Course report 2023

Advanced Higher Engineering Science

This report provides information on candidates' performance. Teachers, lecturers and assessors may find it useful when preparing candidates for future assessment. The report is intended to be constructive and informative, and to promote better understanding. You should read the report in conjunction with the published assessment documents and marking instructions.

The statistics in the report were compiled before any appeals were completed.

Grade boundary and statistical information

Statistical information: update on courses

Number of resulted entries in 2022: 90

Number of resulted entries in 2023: 54

Statistical information: performance of candidates

Distribution of course awards including minimum mark to achieve each grade

A	Number of candidates	8	Percentage	14.8	Cumulative percentage	14.8	Minimum mark required	43
B	Number of candidates	11	Percentage	20.4	Cumulative percentage	35.2	Minimum mark required	34
C	Number of candidates	14	Percentage	25.9	Cumulative percentage	61.1	Minimum mark required	26
D	Number of candidates	12	Percentage	22.2	Cumulative percentage	83.3	Minimum mark required	17
No award	Number of candidates	9	Percentage	16.7	Cumulative percentage	100	Minimum mark required	N/A

Please note that rounding has not been applied to these statistics.

You can read the general commentary on grade boundaries in the appendix.

In this report:

- ‘most’ means greater than 70%
- ‘many’ means 50% to 69%
- ‘some’ means 25% to 49%
- ‘a few’ means less than 25%

You can find more statistical reports on the statistics and information page of SQA’s website.

Section 1: comments on the assessment

Question paper

Every mark in this year's question paper was accessible. Candidate performance this year was in line with candidate performance in 2019. This was an improvement from last year. This was taken into consideration when setting the grade boundaries.

Most candidates responded more successfully to mechanisms and structures and engineering project management questions than to electronics and control questions of a comparable notional difficulty.

Project

The requirement to complete the project was removed for session 2022–23.

Section 2: comments on candidate performance

Areas that candidates performed well in

Question paper

Question 1(a)

Most candidates completed the activity network diagram successfully. A few candidates made errors establishing latest finish time, particularly at node E.

Question 1(b)

Most candidates identified the critical path successfully.

Question 1(c)

Most candidates identified the correct stage of the project life cycle.

Question 2(a)

Most candidates recognised the need to increase voltage and many also explained that this reduces power loss during transmission because the current reduces in magnitude.

Question 2(b)

Many candidates identified nuclear or fossil fuel power stations as being suited to base load generation. A few candidates specified coal power stations.

Question 2(c)

Most candidates identified the requirement for AC-DC and DC-AC conversion from the diagram and some identified that the resulting AC is at a controlled frequency. Far fewer candidates identified rectifiers and inverters as the technologies that do this. There was evidence of a few candidates mistaking AC-DC and DC-AC conversion for A-D and D-A conversion.

Question 3(a)

Many candidates calculated R_c correctly and picked the correct standard resistor. A few candidates, having performed the calculation for the required value of R_e, did not pick a standard resistor.

Question 5

Many candidates attempted this question successfully, gaining at least 3 of the 4 available marks. Most commonly, candidates who gained 3 marks took the efficiency of the photovoltaic system as simply the efficiency of the photovoltaic panel, or they did not correctly calculate the denominator of the formula for the flat-plate collector efficiency.

Question 6(a)

Most candidates used the geometric data correctly to determine the height of the hexagonal hole.

Question 7(a)

Many candidates used the general beam-bending equation and found the maximum distance from the neutral axis correctly. However, many candidates selected the incorrect ultimate stress, or did not apply the factor of safety, or did both. Only a few candidates gained full marks.

Question 7(b)

Many candidates correctly used a standard deflection equation from the data booklet. A few candidates selected the incorrect formula. Some candidates made errors converting a load per metre into a load per millimetre, and some candidates substituted values for distributed load, given in Nm^{-1}, and maximum permissible bending moment, given in Nmm, directly into the formula.

Question 8(a)

Many candidates attempted this question successfully, gaining at least 3 of the 4 available marks. Some candidates did not calculate the beam reactions correctly, but otherwise structured the shear force diagram correctly.

Question 8(b)

Many candidates wrote a correct expression for the UDL, but only some candidates included expressions for the 20 kN point load and the reaction at A correctly.

Question 9(c)

Some candidates gained full marks for this question and most candidates gained at least 2 marks. A few candidates made an error with the components of the 650 N gear force, transposing cos 20° and sin 20°. A few candidates also made arithmetic or interpretive errors with the distances between the applied forces. Most candidates produced well-structured responses.

Areas that candidates found demanding

Question paper

Question 1(d)

Many candidates did not answer this question correctly. They identified an appropriate activity but did not explain the need for it, which suggests that they were not familiar with the phases in the project life cycle.

Question 3(b)

Few candidates answered this question successfully. Few candidates took account of the stated value of the base current. Treatment of a single node in a circuit, using Kirchhoff's current law and Ohm’s law for resistive branches attached to the node, should be a straightforward mark for Advanced Higher candidates. Although this topic is commonly assessed using questions about a resistor network with unknown voltage at two nodes, previous question papers have assessed nodal analysis using nodes in simple transistor and op-amp circuits.

Question 3(c)

Few candidates answered this question successfully. Power dissipation is a product of the collector current and collector-emitter voltage difference for a bipolar transistor. Similarly, it is a product of the drain current and drain-source voltage difference for a MOSFET transistor.

Question 4(a)

Many candidates correctly integrated the input voltage, but few candidates then simplified their expression fully, taking account of the initial value of the output voltage.

Question 4(b)

Many candidates found the correct numerical answer, but their working did not show clearly that they understood that the change in output voltage during the interval would be negative (from 9 V to -9 V, giving a change of -18 V).

Question 4(c)

Many candidates either wrote about the voltage change becoming faster, rather than slower, or the voltage becoming smaller, rather than the voltage amplitude becoming smaller.

Question 6(b)

Most candidates extracted a value for the second moment of area of an I-beam of depth 200 mm from the given table. Few candidates went on to subtract the second moment of area of the rectangular hole, centred on the beam’s neutral axis, that the hexagonal hole forms on the cross-section.

Question 8(c)

Many candidates did not attempt this question. Those who did and achieved full marks related the derivative of the bending moment equation to zero to find the position of the maximum bending moment from the left-hand end of the beam.

Candidates did not gain marks for attempting to read the position from the shear force diagram. However, they did gain marks for using established points on the shear force diagram to derive an equation for the shear force in this region of the graph, which they could then equate to zero.

Question 8(d)

Many candidates did not identify that the shear force diagram showed that shear force was zero at these points as well, and that this would give points at which the bending moment becomes a local maximum or minimum value. Comparing all three points would identify the absolute maximum bending moment that the cross-section of the beam would be designed to withstand.

Question 8(e)

Many candidates gained at least 1 mark for this question. Some candidates gained both marks and demonstrated a real understanding of the problem. Each of the two voltage dividers must include one strain gauge in tension (B or D) and one in compression (A or C) for the voltage from the voltage divider to vary as the beam deflects. For V_{out} to be positive, V_2 must increase and V_1 must decrease.

Question 8(f)

Some candidates gained at least 1 mark for this question. A few candidates gained 2 marks. Some candidates produced solutions for V_2 and V_1 as separate calculations. Those who did so, and gained both marks, recognised that the change in resistance in each potential divider was very small and quoted voltage values in full (6.0012 V and 5.9988 V) when setting down intermediary working, so that the calculated voltage difference remained accurate to two significant figures (2.4 mV).

Question 8(g)

Some candidates gained at least 1 mark for this question. A few candidates gained 2 marks. Those who gained 2 marks used the information in the stem above the question to work out that the ratio R_4 to R_3 is 1 and used this to calculate R_2. R_2 is defined as a resistor having the same tolerance as R_1, so candidates should have calculated its value to three significant figures.

Question 8(h)(i)

Only a few candidates attempted this question, but most attempts were successful. Those attempting solutions did not always use 2^n-1 for the number of voltage steps required to saturate an ‘n’-bit A-D converter.

Question 8(h)(ii)

Candidates who attempted part (i) also attempted this question, though fewer did so successfully.

Question 9(a)

Few candidates gained full marks, but most candidates calculated the torque acting on the gear. Some candidates mistook the tangential component of the force at the gear mesh for the total force at the gear mesh when attempting to establish the magnitude of the force producing the torque. Many of the candidates who established a tangential force went on to establish a radial force correctly using the pressure angle.

Question 9(b)

Few candidates approached this question in terms of a balance of torques on the crankshaft, which there must be when the crankshaft turns at constant speed. Some candidates calculated the torque produced by the downwards force on the crankshaft but made the mistake of multiplying the total downwards force on the pedal by the radius of the crank, ignoring the 45° angle of the crank. Few candidates included the torque applied to the crankshaft by the motor.

Question 9(d)

Some candidates gained 2 or 3 marks for this question. Most candidates who answered the question determined the mean diameter of the coil correctly but only some determined the cross-sectional diameter of the coil correctly. Many candidates adjusted orders of magnitude for some of the quoted variable values, but some candidates did not do so correctly.

Question 9(e)(i)

Some candidates attempted this question. Very few candidates demonstrated an understanding of the variable values assigned, or the values that variable values would take as the control system operated.

Question 9(e)(ii)

Some candidates attempted this question. A few candidates identified that the variable value would become zero but did not explain why the microcontroller would produce the result.

Section 3: preparing candidates for future assessment

Centres should be familiar with the recommended entry information for this course as outlined in the Advanced Higher Engineering Science Course Specification.

The Higher Engineering Science course provides the foundation for candidates to progress to this course. This course requires candidates to be familiar with a range of mathematics skills such as introductory calculus (integration and differentiation in familiar contexts).

Question paper

Candidates should not round their working in calculations until they reach a final value. They should round to the fewest number of significant figures present in quoted data values in the question, as outlined in the general instructions on the question paper.

The numerical value should be:

- accompanied by the correct units for the quantity calculated, as on page 4 of the data booklet
- expressed in engineering notation, as on page 5 of the data booklet

When substituting values in formulae, candidates must be able to adjust the orders of magnitude of variables so that their units are consistent with one another. For example, when considering design calculations for structures and materials, candidates must be able to adjust the orders of magnitude of values of force, length, moment, UDL, Young's modulus, second moment of area, load, and stress, as necessary. Questions 7(a), 7(b), and 9(d) from this year's question paper are good examples to consider. In the case of area, $1m^2 = 10^6\ mm^2$, so in the case of stress, $1\ MNm^{-2} = 1\times10^6\ Nm^{-2} = 1\ Nmm^{-2}$.

When using formulae in any element of the course, teachers and lecturers should encourage candidates to consider which variables are likely to affect the value of the subject of a formula most. For example, in question 9(d), although the question does not ask this, the deflection, δ , of the spring is reduced most significantly by increasing the cross-sectional diameter of the spring by a particular factor. (A 5% increase would decrease the deflection by almost 18%.) Candidates should also consider the effect of tolerances on component values or dimensions. Question 2 in the 2018 question paper has an example of this. These approaches can also help candidates in the mathematical modelling stage of the project.

Candidates can find it difficult to differentiate their responses to 'describe' and 'explain' questions. The examples of valid responses to command words in the marking instructions can help with this.

To do well in the question paper, candidates must devote significant time to their own reading to move their subject knowledge beyond Higher level content, particularly in relation to the Advanced Higher course themes.

Session 2023–24

This course will return to full assessment requirements from session 2023–24 onwards. This means that candidates must complete the question paper and the project.

The current project assessment task was published on the Advanced Higher Engineering Science subject page in session 2019–20. It is not refreshed annually. Candidates will use it for the first time in session 2023–24. Although it has a different format, the project assessment task is broadly similar to the 2018–19 project. Centres and candidates should note that the information about the project in the 2019 Advanced Higher Engineering Science Course Report is still relevant. They should read this alongside the project assessment guidance.

More information and supporting documentation on the full course assessment is available on the Advanced Higher Engineering Science subject page. This includes the course specification, project assessment task, past papers, the specimen question paper, and previous years' course reports.

Teachers and lecturers should continue to make use of the Understanding Standards website. This resource provides candidate evidence from past question papers with supporting commentary, presentations, and webinar recordings that explain the structure and format of the course assessment.

The existing Understanding Standards materials for the project are published on SQA's secure website. Although these materials do not reflect the project's current format, they remain a useful guide. Teachers and lecturers should use these materials with the latest versions of the Advanced Higher Engineering Science Course Specification and the project assessment task.

Appendix: general commentary on grade boundaries

SQA's main aim when setting grade boundaries is to be fair to candidates across all subjects and levels and maintain comparable standards across the years, even as arrangements evolve and change.

For most National Courses, SQA aims to set examinations and other external assessments and create marking instructions that allow:

- a competent candidate to score a minimum of 50% of the available marks (the notional grade C boundary)
- a well-prepared, very competent candidate to score at least 70% of the available marks (the notional grade A boundary)

It is very challenging to get the standard on target every year, in every subject at every level. Therefore, SQA holds a grade boundary meeting for each course to bring together all the information available (statistical and qualitative) and to make final decisions on grade boundaries based on this information. Members of SQA's Executive Management Team normally chair these meetings.

Principal assessors utilise their subject expertise to evaluate the performance of the assessment and propose suitable grade boundaries based on the full range of evidence. SQA can adjust the grade boundaries as a result of the discussion at these meetings. This allows the pass rate to be unaffected in circumstances where there is evidence that the question paper or other assessment has been more, or less, difficult than usual.

- The grade boundaries can be adjusted downwards if there is evidence that the question paper or other assessment has been more difficult than usual.
- The grade boundaries can be adjusted upwards if there is evidence that the question paper or other assessment has been less difficult than usual.
- Where levels of difficulty are comparable to previous years, similar grade boundaries are maintained.

Grade boundaries from question papers in the same subject at the same level tend to be marginally different year on year. This is because the specific questions, and the mix of questions, are different and this has an impact on candidate performance.

This year, a package of support measures was developed to support learners and centres. This included modifications to course assessment, retained from the 2021–22 session. This support was designed to address the ongoing disruption to learning and teaching that young people have experienced as a result of the COVID-19 pandemic while recognising a lessening of the impact of disruption to learning and teaching as a result of the pandemic. The revision support that was available for the 2021–22 session was not offered to learners in 2022–23.

In addition, SQA adopted a sensitive approach to grading for National 5, Higher and Advanced Higher courses, to help ensure fairness for candidates while maintaining standards. This is in recognition of the fact that those preparing for and sitting exams continue to do so in different circumstances from those who sat exams in 2019 and 2022.

The key difference this year is that decisions about where the grade boundaries have been set have also been influenced, where necessary and where appropriate, by the unique circumstances in 2023 and the ongoing impact the disruption from the pandemic has had on learners. On a course-by-course basis, SQA has determined grade boundaries in a way that is fair to candidates, taking into account how the assessment (exams and coursework) has functioned and the impact of assessment modifications and the removal of revision support.

The grade boundaries used in 2023 relate to the specific experience of this year's cohort and should not be used by centres if these assessments are used in the future for exam preparation.

For full details of the approach please refer to the National Qualifications 2023 Awarding — Methodology Report.