National 5 Course Specification

National 5 Engineering Science

Course code:	C823 75
Course assessment code:	X823 75
SCQF:	level 5 (24 SCQF credit points)
Valid from:	session 2017–18

The course specification 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.

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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 a candidate to complete the course is 160 hours.

The course assessment has two components.

Component	Marks	Duration
Component 1: question paper	110	1 hour and 50 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 fourth curriculum level or the National 4 Engineering Science course or equivalent qualifications and/or experience prior to starting this course.	♦ other 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 more time for learning, more focus on skills and applying learning, and 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.

The National 5 Engineering Science course provides progression mainly from the craft, design, engineering and graphics experiences and outcomes. It also builds on some science experiences and outcomes, prior learning in mathematics and numeracy and aspects of technological developments in society.

Engineering shapes the world in which we live, by applying elements of technology, science and mathematics to real-world challenges. Engineers play key roles in meeting the needs of society in fields that include climate change, medicine, IT and transport, and it is important there are more young people with an informed view of engineering.

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

The course helps candidates to develop an understanding of the far-reaching impact of engineering on our society. They learn about the central role of engineers as designers and problem-solvers, able to conceive, design, implement and operate complex systems.

Candidates develop the ability to:

- apply knowledge and understanding of key engineering facts and ideas
- understand the relationships between engineering, mathematics and science
- apply skills in analysis, design, construction and evaluation to a range of engineering problems
- communicate engineering concepts clearly and concisely, using appropriate terminology
- develop an understanding of the role and impact of engineering in changing and influencing our environment and society

Who is this course for?

This course is suitable for learners who can respond to a broad and challenging exploration of engineering. A combination of this course and a pure science course provides a very strong foundation for further study in engineering, the sciences, or related careers.

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 an understanding of engineering concepts by exploring a range of engineered objects, engineering problems and solutions. This allows them to explore some existing and emerging technologies and challenges and to consider the implications relating to the environment, sustainable development and economic and social issues.

Electronics and control
Candidates explore a 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 in a range of contexts.

Mechanisms and structures
Candidates develop an understanding of mechanisms and structures. They develop skills in problem-solving and evaluating through simulation, practical projects and investigative tasks in 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
- 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 of the many types of engineering
- knowledge of the wide role and impact of engineering on society and the environment
- knowledge of the workings of a range of engineered objects
- knowledge and understanding of key concepts related to electronic and microcontroller-based systems and their application
- knowledge and understanding of key concepts related to mechanical, structural and pneumatic systems and their application
- knowledge of the relevance of energy, efficiency and sustainability to engineering problems and solutions
- applying engineering knowledge 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	♦ systems and sub-system diagrams ♦ function of a system in terms of input — process — output and feedback loops ♦ open- and closed-loop control ♦ interaction of sub-systems
Energy and efficiency	♦ applying the law of conservation of energy ♦ calculations involving forms of energy (kinetic, potential, electrical and heat) ♦ energy transfers, losses and transformations in a system ♦ energy audits and calculation of overall efficiency ♦ applied calculations involving efficiency, work done and power using: $E_w = Fd$ $P = E/t$, $E_k = \frac{1}{2} mv^2$ $E_p = mgh$ $E_e = VIt$ $E_h = cm\Delta T$ Efficiency $\eta = E_{out}/E_{in} = P_{out}/P_{in}$
Calculations	♦ manipulating given formulae to obtain answers (see the '*Engineering Science Data Booklet National 4/5*' for the relevant formulae)
Engineering roles and disciplines	♦ examples of applications of environmental, civil, structural, mechanical, chemical, electrical and electronic engineering ♦ examples of the contribution of branches of engineering to solve engineering challenges, that integrate branches of engineering ♦ varied roles of engineers in designing, implementing, testing and controlling complex systems
Impacts of engineering	♦ examples of social and economic impacts (positive and negative) of engineering ♦ examples of environmental impacts (positive and negative) of engineering ♦ ways in which engineering solutions contribute to tackling climate change ♦ explaining how emerging technologies may provide improved solutions to engineering challenges

Analogue electronic control systems	♦ function and purpose within a circuit of: battery, switch, resistor, variable resistor, LDR thermistor, LED, buzzer, diode, motor, lamp, ammeter and voltmeter ♦ describing the function of a circuit in terms of input, process and output ♦ calculations involving the relationship between voltage, current and resistance (Ohm's Law) ♦ calculations involving resistors in series and parallel ♦ calculations of voltage, current, and unknown values in a fixed-voltage divider ♦ designing a voltage divider to provide an input signal for a control circuit ♦ interpreting information given of characteristics for an LDR and an NTC thermistor ♦ function of relays ♦ function of a protection diode in an electronic circuit ♦ explaining the switching function of a transistor ♦ operating an electronic control circuit, which includes a variable voltage divider, transistor, relay and output transducer
Digital electronic control systems	♦ AND, OR and NOT gates and combinations with up to three inputs, using truth tables, logic diagrams and Boolean expressions ♦ examples of using microcontrollers in commercial and industrial applications ♦ advantages and disadvantages of microcontroller-based control systems, compared to a hard-wired electronic equivalent ♦ using correct symbols (start, stop, input, output, branch and loop) to construct flowcharts showing solutions to simple control programs, involving time delays and continuous and fixed loops ♦ using suitable commands (high, low, for…next, if…then, pause, end (or their equivalents)) to design programs to solve simple control problems, involving time delays and continuous and fixed loops
Drive systems	♦ motion in mechanical systems: rotary, linear, reciprocating and oscillating ♦ simple gear train systems, idler gears, diagrams and conventions for representation ♦ compound gear trains ♦ calculating speed (velocity) ratio of simple and compound gear trains ♦ the effects of friction in drive systems ♦ appropriate British Standards symbols

Pneumatics	♦ symbols and operation of standard pneumatic components (restrictor, uni-directional restrictor, reservoir, 5/2 valve and actuators: diaphragm and solenoid) ♦ pneumatic time delay circuits ♦ calculating relationships between force, pressure and area in single-acting and double-acting cylinders ♦ controlling speed and force
Structures and forces	♦ examples of effects of a force (tensile and compressive) ♦ concurrent forces and equilibrium ♦ using triangle of forces and free body diagrams ♦ non-concurrent forces and parallel forces ♦ moment of a force ♦ calculations involving the principle of moments ♦ balance beam, simply-supported beam and reaction forces
Materials	♦ selecting appropriate material for a given application, with justification ♦ calculating the relationship between direct stress, force and area ♦ calculating strain

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 (www.scqf.org.uk).

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

These skills must be built into the course where there are appropriate opportunities and the level should be appropriate to the level of the course.

Further information on building in skills for learning, skills for life and skills for work is given in the course support notes.

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 a challenging practical engineering problem
- knowledge and skills in both practical and theoretical contexts

Course assessment structure: question paper

Question paper 110 marks

The question paper gives candidates an opportunity to demonstrate skills, knowledge and understanding relating to:

Area	Range of marks
Systems	5–9
Energy	5–10
Engineering roles	3–7
Engineering impacts	5–9
Analogue — diagrams and components	13–26
Analogue — electrical circuit	
Analogue — voltage dividers	
Analogue — transistors	
Digital — logic	13–24
Digital — microcontroller systems	
Digital — flowcharts/programming	

Drive systems	7–12
Pneumatics	7–12
Structures/forces	7–12
Materials	6–10

The question paper has 110 marks, which is 69% of the overall marks for the course assessment (160 marks).

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

A data booklet containing relevant data and formulae is provided for candidates to use while they are sitting the question paper.

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 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 formulae to another.

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

Candidates are not asked to write code in response to a programmable control question. However, if developing a flowchart-based program sequence, sufficient and appropriate detail is required, such as input and output pin numbers and a delay unit.

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 complete the paper in 1 hour and 50 minutes.

Specimen question papers for National 5 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 developed and acquired during the course. This is done in the context of defined tasks that require candidates to respond to a problem or situation.

The assignment covers a problem-solving process and is split into five areas. These may, or may not, be thematically related and include various tasks that candidates complete.

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

The assignment has 50 marks, which is 31% of the overall marks for the course assessment (160 marks).

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

The assignment must be carried out:

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

Resources

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

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

Reasonable assistance

Candidates are required to progress through each stage of the assignment without any teacher intervention or guidance, having acquired the skills earlier in the course.

Once assignments are completed, they cannot be returned to candidates for further work.

Evidence to be gathered

Full detail of evidence requirements are contained within each assessment task. It is likely to include completed solution(s), prints from simulation software, photographs of built models, record 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

A candidate's overall grade is 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.

- National 5 Engineering Science subject page
- Assessment arrangements web page
- Building the Curriculum 3–5
- Design Principles for National Courses
- Guide to Assessment
- SCQF Framework and SCQF level descriptors
- SCQF Handbook
- 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

Administrative information

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History of changes to course specification

Version	Description of change	Authorised by	Date

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