Higher
Course Assessment
Specification

Higher Engineering Science Course Assessment Specification (C723 76)

Valid from August 2014

This edition: April 2016, version 1.5

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: Higher Engineering Science

SCQF level: 6 (24 SCQF credit points)

Course code: C723 76

Course assessment code: X723 76

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 — question paper	90 marks
Component 2 — assignment	60 marks
Total marks	**150 marks**

This Course includes six 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 of 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, learners will develop engineering skills, and knowledge and understanding of key engineering concepts in a variety of contexts, including mechanisms, structures, electronics and control systems.

To achieve success in the Course, learners must show that they can **apply** the knowledge and skills developed through the Course, in both practical and theoretical contexts. The added value consists of the following:

The assignment requires learners to demonstrate aspects of challenge and application in a practical context. Learners will **apply** knowledge and skills from the Course to solve an appropriately challenging practical 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 Course 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 question paper and an assignment. The question paper will have two sections.

Component 1 — 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 engineering concepts clearly and concisely, using appropriate terminology
- ability to design and evaluate solutions to engineering problems in a range of contexts
- knowledge of the many types of engineering, and the wide role and impact of engineering (including existing and emerging technologies) on society and the environment
- knowledge and understanding of key concepts related to electronic and microcontroller-based systems, and their application
- knowledge and understanding of key concepts related to mechanisms and structures, and their application
- knowledge of the relevance of energy, efficiency and sustainability to engineering problems and solutions
- application of engineering knowledge and skills in a range of contexts

The question paper will have 90 marks out of a total of 150 marks. This is 60% of the overall marks for the Course assessment.

Approximately 20-30% of the marks will be awarded for questions related to engineering contexts and challenges.

Approximately 30-40% of the marks will be awarded for questions related to electronics and control.

Approximately 30-40% of the marks will be awarded for questions related to mechanisms and structures.

Question will sample within topics, so that each question paper will have some marks related to each of the following:

- the systems approach
- energy and efficiency
- engineering roles and disciplines
- impacts of engineering
- analogue electronic control systems
- digital electronic control systems
- drive systems
- pneumatics
- structures and forces
- materials

Approximately 30-40% of the marks will be awarded for application and manipulation of formulae to solve context-based numerical engineering problems.

A data booklet containing relevant data and formulae will be provided for use by the learner.

The question paper has two sections.

Section 1 will have 20 marks, and will consist of short answer questions.

This Section will give learners an opportunity to demonstrate breadth of knowledge from across the topics specified in the 'Further mandatory information on Course coverage' Section at the end of this Course Assessment Specification.

Section 2 will have 70 marks, and will consist of structured questions.

This Section will give learners an opportunity to demonstrate application of knowledge and understanding to answer appropriately challenging, context-based questions by drawing on and applying knowledge from the table provided in 'Further mandatory information on Course coverage' Section at the end of this Course Assessment Specification.

Component 2 — assignment
The purpose of the assignment is to assess practical application of knowledge and skills from the Units to develop a solution to an appropriately challenging engineering problem. It will assess learners' skills in analysing a problem, designing a solution to the problem, simulating or constructing a solution to the problem, and testing and reporting on that solution.

The assignment will have 60 marks (40% of the total mark).

Time will be required for:

- preparation for the assignment, which could include considering exemplar assignments and practising required skills
- carrying out the stages of the assignment, with teacher guidance and support
- assessing the process and completed solution

The assignment should clearly demonstrate application of knowledge and skills, at an appropriate level, related to mechanisms, structures, electronics and control (as defined in the 'Further mandatory information on Course coverage' Section of this document).

Guidelines for the assignment will include questions/tasks/prompts which will lead learners through the task in clear stages.

Marks will be awarded for:
- Analysing the problem
- Designing a solution
- Constructing/simulating a solution
- Testing the solution
- Reporting on the solution

Evidence should include:

- the completed solution
- a record of progress through the assignment (such as an informal electronic log or diary maintained by the learner)
- a short report on the testing of the solution (in written, electronic and/or oral form)

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 — assignment

The assignment is:

- set by SQA
- conducted under some supervision and control

and

- 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 SQA.

Conducting the assessment

Conducted under some supervision and control.

A bank of assignments will be provided, and there will be choice from this bank.

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

The teacher/lecturer may give learners support and guidance to help them progress through each stage of the assignment; where any significant amount of support is provided, this should be reflected in the marks awarded.

The assignment is designed to discriminate between learners, and therefore would be expected to provide a wide range of marks. Stronger candidates should be able to complete the assignment successfully with minimal support and guidance. Weaker candidates may not be able to complete all aspects of the assignment within a reasonable time, or may require significant assistance, and so would achieve a lower total mark.

Once the assignment has been completed and assessed, it should **not** be returned to the learner for further work to improve their mark.

Further mandatory information on Course coverage

The following gives details of mandatory skills, knowledge and understanding for the 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. This table should be read in conjunction with the descriptions of the question paper and assignment.

Component 1 — question paper
The purpose of the question paper is to assess breadth of knowledge from across the Course, depth of understanding, and application of this knowledge and understanding to answer appropriately challenging questions. The question paper Component of Course assessment will require learners to draw on and apply knowledge and understanding of a sample of all the concepts listed in the tables below.

Course themes	
The systems approach	Complex system, sub-system and control diagrams The role of feedback in a system Closed loop, automatic, two-state and proportional feedback Use of error detection in a closed loop system
Energy and efficiency	Calculations related to energy audits: inputs, outputs, energy losses and efficiency Applied calculations involving efficiency, work done and power, 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	Manipulating and combining given formulae to obtain answers Solving structural problems using trigonometric functions and substitution in simultaneous equations

Engineering Contexts and Challenges	
Engineering roles and disciplines	The role of the professional engineer within a project, including communication and team working The skills and specialist knowledge required within projects

Impacts of engineering	Examples of social and economic impacts (positive and negative) of engineering Examples of environmental impacts (positive and negative) of engineering Sustainability of engineering solutions Emerging technologies and their impact

Electronics and Control	
Analogue electronic control systems	Variable resistors, light and temperature sensors in voltage dividers Use of input transducer characteristics to design voltage dividers to meet specification Function and purpose of BJTs, 741ICs (building blocks) and op-amps (devices for amplifying voltage signals) Function of op-amp configurations: inverting, non-inverting, comparator, difference amplifier, summing amplifier, voltage followers Design of BJT circuit as a current amplifier Calculation of relationship between input and output voltages for different op-amp configurations Calculation of current gain (H_{FE}) of an npn transistor Function and purpose of MOSFETs using diagrams and characteristic graphs Design of MOSFET (n-channel enhancement mode) circuit as a voltage operated switch Calculation of transconductance in a MOSFET Comparison of two types of transistor in a given application
Digital electronic control systems	Digital electronic control: Logic functions: AND, OR, NOT, NAND, NOR, EOR and combinations Conversion to NAND equivalent Development of Boolean expressions from truth tables, logic diagrams or circuit specifications Construction of truth tables and logic diagrams from written specifications Programmable control:

	Controlling a motor using pulse width modulation Control routines with up to four inputs and four outputs, processing analogue inputs Use of infinite and finite loops and time delays Use of logic and arithmetic operations to make decisions

Mechanisms and Structures	
Drive systems	Selection of appropriate drive systems (including simple and compound gear trains, belt drives and chain drives) in different contexts. The purpose of couplings (rigid and flexible — all types), radial and thrust bearings (plain, ball, roller, journal) and joints in shafts Purpose of friction in brakes and clutches Calculation of torque: T = Fr
Pneumatics	Sequential control circuits, with up to two cylinders Electro-pneumatic control circuits
Structures and forces	Resolving triangle/polygon of forces, resultant/equilibrium Calculation of reaction forces in simply supported beams where loads are not exclusively horizontal or vertical, with hinge and roller supports, with uniformly distributed loads Use of nodal analysis to calculate the size and nature of forces in frames
Materials	Properties of materials: brittleness, elasticity, ductility, plasticity, strength, malleability Calculation of Young's Modulus of elasticity Calculation of factor of safety Use of strain gauges Stress/strain (load/extension) graphs Calculation of elastic strain energy: $E_s = ½ Fx$

Component 2 — assignment
The purpose of the assignment is to assess practical application of knowledge and skills from across the Course to develop a solution to an appropriately challenging engineering problem. It will assess learners' skills in analysing a problem, designing a solution to the problem, simulating or constructing a solution to the problem, and testing and reporting on that solution. The assignment Component of Course assessment will require learners to apply knowledge and understanding of integrating a sample of the concepts listed in the Course themes, Electronics and Control, and Mechanisms and Structures sections in the tables above to produce a proposal of how a complete, fully integrated solution could be constructed/simulated whilst working safely and independently.

Administrative information

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History of changes to Course Assessment Specification

Version	Description of change	Authorised by	Date
1.1	Incorrect reference to Units instead of Course changed on page 3. Further detail included in the 'Structure and coverage of the Course assessment' section about the coverage and structure of the question paper and clarification provided on the design and structure of assignment. Component headings have been included in the 'Further mandatory information on 'Course coverage' section and additional detail provided relating to digital electronic control systems, drive systems and materials. Clarification provided regarding coverage of using trigonometric functions and simultaneous equations to solve structural problems. House style corrections made throughout.	Qualifications Development Manager	April 2014
1.2	Page 8 — Setting, conducting and marking of assessment — length of time for question paper amended to reflect Specimen Question Paper already published. Page 10 — 'Further mandatory information on Course coverage' — removed 'from data booklet', as information will be provided in question, when required.	Qualifications Development Manager	June 2014
1.3	Reference to 'shear stress' removed from 'Further mandatory information on Course coverage' section.	Qualifications Manager	April 2015
1.4	Minor changes made to 'Further mandatory information on Course coverage' section. Clarification added regarding integration of Unit content in Course assignment.	Qualifications Manager	August 2015
1.5	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 in the 'Further mandatory information on Course coverage' section.	Qualifications Manager	April 2016