Higher
Course
Specification

Higher Engineering Science

Course code:	C823 76
Course assessment code:	X823 76
SCQF:	level 6 (24 SCQF credit points)
Valid from:	session 2018–19

This document provides detailed information about the course and course assessment to ensure consistent and transparent assessment year on year. It describes the structure of the course and the course assessment in terms of the skills, knowledge and understanding that are assessed.

This document is for teachers and lecturers and contains all the mandatory information you need to deliver the course.

This edition: April 2018 (version 1.0)

Contents

Course overview

The course consists of 24 SCQF credit points which includes time for preparation for course assessment. The notional length of time for candidates to complete the course is 160 hours.

The course assessment has two components.

Component	Marks	Duration
Component 1: question paper	110	2 hours and 30 minutes
Component 2: assignment	50	see 'Course assessment' section

Recommended entry	Progression
Entry to this course is at the discretion of the centre. Candidates should have achieved the National 5 Engineering Science course or equivalent qualifications and/or experience prior to starting this course.	♦ other SQA qualifications in engineering science or related areas ♦ further study, employment and/or training

Conditions of award

The grade awarded is based on the total marks achieved across all course assessment components.

Course rationale

National Courses reflect Curriculum for Excellence values, purposes and principles. They offer flexibility, provide time for learning, focus on skills and applying learning, and provide scope for personalisation and choice.

Every course provides opportunities for candidates to develop breadth, challenge and application. The focus and balance of assessment is tailored to each subject area.

Engineering brings together elements of technology, science and mathematics, and applies these to real-world challenges. This course provides an excellent opportunity to make links across learning in the senior phase.

The course encourages candidates to become successful, responsible and creative in using technologies and to develop a range of qualities, including flexibility, perseverance, confidence and enterprise.

Purpose and aims

Engineering shapes the world in which we live and its future. Engineers play key roles in meeting the needs of society in fields that include climate change, medicine, IT and transport.

The course provides a broad and challenging exploration of engineering, enabling candidates to:

- extend and apply knowledge and understanding of key engineering concepts, principles and practice
- understand the relationships between engineering, mathematics and science
- apply analysis, design, construction and evaluation to a range of engineering problems with some complex features
- communicate engineering concepts clearly and concisely, using appropriate terminology
- develop a greater understanding of the role and impact of engineering in changing and influencing our environment and society

Who is this course for?

The course is suitable for candidates who want to develop a deeper understanding of the central role of engineers as designers and problem solvers. Candidates should be able to respond to a broad and challenging exploration of engineering and will have opportunities to conceive, design, implement and control complex engineering systems.

Course content

The course develops skills in three main areas. Candidates are able to apply these skills through a range of contexts, within the broad discipline of engineering.

Engineering contexts and challenges
Candidates develop a deep understanding of engineering concepts by exploring a range of engineering problems with some complex features, and their solutions. This allows them to explore some existing and emerging technologies and challenges, and to consider implications relating to the environment, sustainable development, and economic and social issues.

Electronics and control
Candidates explore an appropriate range of key concepts and devices used in electronic control systems, including analogue, digital and programmable systems. They develop skills in problem solving and evaluating through simulation, practical projects and investigative tasks across a range of contexts.

Mechanisms and structures
Candidates develop a deep understanding of mechanisms and structures. They develop skills in problem solving and evaluating through simulation, practical projects and investigative tasks across a range of contexts.

Skills, knowledge and understanding

Skills, knowledge and understanding for the course

The following provides a broad overview of the subject skills, knowledge and understanding developed in the course:

- analysing engineering problems with some complex features
- designing, developing, simulating, building, testing and evaluating solutions to engineering problems in a range of contexts
- investigating and evaluating existing and emerging technologies
- communicating engineering concepts clearly and concisely, using appropriate terminology
- knowledge and understanding of:
  - the many types of engineering
  - the wide role and impact of engineering on society and the environment
  - the workings of a range of engineered objects
  - key concepts related to electronic and microcontroller-based systems, and their application
  - key concepts related to mechanical, structural and pneumatic systems, and their application
  - the relevance of energy, efficiency and sustainability to engineering problems and solutions
- applying engineering knowledge, understanding and skills in a range of contexts

Skills, knowledge and understanding for the course assessment

The following provides details of skills, knowledge and understanding sampled in the course assessment:

Question paper and assignment	
The systems approach	♦ complex system, sub-system and control diagrams ♦ role of negative feedback in a system ♦ closed-loop, two-state and proportional feedback ♦ using error detection in a closed-loop system
Energy and efficiency	♦ calculations related to energy audits: — inputs — outputs — energy losses — 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 Relevant formulae are provided in the *Engineering Science Data Booklet* for Higher.
Engineering roles and disciplines	♦ role of the professional engineer within a project, including communication and team working ♦ 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

Question paper and assignment	
Analogue electronic control systems	♦ variable resistors, light and temperature sensors in voltage dividers ♦ using input transducer characteristics, relevant to the above bullet, to design voltage dividers to meet a specification ♦ function and purpose of BJTs ♦ designing a BJT circuit as a current amplifier ♦ calculating the current gain (h_{FE}) of an npn transistor ♦ function and purpose of MOSFETs ♦ designing a MOSFET (n-channel enhancement mode) circuit as a voltage-operated switch ♦ comparing BJT and MOSFET transistors in a given application ♦ function of op-amp configurations: — inverting — non-inverting — comparator — difference amplifier — summing amplifier — voltage followers ♦ calculating relationship between input and output voltages for different op-amp configurations
Digital electronic control systems	♦ Digital electronic control: — logic functions: AND, OR, NOT, NAND, NOR, EOR and combinations with up to four inputs — conversion to NAND equivalent — developing Boolean expressions from truth tables, logic diagrams or circuit specifications — constructing 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 — using infinite and finite loops and time delays — using logic and arithmetic operations to make decisions — using high-level programs to monitor inputs and initiate digital outputs — using high-level programs to make decisions using arithmetic and logic functions

Question paper and assignment	
Drive systems	♦ diagrams of drive systems ♦ selecting and calculating appropriate drive systems: — simple and compound gear trains — belt drives and chain drives — rack and pinion — worm and wheel — worm and nut ♦ purpose of couplings (rigid and flexible), radial and thrust bearings (plain, ball, roller, journal) ♦ purpose of friction in brakes and clutches ♦ calculating torque: $T = Fr$ ♦ calculating power in a drive system: $P = 2 \pi nT$
Pneumatics	♦ sequential control circuits, with up to three cylinders ♦ electro-pneumatic control circuits
Structures and forces	♦ equilibrium of concurrent and non-concurrent forces in 2D ♦ resolving triangle/polygon of forces, resultant/equilibrant ♦ calculating reaction forces in simply-supported beams or structures: — where loads are not exclusively horizontal or vertical — with hinge and roller supports — with uniformly distributed loads (partial or full length) ♦ using nodal analysis to calculate the size and nature of forces in frames ♦ diagrams of structures
Materials	♦ stress/strain (load/extension) graphs ♦ properties of materials: — brittleness — elasticity — ductility — plasticity — strength — malleability ♦ using strain gauges ♦ calculating Young's Modulus of elasticity ♦ calculating factor of safety ♦ calculating elastic strain energy: $Es = \frac{1}{2} Fx$

Skills, knowledge and understanding included in the course are appropriate to the SCQF level of the course. The SCQF level descriptors give further information on characteristics and expected performance at each SCQF level, and can be found on the SCQF website.

Skills for learning, skills for life and skills for work

This course helps candidates to develop broad, generic skills. These skills are based on SQA's Skills Framework: Skills for Learning, Skills for Life and Skills for Work and draw from the following main skills areas:

2 Numeracy

2.1 Number processes
2.3 Information handling

4 Employability, enterprise and citizenship

4.2 Information and communication technology (ICT)

5 Thinking skills

5.3 Applying
5.4 Analysing and evaluating

You must build these skills into the course at an appropriate level, where there are suitable opportunities.

Course assessment

Course assessment is based on the information provided in this document.

The course assessment meets the key purposes and aims of the course by addressing:

- 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

This enables candidates to apply:

- breadth of knowledge and depth of understanding to answer appropriately challenging questions in engineering contexts
- knowledge and skills to solve appropriately challenging practical engineering problems
- knowledge and skills in both practical and theoretical contexts

Course assessment structure: question paper

Question paper 110 marks

The question paper has a total mark allocation of 110 marks. This is 69% of the overall marks for the course assessment.

It gives candidates an opportunity to demonstrate skills, knowledge and understanding relating to the following areas:

Area	Range of marks
Course themes (the systems approach, and energy and efficiency), engineering roles and disciplines, and impacts of engineering	10–17
Analogue electronic control systems	20–35
Digital electronic control systems	15–25
Drive systems and pneumatics	10–20
Structures and forces	15–25
Materials	8–14

The question paper has two sections:

Section 1 has 20 marks, and consists of short answer questions.
Section 2 has 90 marks, and consists of structured questions.

A proportion of marks are available for more challenging questions, which generally require interpretation and/or integration of more complex engineering contexts. This challenge could be in the complexity of the expected response, the descriptions and/or justifications of more detailed and/or complex processes, problem solving and transposition of formulae or substitution of results from one formula to another.

Questions allow for a variety of response types, including calculations, short/limited responses and extended responses.

Candidates do not need to write code in response to a programmable control question. However, if developing a flowchart-based program sequence, they must provide sufficient and appropriate detail, such as input and output pin numbers and a delay unit.

SQA provides candidates with a data booklet containing relevant data and formulae for the examination.

Setting, conducting and marking the question paper

The question paper is set and marked by SQA, and conducted in centres under conditions specified for external examinations by SQA.

Candidates have 2 hours and 30 minutes to complete the question paper.

Specimen question papers for Higher courses are published on SQA's website. These illustrate the standard, structure and requirements of the question papers candidates sit. The specimen papers also include marking instructions.

Course assessment structure: assignment

Assignment 50 marks

The assignment assesses candidates' ability to apply engineering science skills and knowledge acquired and developed during the course. This is in the context of defined tasks that require candidates to respond to a problem or situation.

The assignment is a problem-solving activity, with a number of tasks that candidates must complete. Tasks may be thematically related.

The assignment has a total mark allocation of 50 marks. This is 31% of the overall marks for the course assessment. Marks are awarded for:

Area	Range of marks
Analysis	4–8
Designing a solution	8–12
Building the solution	8–12
Testing	8–14
Evaluation	8–14

The assignment provides an opportunity for candidates to:

- demonstrate engineering science skills and creativity
- analyse engineering problems
- design and build/simulate solutions to engineering problems
- test and evaluate solutions to engineering problems

Setting, conducting and marking the assignment

The assignment is:

- set by SQA, on an annual basis
- conducted under a high degree of supervision and control
- submitted to SQA for external marking

All marking is quality assured by SQA.

Assessment conditions

Time

The assignment is carried out over 8 hours, starting at an appropriate point in the course once all content has been delivered.

Supervision, control and authentication

Candidates must carry out the assignment:

- without interruption by periods of learning and teaching
- in a classroom environment
- on an individual basis, ie no group work is permitted
- in a supervised environment, to ensure that work presented is their own

Resources

This is a closed-book assessment. Candidates must not have access to learning and teaching materials, the internet, notes, exemplar materials, resources on classroom walls or anything similar.

A data booklet containing relevant data and formulae is available on the Higher Engineering Science subject page on SQA's website. This can be used for the assignment.

Each assessment task includes instructions and details of any equipment or materials required.

Reasonable assistance

Candidates must progress through each stage of the assignment without any teacher or lecturer intervention or guidance.

Once completed assignments are handed in, they must not be returned to candidates for further work.

Evidence to be gathered

Full details of evidence requirements are contained within each assessment task. The required evidence is likely to include completed solution(s), prints from simulation software, photographs of built models, records of testing and evaluation(s).

All candidate evidence (whether created manually or electronically) must be submitted to SQA in paper-based format.

Volume

There is no word count.

Grading

Candidates' overall grades are determined by their performance across the course assessment. The course assessment is graded A–D on the basis of the total mark for all course assessment components.

Grade description for C

For the award of grade C, candidates will typically have demonstrated successful performance in relation to the skills, knowledge and understanding for the course.

Grade description for A

For the award of grade A, candidates will typically have demonstrated a consistently high level of performance in relation to the skills, knowledge and understanding for the course.

Equality and inclusion

This course is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

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

Further information

The following reference documents provide useful information and background.

- Higher Engineering Science subject page
- Assessment arrangements web page
- Building the Curriculum 3–5
- Guide to Assessment
- Guidance on conditions of assessment for coursework
- SQA Skills Framework: Skills for Learning, Skills for Life and Skills for Work
- Coursework Authenticity: A Guide for Teachers and Lecturers
- Educational Research Reports
- SQA Guidelines on e-assessment for Schools
- SQA e-assessment web page

The SCQF framework, level descriptors and handbook are available on the SCQF website.

Administrative information

Published: April 2018 (version 1.0)

History of changes

Version	Description of change	Date

Note: you are advised to check SQA's website to ensure you are using the most up-to-date version of this document.