their assessments and the SQA question paper, the centre applies cut-off scores of:

77% A grade
67% B grade
57% C grade
47% D grade

It is important to note that not all questions intended to challenge A-grade candidates actually do so; sometimes intended A-type marks turn out to be relatively straightforward and the majority of candidates achieve the marks. Therefore, once all candidates' prelims have been marked, overall class performance should be reviewed, especially whether marks intended to perform as an A-type did so; if not, consider why this might be and whether the grade cut-off score should be adjusted upwards/downwards to reflect candidate performance.

A question considered to be quite straightforward may yield responses significantly different to the marking instructions, suggesting that the wording of the question caused confusion, or that the question was too challenging. Again, the grade cut-off scores may need to be adjusted to reflect this.

Producing estimates

There is no requirement, or obligation, on centres to construct new assessments on which to base estimates.

However, centres **should** judge the methods used to generate the evidence on which candidate estimates are made and compare these with SQA-produced question papers.

Factors to be considered are:

- conditions of assessment
- coverage of course content
- coverage of course skills
- level of demand of the assessment

If the methods used by the centre to generate estimates do not exactly mirror SQA course assessment, then, as described above, the centre should amend the cut-off scores used to grade the candidates.

Frequently asked questions

How can I look more closely at prelim and test performance to be sure of making an appropriate estimate for each candidate?

Whilst the overall percentage score for each candidate is often used by centres as a basis for estimating grades, it is important to look at the level of demand of the assessment too. Across the various assessment components, SQA aims for approximately 30% of the marks to address the A-grade criteria and therefore be more discriminating.

A candidate who scores highly in evidence that contains an appropriate proportion of A-type marks is likely to also score highly in the SQA assessment. However, if the assessments contain no or few discriminating questions or tasks, then a candidate who scores highly is probably only demonstrating that they are a strong C-grade candidate rather than an A-grade candidate.

Looking at how candidates performed in the more demanding questions or parts of a task will often give a fair idea of whether the candidate is likely to attain a grade A or not.

The cut-off scores I used for the prelim were higher than the notional cut-offs of 50% for a C and 70% for an A, to reflect the fact that the prelim wasn't as demanding as an SQA-produced question paper and only covered two-thirds of the course. Should I be changing to use notional cut-off scores?

Adjusting cut-off scores to reflect the level of demand of the evidence is good practice and centres are encouraged to continue to follow this good practice.

In this case, using notional cut-off scores of 50% for a C and 70% for an A, or arbitrarily adding a set percentage to every candidate's prelim score is likely to inflate estimates unrealistically and lead to unreliable information.

Should I be including homework and classwork in my evidence for estimates?

It is important to consider the **quality** of the evidence rather than the **quantity** of the evidence when considering estimates. Centres should be cautious about such evidence. Performance in homework may be an indicator of candidate performance but equally, candidates may have support from a sibling, parent, carer or tutor, and many teachers and lecturers encourage candidates to seek help from them if there are aspects of the homework with which the candidate is struggling. Homework is usually open-book in nature and that may also mean it is not a true reflection of a candidate's ability. Consequently, homework marks may not be reliable evidence of a candidate's understanding or ability, although teachers or lecturers may be aware of how much support was required.

Classwork is another area where caution should be exercised. Most classwork is conducted open-book, and teachers and lecturers encourage candidates to seek help either directly from them or from other students in the class. It may therefore not always give a true reflection of candidate performance.

I plan to give my candidates the opportunity to do some online assessment in the event of the school being closed. Should I be including this in my estimate?

Centres should be cautious about including such evidence. The conditions of assessment may be such that the result is not a true reflection of the candidate's ability, and may be influenced by external factors such as candidates having open-books, collusion between candidates, or support from a parent, carer or tutor. Centres should also consider whether it is fair to include such evidence when all candidates may not have taken part, or some may not have adhered to the necessary conditions of assessment.

It must also be considered whether **all** candidates in the class have appropriate access to technology (computer and/or broadband connection) to be able to participate in online assessment.

Are progression statistics, showing how candidates performed at the next level in relation to how they performed at a previous level, for example, National 5 to Higher, available? This would be useful information to help supplement the evidence in making estimates.

SQA still publishes progression statistics. These can be found in the statistics section of the SQA website.

Care should be exercised when using progression statistics. Whilst large uptake subjects do provide reliable statistics, there are always outliers and atypical results. For smaller uptake subjects where many candidates have no prior attainment in the subject, the progression statistics will be of limited use.

Case studies

Case study 1

A centre has provided the following evidence for a candidate:

- A prelim covering two-thirds of the course, made up of a selection of questions from past papers, with 25% of the marks testing A-grade criteria. The centre has applied notional cut-off scores.

The candidate scored 61% (borderline B/C).

- Six ‘end-of-topic tests’, each out of 30 marks, covering the whole course. Each main topic area has been split in two. There is no integration of topics or testing of long-term recall/application. The proportion of A-type marks varies between 17% and 26%.

  The candidate’s performance in the tests was: 60%, 83%, 63%, 73%, 67% and 70%.

  The centre estimates the candidate at grade B.

Comments on the prelim

The prelim was constructed using a selection of questions from SQA National 5 Physics past papers and the specimen question paper.

It has an approximately even spread between two main topic areas.

It includes open-ended questions and a question requiring graphical analysis. It is slightly top heavy in calculations but not excessively so.

Overall, it is a reasonable attempt at mirroring an SQA paper.

The centre has applied the *Physics: general marking principles* in marking, and there has been cross-marking to provide quality assurance.

Comments on the end of topic tests

The tests are much more variable in standard, with some having as few as 17% of the marks addressing the A-grade criteria.

The tests contain one open-ended question each; however, some of them are not really open-ended and would have been better just as an ‘explain’ question.

The candidate’s performance in the tests is better in the ones that have fewer A-type marks.

The centre has applied the *Physics: general marking principles* but there has been no quality assurance of the marking.

Overall comments on evidence provided

Although the candidate has on some occasions appeared to perform at A-grade, it has only been in short tests, some of which have insufficient A-type marks. The main, and most reliable piece of evidence suggests the candidate is a borderline B/C. Taking all the evidence together and looking at the actual attainment against the A-grade criteria, the best estimate for this candidate is a grade B. (The fact the candidate occasionally scored 70% or more in short tests does not outweigh the overall attainment they demonstrated.)

Case study 2

A centre has opted not to hold a formal prelim diet for National 5 candidates.

Last year, the physics department used a prelim made up of questions drawn from a number of SQA past papers. The content coverage, the coverage of skills, knowledge and understanding, and the level of demand of the paper is similar to an SQA-produced paper.

Four class tests were created by 'chunking' the prelim. Candidates were allowed 45 minutes in class, under close supervised conditions, to complete each class test. The tests were sat over a four-week period in January and February. Candidates were aware of the areas of the course being assessed in each test. In addition, there was an 'A/B-type' class test at the end of the course, covering only the topic areas not covered in the 'chunked' prelim. Around 20% of the marks in this test are A-type.

Over the year, candidates also sat three tests from the SQA secure site assessing outcome 2 from the SCQF level 5 units, which were formerly part of the National 5 course.

The centre applied the *Physics: general marking principles* and ensured that a proportion of all of the tests were cross marked as a check that the marking is reliable and consistent. The evidence submitted for one candidate was the class tests made from the 'chunked' prelim combined to give a mark of 74%, the end-of-course class test marked at 73%, and the three SCQF level 5 tests, marked at 80%, 85% and 76%.

The centre estimated the candidate at grade A.

Comments on the 'chunked' prelim

The level of demand of the 'chunked' prelim is lower than the full prelim would have been.

Even assuming that all National 5 Physics candidates in the centre sat the tests simultaneously, candidates were aware of topics covered in each test, meaning that they only needed to revise and remember limited areas of the course for each test. Overall, the time allocation was greater than the 2 hours 30 minutes of the full prelim.

In these circumstances, the notional 70% cut-off score for a grade A estimate should be raised. A prelim mark of 74% would most likely be evidence for an estimate of grade B.

Comments on the 'end-of-course' class test

Again, the level of demand of this test is lower than an SQA-produced course assessment.

In addition to the reasons given above, the percentage of A-type marks is lower than the 30% target in SQA-produced papers and there is no integration of skills, knowledge and understanding from across the course.

Again, these would be reasons for the notional 70% cut-off score for a grade A to be raised, and a mark of 73% would confirm a prelim estimate of grade B.

Comments on the SCQF level 5 tests

These tests consist of questions that have no A-type marks associated with them.
A series of high scores in these assessments would only be evidence for an estimate of grade C.

On their own, the marks scored in these assessments would not support an estimate of grade A or grade B, but, taking a holistic view, all of the evidence submitted for this candidate, would be consistent with an estimate of grade B.

Overall comments on evidence provided

Adopting a holistic approach, the evidence produced by this candidate supports an estimate of grade B.

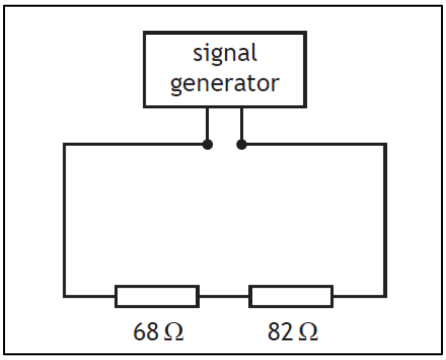
Appendix 1 – A-type marks

Calculations

- Standard 3-markers do not contain A-type marks.
- Multi-stage calculations tend to have some A-type marks allocated to them. In the case of a 5-mark question, which requires candidates to use two relationships to determine a final answer, then usually the last three marks are designated as A-type marks.

For example, 2018 Higher Physics question 12(b):

The signal generator is now connected in a circuit as shown.
The settings on the signal generator are unchanged.
The signal generator has negligible internal resistance.



Determine the r.m.s. voltage across the 82 Ω resistor. **5**

In this question the first two marks, for the potential divider relationship and the substitution of the data, are C-type marks since that step is straightforward.

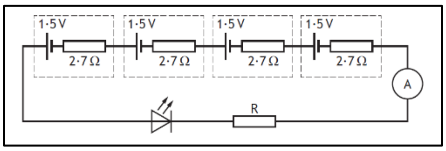
The demanding step is then identifying and using the r.m.s. relationship with the voltage across the 82 Ω resistor.

So, three of the marks would be identified as A-type marks.

However, for some multi-stage calculations, all of the marks may be designated as A-type marks.

For example, 2017 Higher Physics question 12(c):

(c) In a different circuit, an LED is connected to a battery containing four cells.



The potential difference across the LED is 3·6 V when the current is 26 mA.
Determine the resistance of resistor R. **4**

In this question, the first mark was allocated for the two relationships required ($V_{total}=V_R+V_{LED}$, $V=IR$), and candidates could gain no marks unless both relationships were quoted or implied.

Consequently, all of the marks were designated as A-type.

Note: Not all multi-stage calculations contain A-type marks. For example, determining the energy released in a fission or fusion reaction has no A-type marks associated with it.

Must justify

In this type of question, the candidate is asked to make a statement and told they must justify their statement (in terms of relevant and correct physics).

The mark for justification is often A-type, and since the mark for a correct statement is **dependent** on the mark for the justification, both marks in ‘must justify’ questions are designated A-type.

‘Must justify’ questions are described more fully in Appendix 3.

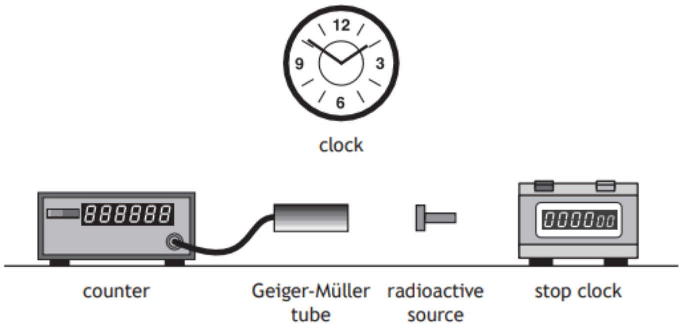
Analytical thinking

Depending on level, the steps in analytical thinking involve:

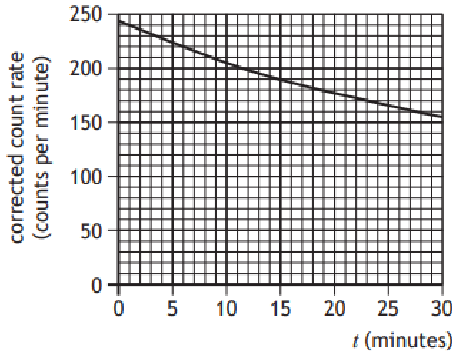
- assimilating information from the question
- relating this to the appropriate physics principles
- articulating an explanation or making a prediction

For example, 2019 National 5 Physics question 12(b):

12. A technician carries out an experiment, using the apparatus shown, to determine the half-life of a radioactive source.



(b) The technician carries out the experiment over a period of 30 minutes, and displays the data obtained in a graph as shown.

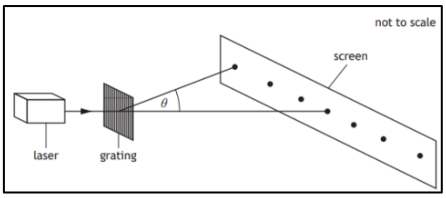


Suggest an improvement that the technician could make to the procedure to more easily determine a value for the half-life of this source. **1**

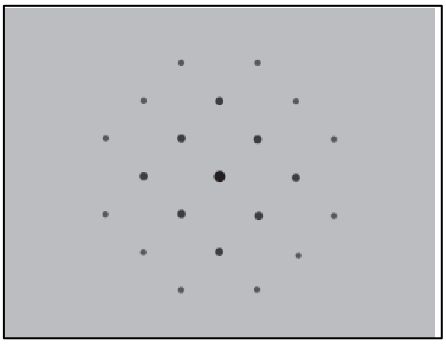
Candidates deduce from the graph that a halving of the count rate had not occurred in the 30 minutes (… and are unlikely to be aware of exponential relationships), and then suggest an adjustment to the procedure to allow the half-life to be determined, and so the mark is designated A-type.

Another example is 2018 Higher Physics question 8(b):

The question involves interference of laser light by a grating.



In (b), candidates are told that the student now shines light from the laser onto a £5 note. When it is shone through the transparent section of the note, the student observes a pattern of bright spots on the screen.



Candidates are asked to 'Suggest a reason for the difference in the pattern using the £5 note and the pattern produced by the grating. **1**

The candidate has to assimilate the information given about the 'new' pattern produced, relate this to grating interference, and articulate a possible explanation for the difference between the patterns. This is designated an A-type mark.

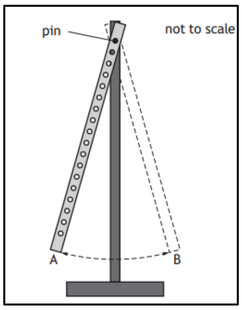
Evaluating experimental procedures

The steps in the evaluation of experimental procedures:

- assimilating the given experimental design
- depending on level, relating this to their knowledge of experimental physics, uncertainties, accuracy, and precision
- articulating a valid evaluation of the given design

For example, 2019 Higher Physics question 15(b)(iii)(B)

The context is an experiment likely to be unfamiliar to candidates, measuring the period of a compound pendulum.



(B) Suggest an improvement to the experimental procedure that would allow a more precise value for the minimum period *T* to be determined. **1**

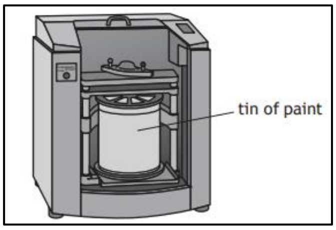
To answer this, candidates must fully understand both the steps in the procedure described in the question, and the significance of the word 'precise' in the question, relate this to their knowledge of experimental physics and articulate how the experimental procedure could be improved. This is designated an A-type mark.

Integration of knowledge

Integration of knowledge involves candidates applying knowledge from out with the topic being examined in the question.

For example, 2019 Advanced Higher Physics question 11(b)(i):

A tin of paint is placed in the paint-mixing machine and clamped securely. During shaking, the oscillation of the tin in the vertical plane can be modelled as simple harmonic motion.



(b) A coin falls on to the lid of the tin of paint as it is being clamped into position. The coin loses contact with the lid during the first oscillation.

(i) State the magnitude of the acceleration of the tin when the coin just loses contact with the lid. **1**

To answer the question, the candidate requires knowledge form another part of the course – that the coin will lose contact with the tin when the reaction force between the coin and the tin is zero, as well as the acceleration of the tin at the instant this happens.

Open-ended question

All open-ended questions are allocated two A-type marks.

A good open-ended question will afford the candidate a number of possible approaches, with the first mark straightforward to score.

The context of open-ended questions can include comments on student conversations, effectiveness of analogies to explain physical concepts, evaluation of experimental technique, or a quotation from a teacher/lecturer or a textbook.

An example from Higher Physics is:

The use of analogies from everyday life can help better understanding of physics concepts. Throwing different balls at a coconut shy to dislodge a coconut is an analogy that can help understanding of the photoelectric effect.

Use your knowledge of physics to comment on this analogy.**3**

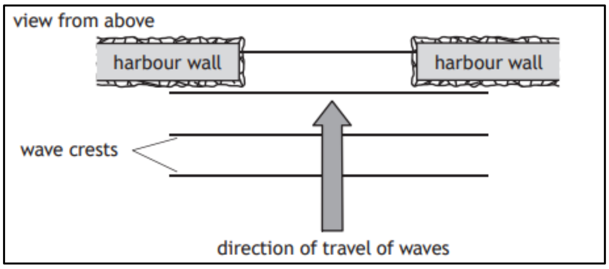
A potential approach for a candidate to respond might be to identify the balls as photons and the coconuts as electrons, which would be a straightforward C-type mark, and to go on to discuss the degree of suitability of more complex aspects of the analogy.

Drawing valid conclusions and giving explanations

Depending on level, the steps in the analysis of complex data involve:

- assimilating the given data or information
- relating this to the appropriate physics principle or relationship
- articulating a valid conclusion or explanation

For example, 2017 National 5 Physics question 4(d)



As the waves pass into the harbour the student observes that the amplitude of the waves decreases.

Explain this observation. **1**

The preceding part of the question is based on diffraction of the wave. In this question, the candidate is required to link the diffraction of the wave to the dispersion of the energy of the wave over a greater area and to the resulting effect on the amplitude of the wave.

Analysis of complex data

Depending on level, the steps in the analysis of complex data involve:

- assimilating the given data, together with the relationship or physical constant required
- relating this to the appropriate physics principle or relationship
- calculating and graphing values derived from the given data
- calculating the gradient of the resulting line of best fit

For example, 2016 Advanced Higher Physics question 16(b):

The following equation describes the conservation of energy as the sphere rolls down the slope

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

where the symbols have their usual meanings.

The equation can be rearranged to give the following expression

$$2gh = \left(\frac{I}{mr^2} + 1\right)v^2$$

This expression is in the form of the equation of a straight line through the origin,

$$y = gradient \times x$$

The following is an extract from the student's notebook.

h (m)	v (m s^{-1})	$2gh$ ($m^2 s^{-2}$)	v^2 ($m^2 s^{-2}$)
0·020	0·42	0·39	0·18
0·040	0·63	0·78	0·40
0·060	0·68	1·18	0·46
0·080	0·95	1·57	0·90
0·100	1·05	1·96	1·10

$m = 3{\cdot}8$ kg $r = 0{\cdot}053$ m

(i) On the square-ruled paper on *Page 37*, draw a graph that would allow the student to determine the moment of inertia of the sphere. **3**

(ii) Use the gradient of your line to determine the moment of inertia of the sphere. **3**

The necessary derived values were provided, but candidates had to select the values to graph, draw an acceptable line of best fit, calculate its gradient, and use the gradient to determine the required value of moment of inertia.

Of the six marks, three were A-type:

b(i) One A-type mark for recognising a rogue point and discounting it when drawing the line of best fit.

b(ii) Two A-type marks for substituting the calculated gradient into the correct relationship and calculating the moment of inertia.

Appendix 2 – guidance to SQA question writers

For your extended-response questions, pick a context such as an application of the physics involved, or practical work related to the physics.

If you choose to write a skills-based question, look for physics that is outwith the course and try to avoid making it about physics at levels above the one you are writing for (not applicable for Advanced Higher). A small number of people complain when skills-based questions contain physics at a higher level than that being studied, as they do not realise the question contains all necessary information and is testing skills.

It is always better to have too many marks in a question than too few. When used in a paper, parts can be chopped from questions, whereas when the questions are too short it can mean that parts need to be added for use in a paper.

Ensure questions have a clear command word. The most commonly used command words in physics are:

- **State**, **name**, or **give** – they need only name or present in brief form.
- **Describe** – they must provide a statement or structure of characteristics and/or features.
- **Explain** – they must relate cause and effect and/or make relationships between things clear.
- **Determine** or **calculate** – they must determine a number from given facts, figures or information.
- **Estimate** – they must determine an approximate value for something.
- **Justify** – they must give reasons to support their suggestions or conclusions, for example, this might be by identifying an appropriate relationship and the effect of changing variables.
- **Show that** – they must use physics (and mathematics) to prove something, for example, a given value. All steps, including the stated answer, must be shown.
- **Predict** – they must suggest what may happen based on available information.
- **Suggest** – they must apply their knowledge and understanding of physics to a new situation. A number of responses are acceptable: marks will be awarded for any suggestions that are supported by knowledge and understanding of physics.
- **Using your knowledge of physics or aspect of physics, comment on** – they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented, for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation. Use only for open-ended questions.

Note that this list is not exhaustive and on rare occasions it may be necessary to ask a question in order to avoid complicating the wording. However, never start a question with ‘How …’, although it is okay to use it after a command word, for example, ‘Describe how …’ or ‘Explain how …’.

It is important **not** to use double commands in a sentence, such as ‘state and explain’ – this can be problematical for some candidates as they miss one of the commands. It is much better to go for the usual physics approach of ‘State …’ followed by ‘Justify/you must justify your answer’ on a new line.

Further things to consider:

- Consider whether to use ‘justify’ (candidates can be awarded the mark for effect regardless of explanation) or ‘must justify’ (must have an explanation, so all A-marks).
- Avoid too much information in one sentence – if necessary, break text up into separate paragraphs.
- Be careful with contexts. If you are having to write a large amount of information to explain the context to candidates, then it is probably too complicated.
- When you choose a context, make sure that you do not have to oversimplify to make it work. The physics still must be correct, even if it has been simplified.
- Try to pick contexts that most candidates will be aware of or familiar with irrespective of gender, ethnicity, economic circumstances, geographic location, etc. However, unfamiliar contexts can still be used, they just require careful description and the inclusion of useful graphics.
- When writing a multipart question try to lead the candidate through the question.
- Temporal sequencing in a question is important. Do not ask about a setup, change the setup, and then revert to the original setup.
- Make sure the original state of things in a scenario is clear to a candidate, for example, ‘the trolley starts from rest’, ‘the capacitor is initially uncharged’.
- Be careful where you use ‘show’ questions. They can be useful when a value is required for use later in a question but try not to overuse them.
- Take care to give values to an appropriate number of significant figures, for example, 6.0 Ω rather than just 6 Ω.
- Clarify the number of significant figures, for example, use 1.20×10^3 kg, instead of 1200 kg.
- Avoid multiple variables with the same value or multiples of 10 of the value, which can lead to confusion at substitution stage.
- Avoid ‘perfect physics world’ values such as 10, 50, etc as they only have one significant figure.
- Use actual values. If you are asking a question about a golf ball involving mass, then use the actual mass of a golf ball.
- Do not use 'pupils', it is always ‘students’.
- Do not state distances in cm (except for thicknesses of absorbers in radioactivity questions).
- Do not state values for data that differ from those given in the data sheet.
- Do not use the conditional 'if’, for example, 'If the resistance of the variable resistor is increased' becomes ’The resistance of the variable resistor is increased'.

Appendix 3 – some common marking issues

Substitution of data

Candidates are expected to substitute data as they appear in the data sheet and as they are given in the stem of the question.

$g = 9{\cdot}8\ \text{Nkg}^{-1}$ is correct, but the use of $g = 10\ \text{Nkg}^{-1}$, or $g = 9{\cdot}81\ \text{Nkg}^{-1}$ would be incorrect substitution.

Open-ended questions

For open-ended questions, mark the response holistically and make a judgement based on the knowledge and understanding demonstrated by the candidate.

The candidate demonstrates:

-	no understanding	0 marks
-	limited understanding	1 mark
-	reasonable understanding	2 marks
-	good understanding	3 marks

Do not count the correct points or deduct marks for incorrect statements.

Do not worry about the same mark awarded for responses which are not exactly ‘equal’.

Calculations with a ‘carry forward’

In questions requiring data ‘carried forward’ from the answer of an earlier question, candidates must carry forward and use the stated **final answer** from the earlier question. For example:

(a) determine the time at which the acceleration of the spacecraft is $24\ \text{m s}^{-2}$

$t = 2.7\ \text{s}$

For their final answer, a candidate correctly rounds ‘2·6666666667 s’ to 2·7 s.

(b) determine the distance travelled by the spacecraft in this time.

$$s = \frac{4\cdot 2t^3}{3} + \frac{1\cdot 6t^2}{2}(+c)$$

$$s = \frac{4\cdot 2 \times 2\cdot 7^3}{3} + \frac{1\cdot 6 \times 2\cdot 7^2}{2}$$

$s = 33$ m

Accept:
30, 33·4, 33·39

$$s = \frac{4.2t^3}{3} + \frac{1}{2} \times 1.6t^2$$

$$s = \frac{4.2 \times 2.7^3}{3} + \frac{1}{2} \times 1.6 \times 2.7^2$$

$s = 32$ m

In answering (b), the candidate's substitutions are correct, but their final answer is not acceptable, possibly because they have carried forward unrounded data from (a). The mark for an acceptable final answer for (b) is not awarded.

'Show'-type questions

In this type of question, the candidate must state an appropriate relationship, clearly show substitutions, and state the required final answer.

All steps must be clearly and explicitly shown. For example:

The tin of paint has a mass of 3·67 kg.

The tin is shaken at a rate of 580 oscillations per minute.

Show that the angular frequency ω of the tin is 61 rad s^{-1}. **2**

$\omega = 2\pi f$	**(1)**
$\omega = 2\pi \times \frac{580}{60}$	**(1)**
$\omega = 61$ **rad s^{-1}**	

1 mark is awarded for the selection of an appropriate relationship and 1 mark for the correct substitution of data into the relationship.

The first line is necessary. In a 'show'- type question, an appropriate relationship cannot be implied by apparently correct substitutions. A candidate writing $\omega = 2 \times \pi \times \frac{580}{60}$ as the first line would be awarded zero marks for the question.

1 mark is awarded for the substitution of data. The data must be explicitly substituted. A candidate whose second line is $\omega = 2 \times \pi \times 9 \cdot 67$ would be not be awarded the mark for substitution and have a maximum of 1 mark (if $\omega = 2\pi f$ is included), even although $\frac{580}{60} = 9 \cdot 67$. The substitutions must be explicitly shown.

A candidate not stating the final answer , $\omega = 61$ rad s^{-1}, would be awarded a maximum of 1 mark – the required final answer must be stated.

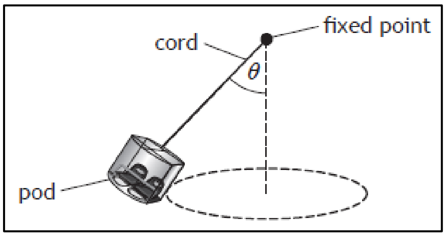
'Must justify' and 'Justify' questions

The candidate is asked to make a statement, which they are asked to justify. Normally, there is 1 mark for a correct statement, and 1 mark for a justification using correct physics.

In 'must justify' questions, the mark for a correct statement is **dependent** on the candidate attempting a justification which does not use wrong physics.

In 'justify' questions, the mark for a correct statement is **independent** of the justification.

For example, a ‘pod’ spinning round a fixed point at the end of a cord.



The speed of the pod decreases.

State the effect this has on the angle θ.

You must justify your answer in terms of the forces acting on the pod. **2**

θ decreases
(1)

(Horizontal component of) tension decreases. Weight unchanged
(1)

Response	Mark
Correct statement justified using correct physics	2
Correct statement with correct, but irrelevant/insufficient justification	1
Correct statement with attempted justification using incorrect physics	0
Correct statement with no attempted justification	0
Incorrect statement	0

The mark for a correct statement is dependent on the justification, so no mark is awarded for a correct statement, if the justification is incorrect or missing.

However, had the question been ‘State the effect this has on the angle θ. Justify your answer in terms of the forces acting on the pod.’

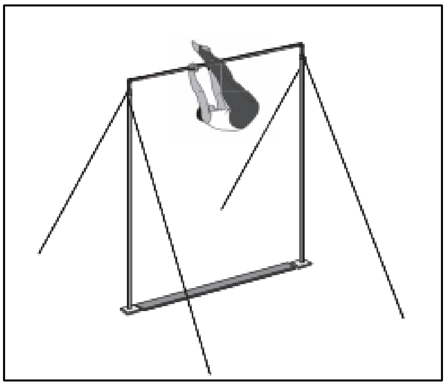
Response	Mark
Correct statement justified using correct physics	2
Correct statement with correct, but irrelevant/insufficient justification	1
Correct statement with attempted justification using incorrect physics	1
Correct statement with no attempted justification	1
Incorrect statement	0

The mark for a correct statement is independent of the justification, so 1 mark is awarded for a correct statement, even if the justification is incorrect or missing.

Explain questions

Candidates are required to give explanations using *directly relevant* and *correct* physics.

For example:



Explain why making a pike position results in a decrease in the moment of inertia of the gymnast.

The acceptable response given in the marking instructions is ‘Mass is now nearer the bar’.

It would be great if all candidates used the same words as the marking instructions, but it is likely they will use their own, and it is possible that many will give responses that are not incorrect, but may not sufficiently answer the question.

In these cases, there are two dangers for the marker:

- Concluding that the answer is not exactly the same as the stated marking instructions and therefore giving less credit than that answer is worth. This would be unfair to candidates who have given good physics in their own words.
- Subconsciously ‘filling in the gaps’ in the candidates answer and therefore giving more credit than the answer is worth. This would be unfair to other candidates who answered fully and correctly. Markers should not adopt the strategy of ‘I know what they meant, so I’ll award the mark’.

  For example, a candidate’s response ‘The radius of the gymnast is less so the moment of inertia is less’ requires some gaps to be filled.