Advanced Higher Course Assessment Specification

Advanced Higher Engineering Science Course Assessment Specification (C723 77)

Valid from August 2015

This edition: April 2016, version 2.1

Please refer to the note of changes at the end of this Course Assessment Specification for details of changes from previous version (where applicable).

Course outline

Course title:	Advanced Higher Engineering Science
SCQF level:	7 (32 SCQF credit points)
Course code:	C723 77
Course assessment code:	X723 77

The purpose of the Course Assessment Specification is to ensure consistent and transparent assessment year on year. It describes the structure of the Course assessment and the mandatory skills, knowledge and understanding that will be assessed.

Course assessment structure

Component 1 — project	90 marks
Component 2 — question paper	60 marks
Total marks	**150 marks**

This Course includes eight SCQF credit points to allow additional time for preparation for Course assessment. The Course assessment covers the added value of the Course.

Equality and inclusion

This Course Assessment Specification has been designed to ensure that there are no unnecessary barriers to assessment. Assessments have been designed to promote equal opportunities while maintaining the integrity of the qualification.

For guidance on assessment arrangements for disabled learners and/or those with additional support needs, please follow the link to the Assessment Arrangements web page: www.sqa.org.uk/sqa/14977.html.

Guidance on inclusive approaches to delivery and assessment of this Course is provided in the *Course/Unit Support Notes*.

Assessment

To gain the award of the Course, the learner must pass all the Units as well as the Course assessment. Course assessment will provide the basis for grading attainment in the Course award.

Course assessment

SQA will produce and give instructions for the production and conduct of Course assessments based on the information provided in this document.

Added value

The purpose of the Course assessment is to assess added value of the Course as well as confirming attainment in the Course and providing a grade. The added value for the Course will address the key purposes and aims of the Course, as defined in the Course Rationale. It will do this by addressing one or more of breadth, challenge, or application.

In this Course assessment, added value will focus on the following:

- breadth — drawing on knowledge and skills from across the Course
- challenge — requiring greater depth or extension of knowledge and/or skills
- application — requiring application of knowledge and/or skills in practical or theoretical contexts as appropriate

Through the Units (and in a variety of contexts related to mechanisms, structures, electronics and control systems), learners will develop engineering skills, knowledge and understanding of the application of mathematical techniques in engineering, and knowledge and understanding of key engineering concepts.

To achieve success in the Course, learners must show that they can **apply** the knowledge and skills developed through the Units, in both practical and theoretical contexts. Added value will be assessed through a project and a question paper.

The project requires learners to demonstrate aspects of challenge and application in a practical context. Learners will **apply** knowledge and skills from the Units to develop, implement, evaluate and report on a solution to an appropriately challenging and complex engineering problem.

The question paper requires learners to demonstrate aspects of breadth and application in theoretical contexts. Learners will **apply** breadth of knowledge from across the Units and depth of understanding, to answer appropriately challenging questions in engineering contexts.

Grading

Course assessment will provide the basis for grading attainment in the Course award.

The Course assessment is graded A–D. The grade is determined on the basis of the total mark for all Course assessments together.

A learner's overall grade will be determined by their performance across the Course assessment.

Grade description for C
For the award of Grade C, learners will have demonstrated successful performance in all of the Units of the Course. In the Course assessment, learners will typically have demonstrated successful performance in relation to the mandatory skills, knowledge and understanding for the Course.

Grade description for A
For the award of Grade A, learners will have demonstrated successful performance in all of the Units of the Course. In the Course assessment, learners will typically have demonstrated a consistently high level of performance in relation to the mandatory skills, knowledge and understanding for the Course.

Credit
To take account of the extended range of learning and teaching approaches, remediation, consolidation of learning and integration needed for preparation for external assessment, six SCQF credit points are available in Courses at National 5 and Higher, and eight SCQF credit points in Courses at Advanced Higher. These points will be awarded when a Grade D or better is achieved.

Structure and coverage of the Course assessment

The Course assessment will consist of two Components: a project and a question paper.

Component 1 — project

The purpose of the project is to assess practical application of knowledge and skills from the Units to develop a solution to an appropriately challenging and complex engineering problem. It will assess learners' skills in implementing a solution to a problem, and evaluating and reporting on that solution.

The project will have 90 marks (60% of the total mark).

The project will be based on a meaningful task providing appropriate challenge and requiring application. This may be based on the design proposal and project plan developed in the *Engineering Project Management* Unit.

Time will be required for:

- preparation for the project, which could include developing an initial design proposal into a specification, reviewing and finalising a project plan, and carrying out any initial research required
- implementing a solution to meet the specification — this will involve some mathematical modelling/analysis, leading to construction and/or simulation of a solution (or aspects of a solution)
- evaluating the development process and completed solution
- presenting/communicating the solution

The project should clearly demonstrate application of knowledge and/or skills (including the use of mathematical techniques) at an appropriate level, related to one or more of mechanisms, structures, electronics and control (as defined in the 'Further mandatory information on Course coverage' section of this document), and application of knowledge and/or skills from the candidate's own research into other aspects of engineering.

Marks will be awarded for:

- research and analysis of the chosen problem
- producing a specification
- producing a detailed project plan
- mathematical modelling/analysis
- constructing/simulating a solution
- evaluating the development process and solution, and identifying possible further developments
- presenting/communicating the solution, including its possible uses and implications

Evidence produced by the learner should include:

- the specification and detailed project plan
- a record of progress through the project, including reflective commentary and all items of evidence specified within the task
- evidence of the completed solution

- qualitative and quantitative evaluation of the solution and development process
- a presentation or report on the solution, its possible uses and its implications
- detailed assessor observation notes, providing evidence of the candidate's degree of independence and safe working

Component 2 — question paper
The purpose of the question paper is to assess breadth of knowledge from across the Units, depth of understanding, and application of this knowledge and understanding to answer appropriately challenging questions.

This question paper will give learners an opportunity to demonstrate the following skills, knowledge and understanding:

- ability to communicate complex engineering concepts clearly and concisely, using appropriate terminology
- knowledge and understanding of the wide role and impact of engineering on society and the environment, including ethical implications
- in-depth knowledge and understanding of aspects of electronic and microcontroller-based systems, and their application
- in-depth knowledge and understanding of aspects of mechanisms and structures, and their application
- knowledge and understanding of the relevance of energy, efficiency and sustainability to complex engineering problems and solutions
- application of mathematical techniques to analyse and solve engineering problems

The question paper will give learners an opportunity to demonstrate application of knowledge and understanding to answer appropriately challenging, context-based questions. Learners will draw on and apply knowledge from the table provided in the 'Further mandatory information on Course coverage' section at the end of this *Course Assessment Specification*.

The question paper will have 60 marks (40% of the total mark) and will consist of two sections. Section 1 will consist of short topic-specific questions, totaling 30 marks. Section 2 will consist of two structured questions of 15 marks each, which may draw on understanding from two or more topics or Units.

Approximately 22 to 28 marks will be awarded for questions (or parts of questions) related to Electronics and Control. Where required, sections of code will be presented in both Arduino C and PBASIC, but candidates may respond in any appropriate language.

Approximately 22 to 28 marks will be awarded for questions (or parts of questions) related to Mechanisms and Structures.

Approximately 8 to 12 marks will be awarded for questions (or parts of questions) related to broad Course themes, including project management, impact on society and environment, energy, efficiency and sustainability.

Across these three main areas of the Course, at least 50% of the marks will require application of mathematical techniques.

A standard resource containing relevant data and formulae will be provided for use by candidates while sitting the question paper.

For more information about the structure and coverage of this Component of the Course assessment, please refer to the Question Paper Brief.

Setting, conducting and marking of assessment

Question paper

This question paper will be set and marked by SQA, and conducted in centres under conditions specified for external examinations by SQA. Learners will complete this in 2 hours.

Controlled assessment — project

The project is:

- set by centres within SQA guidelines
- conducted under some supervision and control

Evidence will be internally marked by centre staff in line with SQA Marking Instructions.

All marking will be quality assured by SQA.

Setting the assessment

Set by centres within SQA guidelines.

The specification for the project will be agreed between the learner and the teacher/lecturer. It will normally be based on the design proposal and project plan developed by the learner for the *Engineering Project Management* Unit.

The project should clearly demonstrate application of knowledge and/or skills (including the use of mathematical techniques) at an appropriate level, related to one or more of mechanisms, structures, electronics and control (as defined in the 'Further mandatory information on Course coverage' section of this document), and application of knowledge and/or skills from the candidate's own research into other aspects of engineering.

Conducting the assessment

Conducted under some supervision and control.

The project will be carried out under open book conditions, but supervised to ensure that the work presented is the candidate's own work.

The teacher/lecturer may give learners limited support and guidance to ensure that they progress through each stage of the project; however, the learners are expected to work independently. The project is designed to discriminate between candidates, and therefore would be expected to provide a wide range of marks. Stronger candidates should be able to complete the project successfully with minimal support and guidance. Weaker candidates may not complete all aspects of the project to a satisfactory standard.

Further mandatory information on Course coverage

The following gives details of mandatory skills, knowledge and understanding for the Advanced Higher Engineering Science Course. Course assessment will involve sampling the skills, knowledge and understanding. This list of skills, knowledge and understanding also provides the basis for the assessment of Units of the Course.

The Course assessment will require learners to draw on and apply knowledge of any of the concepts listed below. This table should be read in conjunction with the descriptions of the question paper and assignment.

Course themes	
The systems approach	Use of system, sub-system and control diagrams to analyse complex engineering systems, including time- and event-based systems
Energy and efficiency	Use of energy audits and cost implications to inform engineering decisions Applied calculations involving efficiency, work done and power, in complex situations, using: $E_w = Fd$ $P = E/t$, $E_k = ½ mv^2$ $E_p = mgh$ $E_e = VIt$ $E_h = cm\Delta T$ Efficiency $\eta = E_{out}/E_{in} = P_{out}/P_{in}$
Calculations	extracting data for use in analysis and calculations manipulating and combining given formulae to obtain answers solving simultaneous equations solving quadratic equations applying trigonometric techniques using integration and differentiation in familiar contexts

Engineering Project Management	
Engineering roles and disciplines	Research and development Resource management Time management (including critical path analysis and Gantt charts) Cost allocation management (capital costs, direct costs, indirect costs, oncosts) Product life cycle planning
Impacts of engineering	Social and economic impacts of engineering Sustainability and environmental impacts of engineering

Electronics and Control	
Analogue electronics	Kirchhoff's Laws and nodal analysis (with two unknowns) of circuits Designing transistor biasing circuits for a given output load for class A amplifier circuits, using BJT and MOSFET transistor and voltage-divider biasing. Use of DC Load Line and Q-point Schmitt triggers, including use to produce square waves Integrating amplifiers Use of 555 and Wien Bridge oscillators to generate shaped waveforms and clock signals
Digital electronic control systems	Interfacing microcontrollers: ♦ Connecting digital and analogue input devices (including a conditioning circuit to suit ADC input if required) ♦ Connecting digital and analogue output devices (including drive circuits or relay interfaces if required) Principles and applications of A-D conversion: ♦ ADC designs in relation to speed, linearity of conversion and resolution, etc ♦ Calculation of anticipated binary output for a given analogue input Principles and applications of D-A conversion Calculation of analogue output for a known binary input based on a summing amplifier
	Developing programs using an appropriate high-level language to solve control problems involving multiple inputs and outputs, and proportional control Using a range of constructs which include input, output, branching, loops (fixed, continuous, nested), time delays, logic and arithmetical operations, subroutines
Generation and transmission	Basic principles and examples of electrical power generation. Basic principles of electrical power transmission, including: transformers (bus bar and circuit-breaker), advantages of AC, main components of the national grid (step-up and step-down transformers, high voltage transmission, control centre) AC-DC and DC-AC conversion

Mechanisms and Structures	
Drive systems	Analysis and calculation of forces and torque within drive systems, comprised of spur gears and/or belts and pulleys
Structures and forces	Free body diagram for a beam under the action of gear or pulley forces Use of equations of equilibrium for simply supported beams (including forces acting in three dimensions, by resolving into two orthogonal planes) and cantilever beams Bending moment diagrams and shear force diagrams
Materials	Second moment of area General beam bending equation Maximum values of deflection for cantilever, simply supported and built-in beams subject to either a point load or a UDL

Administrative information

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History of changes to Course Assessment Specification

Version	Description of change	Authorised by	Date
2.0	Further detail given within the 'Structure and coverage of the Course assessment' section, including mark allocation for the question paper. Clarification and amendments made to the concept tables in the following areas: engineering roles and disciplines; electrical generation and transmission; structures and forces; materials.	Qualifications Development Manager	April 2015
2.1	Rewording of paragraphs within the 'Course assessment' section and reference to the Question Paper Brief added to the 'Structure and coverage of the Course assessment' section. Further information given and minor amendments made for clarity, particularly in the 'Further mandatory information on Course coverage' section.	Qualifications Manager	April 2016

Note: You are advised to check SQA's website (**www.sqa.org.uk**) to ensure you are using the most up-to-date version of the Course Specification.