# Course report 2019

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| 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 post-results services.

# Section 1: comments on the assessment

## Question paper

Candidates found the question paper challenging and it generally discriminated well between them. Section 1 was well-attempted, however the two electronics-based questions were challenging for a number of candidates.

## Project

All verified centres used the project provided on the secure area of SQA's website therefore the instrument of assessment they used was valid.

The open nature of the project allows for personalisation and choice, however, care must be taken to ensure that a topic/situation appropriate for Advanced Higher level is selected. In addition, candidates must ensure that it will be possible to access enough appropriate information in order to carry out sufficient research. Where there is any element of doubt in this area, centres are encouraged to make contact with the Qualifications Team at SQA to seek advice and guidance.

All centres verified were found to be making assessment judgements correctly, to the national standard.

# Section 2: comments on candidate performance

## Areas that candidates performed well in

### Question paper

Question 1 Very well attempted. Decomposition of forces and application of moments in two orthogonal planes was done well, and reaction magnitude was found correctly. Centres should remind candidates that the number value of the angle is insufficient to describe the direction of the reaction: the angle must be related diagrammatically to a known force or the axes given in the question.

Question 2

a)

i) Very well attempted.

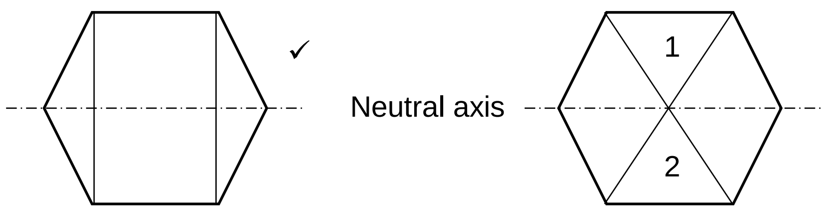
ii) There was a clear understanding of float and how to interpret it from the precedence table and Gantt chart.

iii) A significant number of candidates found it difficult to pick out the critical path from a Gantt chart and precedence table, rather than a network diagram.

b) The majority of candidates could give clear examples of direct costs, but were less assured explaining indirect costs.

Question 3 The vast majority picked out symmetry about the neutral axis and attempted this question well. When examined, this subject content — calculation of second moment of area of a cross-section — will always involve cross-sectional geometries symmetric about the neutral axis and so will not require use of the parallel axis theorem.

A number of candidates treated the hexagon as made up entirely of triangles but, for some of the triangles, the base does not then sit on the neutral axis, so the formula given to determine second moment of area for the triangle is not then valid.




× Unless parallel axis theorem is used for triangles 1 and 2

Question 6

a) Generally well answered and most candidates did make reference to the graphs supplied. Candidates were not fully aware of the agility of energy sources. Coal and nuclear are predominantly base load, but CCGT and wind are the main sources used to match load (because they can be run up or run down relatively quickly). A few candidates mentioned continental interconnectors for base load which showed good background knowledge because imported energy did not appear in the given data.

b) A proportion of candidates who answered this question did so using an approach to determine current in the secondary winding when transformer efficiency is not known — efficiency is given here, so the approach is unnecessarily complicated. Current in the primary winding can be found using supply voltage and power. The winding resistance is given, so power dissipation can be calculated directly. Knowing efficiency, output power can be calculated and the total power loss must then be the difference between input power and output power. Knowing the primary winding loss and core loss, the only other loss is the secondary winding loss.

$$P_{in} = P_{out} + P_{core} + P_{primary\ and\ secondary\ windings}$$

$$P_{in} = \eta \times P_{in} + P_{core} + P_{primary\ and\ secondary\ windings}$$

Nearly all candidates attempted this question and those who recognised the above, answered successfully.

Question 7

a) A number of candidates answered this question fully, but a significant number did not determine bending moment at a point on a beam correctly. The extended nature of the question meant that the majority of candidates gained partial credit for their work.

Question 8

a) The question was well-attempted. However, a significant number of candidates could not interpret the angle to select for $\theta$ from the diagram of the belt drive: this is the angle subtended by the belt contact. The smaller the angle of contact, the more likely slip will occur, so the angle lies on the drive pulley. The calculation of that angle is geometry (angles in any quadrilateral add to 360°), the belt makes and loses contact with the pulley tangentially (90° to the radius of the pulley), and expression in radians and the use of an exponential form are mathematics knowledge. Candidates were confident with the latter, but less confident with the former. A significant number of candidates selected an incorrect value for angle, but subsequently completed the required calculation correctly.

c) Generally well attempted — this question is an unfamiliar context that requires interpretation of supplied data. A significant number of candidates misinterpreted the number of switching occurrences and/or the period (10ms – frequency 100Hz), but otherwise completed the question successfully.

## Project

Candidates performed particularly well in the construction/simulation areas of the project. Flowcharts and mechanical system designs were also relatively well done.

## Areas that candidates found demanding

### Question paper

Question 4

a) This question was not well attempted. It is not the intention to define types of A-D converter, but this circuit required knowledge of potential divider, comparator and combinational logic operation — prior learning at Higher level. It was attempted by a significant number of candidates and completed successfully by 30% of candidates.

b) The intention of this question was to test the understanding that A-D converters have a resolution that determines definite input voltage intervals for each digital output level — a common feature of any A-D architecture. This comes from the potential divider, which divides the supply voltage into eight equal intervals.

Question 5

a) This question tested the ability to draw a load-line on the characteristics of a transistor. When switched fully off, the drain-source voltage will be 10 V and the drain current will be zero. When switched fully on the drain-source voltage would ideally be zero. If resistance in the drain current path, connected between the drain and the supply (and the source and ground) is large compared to the resistance of the MOSFET when switched on fully by a high enough value of gate-source voltage, then this is a very close approximation. The drain current is then the supply voltage divided by the total resistance in the current path, in this case 10 V / 1.25 kΩ giving 8 mA.

b) The potential divider sets the voltage at the gate of the transistor. The design rule allows two resistances to be calculated. The resistance of the two resistors connected in parallel is the effective resistance ‘seen’ by the source of the signal connected to the amplifying stage via the capacitor. Confident candidates interpreted the design rule successfully.

This course content had not been assessed in previous question papers. Both bipolar and MOSFET transistors operating as class-A amplifiers with a two-resistor potential divider biasing either the base or the gate of the respective transistors are listed in the ‘Skills, knowledge and understanding’ section of the course specification.

Question 7

b)+c) Whilst this was an intentionally demanding question, a number of candidates struggled with their understanding of how to use the bending moment and bending beam equation in this situation..

d) Many candidates found this question demanding because they could not recognise the relationship between the upper threshold voltage and the higher value of the op-amp output, and the lower threshold voltage and the lower value of the op-amp output.

Question 8

b) Many candidates found this a demanding question, however it involved a circuit that has been used in a previous question paper and appeared in the original subject specimen paper. It involved nodal analysis of a two-resistor potential divider. However, its central voltage was known (0 V — the potential at which the comparator output switches states) and the unknown is the voltage value at one end. The integrator was recognised by a significant number, but candidates require clear understanding of the concept of period and frequency in an electronic signal that varies.

d) Some candidates saw the averaging but were not able to see why values were subtracted from 1023, as the maximum possible voltage reading from the circuit converted by the A-D converter, rather than being used directly.

## Project

Aspects of the assignment where candidates found additional demand were:

**Research and analysis and producing a specification**
Candidates should analyse the problem, detailing top level systems diagram, subsequent sub-systems diagrams, inputs, outputs etc. Although no marks are allocated to these, candidates should be familiar with this from previous Engineering Science courses. This will allow candidates to identify individual sub-systems, inputs and outputs, and areas requiring research. Once the research factors have been identified, candidates should plan how they are actually going to conduct their research (internet, library, site visits, telephone interviews, questionnaires etc.) A detailed plan of exactly what information they are looking for should be provided — for every factor. Candidates should then carry out the research, providing evidence of this, referenced quotations from websites or books, completed questionnaires, collated results etc. Results of the overall research should be provided, drawing meaningful conclusions, relevant to their chosen assignment task. Candidates should then provide a detailed specification drawn from their relevant research.

Section 3 should plan the progress of the project and candidates should regularly review it to ensure that individual milestones are being met. A detailed list of required resources (and how they are going to be sourced) should be included, a Critical Path Analysis to identify the order in which the work will need to be carried out and a Gantt Chart, or similar, detailing timescales, individual milestones etc. The project plan should include evidence of the continual review (annotations, highlights etc) along with any subsequent adaptation as a result of the reviews.

**Mathematical modelling/analysis**
Mathematical modelling does not just refer to mathematical calculations: it could also reflect techniques such as circuit simulation. However, it must reflect learning in the course or beyond. Any mathematical calculations must be of a level at least of the demand of SCQF level 6 Mathematics. Page 31 of the session 18–19 project document provided a possible list of activities — the results of the modelling must be relevant and applied to the problem. Any calculations should be appropriately annotated to ensure that the process makes sense to the reader. A detailed description of how simulated sub-systems could be integrated should be included.

**Evaluating the development process and solution**
Although no marks are awarded for testing the solution, it would be extremely difficult to compile a detailed evaluation without it. The evaluation, requires complex engineering science concepts to be communicated clearly and in detail. The evaluation should reflect on the solution when compared to the specification (sub-system by sub-system) and should also evaluate progress through the project by reflecting on the project plan and record of progress. Evaluative comments may be found anywhere in the report and be included in the mark allocation.

**Presenting/communicating the solution**
The report should be well presented, in a logical order and should read well. It should make sense to the reader. Diagrams and other figures should be appropriately titled and referred to in the text. The record of progress should be very detailed and reflect the level of Advanced Higher.

# Section 3: preparing candidates for future assessment

## Question paper

Centres should remind candidates that their working in calculations should not be rounded until a final value is reached, and they must follow the guidance given on the use of significant figures (as printed on the front of the question paper) when writing their final answer.

For the purposes of the question paper, values will be selected for parameters that have an appropriate degree of significance, for example 125 mm (enabling a calculation involving this value to be rounded to three significant figures if all other parameters have at least three significant figures) or 220 Ω (enabling a calculation involving this value to be rounded to two significant figures if all other parameters have at least two significant figures). Alternatively, a statement on the accuracy of the value of parameters — force, length, resistance, voltage, current etc, — will be made in the question, for example 'all voltage values are accurate to ±100 mV'.

Centres should remind candidates that in the context of a question, in order to gain full marks, calculated values must include correct units and engineering notation for the numerical value quoted.

Candidates should devote significant time to their own study in the subject in order to move their own subject knowledge beyond that of Higher level, particularly in relation to course themes.

Generally, candidates' responses to questions related to the topic areas of 'mechanisms and structures', and in particular 3D forces, second moment of area and power transmission in belt drives saw more confident responses than questions related to the topic areas of 'electronics and control' therefore centres/candidates should devote more time to study these areas.

'Electronics and control' questions will extend on the Higher course content as well as introduce some new content, an example being the extension of the use of Ohm's Law in circuits to combine with Kirchhoff's Current Law in nodal analysis. This approach will continue to be tested in a number of possible scenarios around transistors and op-amps as well as purely resistive networks. (See past papers 2017 Q5, Q9(b), 2018 Q4, 2019 Q7(d), Q8(b)). For example, in question 7 successful responses generally included diagrams of the node with current directions and voltages clearly marked. Note that candidates can gain 3 of 5 marks before attempting to solve simultaneous equations; the conceptual understanding and application of physical principles is the key to gaining marks.

Centres should ensure candidates gain knowledge of bipolar transistor amplifier transistors (see past paper 2018 Q4) used as amplifiers in similar circuit arrangements to the MOSFET (see 2019 Q5), along with resistance between source and ground.

## Project

Centres should ensure that candidates are not given excessive guidance and, where guidance is given, it must be recorded and reflected in the marks awarded. Centres must ensure that the project is carried out under open-book conditions, but supervised to ensure that the work presented is the candidate’s own.

Although this is the final year of this assessment in its current format, the new format will be broadly similar. This means that centres and candidates should take notice of the information given in this report as it still relevant and should be read in conjunction with all the project assessment guidance.

# Grade boundary and statistical information:

## Statistical information: update on courses

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| **Number of resulted entries in 2018** | 59 |

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|---|---|
| **Number of resulted entries in 2019** | 36 |

## Statistical information: performance of candidates

### Distribution of course awards including grade boundaries

| Distribution of course awards | Percentage | Cumulative % | Number of candidates | Lowest mark |
|---|---|---|---|---|
| **Maximum mark** | | | | |
| **A** | 25.0% | 25.0% | 9 | 103 |
| **B** | 19.4% | 44.4% | 7 | 88 |
| **C** | 38.9% | 83.3% | 14 | 73 |
| **D** | 11.1% | 94.4% | 4 | 65 |
| **No award** | 5.6% | - | 2 | - |

## General commentary on grade boundaries

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

SQA aims to set examinations and create marking instructions that allow:

- a competent candidate to score a minimum of 50% of the available marks (the notional C boundary)
- a well-prepared, very competent candidate to score at least 70% of the available marks (the notional 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 every year for each subject at each level to bring together all the information available (statistical and judgemental). The principal assessor and SQA qualifications manager meet with the relevant SQA head of service and statistician to discuss the evidence and make decisions. Members of the SQA management team chair these meetings. SQA can adjust the grade boundaries as a result of the meetings. This allows the pass rate to be unaffected in circumstances where there is evidence that the question paper has been more, or less, challenging than usual.

- The grade boundaries can be adjusted downwards if there is evidence that the question paper is more challenging than usual.
- The grade boundaries can be adjusted upwards if there is evidence that the exam is less challenging than usual.
- Where standards 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 to year. This is because the particular questions, and the mix of questions, are different. This is also the case for question papers set by centres. If SQA alters a boundary, this does not mean that centres should necessarily alter their boundary in the question papers that they set themselves.