Course report 2022

Subject	Engineering Science
Level	Advanced Higher

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. It would be helpful to read this report in conjunction with the published assessment documents and marking instructions.

The statistics used in this report have been compiled before the completion of any appeals.

Grade boundary and statistical information

Statistical information: update on courses

Number of resulted entries in 2022	**90**

Statistical information: performance of candidates

Distribution of course awards including grade boundaries

A	Percentage	15.6	Cumulative percentage	15.6	Number of candidates	15	Minimum mark required	41
B	Percentage	13.3	Cumulative percentage	28.9	Number of candidates	10	Minimum mark required	33
C	Percentage	20.0	Cumulative percentage	48.9	Number of candidates	20	Minimum mark required	25
D	Percentage	20.0	Cumulative percentage	68.9	Number of candidates	15	Minimum mark required	17
No award	Percentage	31.1	Cumulative percentage	N/A	Number of candidates	30	Minimum mark required	N/A

You can read the general commentary on grade boundaries in appendix 1 of this report.

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 page of SQA’s website.

Section 1: comments on the assessment

Question paper

Candidates' marks for the question paper were lower than expected. This was taken into account when setting the grade boundaries.

Candidates' responses to structures and project management questions were more confident than responses to mechanisms, electronics, electrical and programmable control questions which had comparable notional difficulty.

Project

The requirement to complete the project was removed for session 2021-22.

Section 2: comments on candidate performance

Question paper

Most candidates who performed well demonstrated an:

Q2(a)	understanding of the use of pumped-hydro systems to balance energy on the grid
Q2(b)	understanding of how to calculate overall efficiency within an energy audit
Q3	understanding of a Gantt Chart and its use in project management
Q5	ability to interpret graphical data and extract the data values needed to calculate power loss in transistor switching
Q6	understanding of op-amp integrator operation and an ability to determine component values to meet a performance requirement
Q8(f)	ability to analyse the equilibrium of non-concurrent forces by considering the action of their components in two perpendicular planes
Q9(a)	understanding of shear force and an ability to construct a shear force diagram.
Q9(c)	ability to analyse a resistive circuit using nodal analysis, Kirchhoff's (1st) current law and Ohm's Law

Question 1

Most candidates used the diagram and applied the given formula for a triangle correctly to calculate its second moment of area.

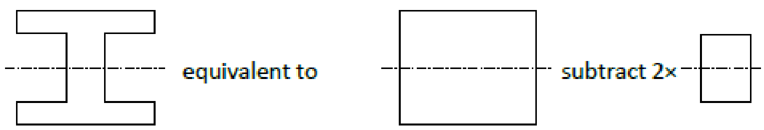
Many candidates did not go on to reach a complete solution using subtraction of forms.

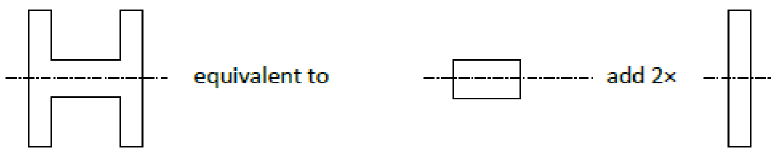
Many candidates added values for four triangles, two 30x10 mm rectangles and two 10x10 mm rectangles. The rectangle values were calculated using the standard formula given on page 9 of the data booklet. This is not correct in either case. The axis x-x for each section, as given in the data booklet, does not lie on the axis of symmetry of the cross-section in the question, it lies 15 mm above or below for the first rectangle and 5 mm above or below for the second rectangle. Likewise, if the four triangles are added, the axis x-x for the formula lies 10 mm above or below the axis of symmetry of the cross-section.

The parallel-axis theorem would have to be used to obtain correct values for each.

Questions will not be asked where the use of this theorem is a necessity.

The two examples below illustrate when to add and when to subtract areas. Note that the axis is shared between the whole section and the parts in each case.





Questions in past papers have required either one or other of these approaches.

Prepared candidates should have seen sufficient examples to be able to pick which approach to use when looking at an unfamiliar cross-section.

Question 3(a)
Definition of capital cost as investment — finance for a project that is required before any commercial benefit can be accrued.

Most candidates did not define capital costs clearly as investment which has to be financed prior to any commercial profit from a project. In cases of government spending, 'profit' would be gain in social capital arising from the project. However, many candidates could give reasons for capital costs reducing between prototype and commercial phases of development.

Question 4(a)
The addition of a load line on the characteristics for a MOSFET-base amplifier and the selection of an operating point using the load line.

MOSFET and bipolar transistor amplifiers have been exemplified in previous papers. The use of a load line is only applicable in the type of circuit used in this example. Some candidates knew how to position the load line, by calculating the drain current when the drain-source voltage is zero and using this point on the ID-axis, along with the supply voltage on the VDS-axis. However, they did not use the load line to find the best operating point (quiescent point) for the transistor, which should lie at the midpoint between the supply voltage and the value of VDS at the onset of saturation (the value of VDS at the point where the load line crosses the dashed line).

Question 6(c)
Analysing the operation of a two-stage integrator circuit.

Most candidates answered parts (a) and (b) of this question well but found part (c) more difficult. To complete part (c), find an expression for the first stage and then integrate this expression for the second stage. Candidates must be aware that the constant voltage input, 5, will integrate to 5t, and that 5t will then integrate to $5(t^2/2)$. However, these results are at the introductory end of the teaching of integration in Higher Mathematics. Note also that a constant of integration arises for each stage. The question states that $V_2=0$ and $V_{out}=0$ when t=0 and this results in the constant of integration being zero for each stage.

Question 7(a)
Substitution of values into a deflection equation so that each quantity's unit is consistent with those of the other quantities.

Many candidates selected a value of Young's modulus from page 7 of the data booklet, but some did not pick the lowest value, 200 $kNmm^{-2}$. Selection of the lowest value gives the largest deflection because E appears on the denominator of the formula. Engineering calculations are generally conservative — they aim to give the worst-case scenario.

Many candidates did not multiply the mass by g=9.8 ms^{-2}, given on page 6 of the data booklet, to produce the force, P. Some did not halve the mass as suggested by the diagram of the weightlifter.

The question deliberately used quantities that involved millimetre and metre measurements — lengths were given in metres while Young's modulus was given as 200-207 $kNmm^{-2}$ and second moment of area was given as 120 mm^4. A correct solution requires either the lengths to be used as 500 mm and 1.5×10^3 mm, or the lengths to be used as given and the values $E=200\times10^9$ Nm^{-2}, $I=120\times10^{-12}$ m^4 to be substituted. Converting lengths from metre to millimetre measurements is less likely to lead to errors.

Question 7(b)
Calculation of stress using the general bending equation.

Few candidates recognised that the first two terms of the general bending equation, found on page 7 of the data booklet, is the approach to this question. This is generally the link to stress in any elastic beam bending question. Questions will either assume the material behaves elastically or ask a question about whether or not the stress level takes the material beyond elastic behaviour.

Question 8(a)
Identification of sub-systems within an electrical transmission diagram.

Few candidates could identify the first sub-system as a DC-AC converter (rectifier), which would produce DC current at a fixed voltage controlled by the input AC voltage. Few candidates could identify the second sub-system as an AC-DC converter (inverter), which would produce AC current at a fixed frequency from a DC voltage source.

Question 8(b)
Transformer calculations involving power losses in the windings and the core.

Few candidates wrote down anything to represent energy conservation. Input power would balance the sum of output power and power losses in the core, the primary winding, and the secondary winding. Accounting for power losses, which create heating effects, would differentiate this from an ideal transformer having no power losses.

Question 8(c)
Programmable control questions must be set at a level above Higher demand. They tend to focus on the interpretation of short pieces of code and the effect that variables have within them. Questions will continue to appear in both Arduino and PBasic programming languages. Candidates must be familiar with one or the other.

This question relates to timing. The pulse-width modulation (PWM) pins on a microcontroller produce an analogue signal by playing out a pulse train whose mark:space ratio is fixed by the duty cycle. The frequency of PWM that plays out on microcontroller pins is generally fixed but can be adjusted by setting values in particular control registers within the microcontroller.

In this application, the PWM frequency 15.6kHz is a lot higher than the frequency of the sine wave, 59.5 Hz, so the small piece of program plays out 12 different values of 'analogue' voltage for fixed time intervals, 1.4 ms, to approximate a sine wave. The twelve different values are controlled by the twelve duty cycle values in the table.

The period of the sine wave is controlled by the duration of the delay. It could also be altered (lengthened) by increasing the number of data values in the data table without adjusting the duration of the delay, but the number of repeats of the counted loop would also have to increase to match.

Question 8(d)
This question relates to timing. When playing out signals, reading a value from a memory location to control the PWM duty cycle takes a fixed number of clock cycles. Calculations may take a varying number of clock cycles. At high frequencies of output value, calculations may take too long to perform between required updates in output values. This would distort the shape of the signal generated on the output pin.

Question 8(e)
Calculation of torque and force in a spur gear train, rather than between two spur gears.

Some candidates could calculate the torque generated by the motor being transmitted by the gear on the motor shaft. However, very few candidates related the 480 mm diameter of the bogie gear to the diameter of the gear on the motor shaft to calculate the tangential force after calculating the torque.

The gear on the motor shaft has a pitch circle diameter of 360 mm (480 × (45/60)). The radius of the gear would have to be taken as 0.18 m to calculate the tangential force correctly from the torque. Some candidates used millimetres rather than metres here. Few candidates calculated the magnitude of the force acting on the gear, of which the tangential force producing the torque is a component.

Very few candidates could indicate the direction of the force acting on the motor shaft gear at the mesh with the idler gear. The gear drives the idler gear clockwise, which requires an upwards tangential force to act on the idler gear. The radial force on the idler gear will act towards its centre. The reaction acts on the motor shaft gear – downwards and to the left, at 20° to the vertical.

Question 9(d) and Question 9(e)
These questions relate to counting pulses on a microcontroller input pin over a fixed time interval. A few candidates interpreted the information supplied to answer Q9(d) correctly.

The maximum possible error the code produces is always one counted pulse. If you aim to count ten pulses your actual count may be nine instead. This is an error of one in ten, or 10%.

To produce an error of 5%, twenty pulses must be counted. This is one complete revolution. At a minimum speed of 5 rev min^{-1} this would equate to a time interval of 12 seconds, so the delay would need to become 12000. The count would need to be multiplied by 100 to produce a 3-digit value. Then, it must be divided by 4 to equate to a speed in revs min^{-1}, since pulses counted over 3 seconds relate directly to speed in revs min^{-1}.

Section 3: preparing candidates for future assessment

Question paper

Working in calculations should not be rounded until a final value is reached. Rounding should then be to the fewest number of significant figures that are present in quoted data values within 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 being calculated, as on page 4 of the data booklet
- expressed in engineering notation, as on page 5 of the data booklet.

In section A, some candidates had difficulty answering questions that asked them to describe or explain. There are examples of valid responses to command words within the marking instructions.

When substituting values in formulae, particularly when considering structures and mechanisms calculations, 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, stress, torque and power, so that their units are consistent with one another. Q7(a), Q7(b) and Q8(e) are good examples to consider.

Appendix 1: 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 including assessment modifications and revision support, was introduced to support candidates as they returned to formal national exams and other forms of external assessment. This was designed to address the ongoing disruption to learning and teaching that young people have experienced as a result of the COVID-19 pandemic. In addition, SQA adopted a more generous approach to grading for National 5, Higher and Advanced Higher courses than it would do in a normal exam year, to help ensure fairness for candidates while maintaining standards. This is in recognition of the fact that those preparing for and sitting exams have done so in very different circumstances from those who sat exams in 2019.

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 2022. 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 revision support.

The grade boundaries used in 2022 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 2022 Awarding — Methodology Report.