N5 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: $E_w = Fd \quad P = E/t,$ $E_k = \frac{1}{2} mv^2 \quad E_p = mgh \quad E_e = VIt \quad E_h = cm\Delta T$ 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:

<table>
<tr><th>Area</th><th>Range of marks</th></tr>
<tr><td>Systems</td><td>5–9</td></tr>
<tr><td>Energy</td><td>5–10</td></tr>
<tr><td>Engineering roles</td><td>3–7</td></tr>
<tr><td>Engineering impacts</td><td>5–9</td></tr>
<tr><td>Analogue — diagrams and components</td><td rowspan="4">13–26</td></tr>
<tr><td>Analogue — electrical circuit</td></tr>
<tr><td>Analogue — voltage dividers</td></tr>
<tr><td>Analogue — transistors</td></tr>
<tr><td>Digital — logic</td><td rowspan="3">13–24</td></tr>
<tr><td>Digital — microcontroller systems</td></tr>
<tr><td>Digital — flowcharts/programming</td></tr>
</table>

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

Appendix: course support notes

Introduction

These support notes are not mandatory. They provide advice and guidance to teachers and lecturers on approaches to delivering the course. They should be read in conjunction with this course specification, specimen question paper and coursework.

The course is delivered over 160 hours of class time (as indicated by its SCQF level and points). This includes 40 hours for induction, extending the range of learning and teaching approaches, support, consolidation, and integration of learning, together with preparation for course assessment and the course assessment itself.

Developing skills, knowledge and understanding

This section provides further advice and guidance about skills, knowledge and understanding that could be included in the course. Teachers and lecturers should refer to this course specification for the skills, knowledge and understanding for the course assessment. Course planners have considerable flexibility to select coherent contexts which will stimulate and challenge their candidates, offering both breadth and depth.

The ‘approaches to learning and teaching’ section provides suggested experiences and activities that teachers and lecturers can build into their delivery, to develop the skills, knowledge and understanding of the course.

Approaches to learning and teaching

National 5 Engineering Science, like all National Courses, has been developed to reflect Curriculum for Excellence values, purposes and principles. The approach to learning and teaching developed by individual centres should reflect these principles.

An appropriate balance of teaching methods should be used to deliver the course. Whole-class, direct teaching should be balanced with activity-based learning on practical tasks. An investigatory approach is encouraged, with candidates actively involved in developing their skills, knowledge and understanding by investigating a range of real-life and relevant engineering systems, problems and solutions.

Using a variety of other active learning approaches is encouraged, including group work, peer-to-peer teaching, individual and group presentations, role-playing, reflection and game-based learning with candidate-generated questions. Group work **cannot** be used for the course assessment.

Learning should be supported by appropriate practical activities, so that skills are developed simultaneously with knowledge and understanding.

Learning and teaching strategies

Teachers and lecturers are encouraged to use an array of learning and teaching strategies to enrich candidates' experiences, for example:

Co-operative and collaborative learning approaches support, encourage and enable all candidates to achieve their full potential. Candidates engaging in these approaches can capitalise on each other's knowledge and skills, eg sharing information, evaluating one another's ideas and monitoring the group's work. Although 'working with others' is not specifically assessed, it is a fundamental aspect of working in the engineering industry and so should be encouraged and developed by teachers and lecturers.

Problem-based learning (PBL) develops candidates' problem-solving, decision making, investigative skills, creative thinking, team working and evaluative skills. It prepares them for problem-based assessment activities and may be best used at the end of a topic. This ensures that candidates are secure in their knowledge and understanding, as it requires them to develop the ability to apply knowledge and skills in less familiar contexts.

For example, candidates could be asked to design a machine to transport tyres in a factory. Candidates would then apply their knowledge of friction, drive systems and motion to devise, then present, a solution.

Throughout the course, the stimulation of candidates' interest and curiosity should be a prime objective and where possible, locally relevant contexts should be studied, with educational visits to support this.

Learning about Scotland and Scottish culture could enrich the learning experience and help develop the skills for learning, skills for life and skills for work. Where there are opportunities to contextualise approaches to learning and teaching in Scottish contexts, teachers and lecturers should consider this.

Teachers and lecturers can enrich the learning experience with guest speakers from industry and further and higher education — bringing the world of engineering into the classroom. Where this is not possible, online resources may be valuable alternatives. Computer-based simulations encourage learning, as candidates can manipulate and investigate systems without requiring expensive equipment.

Areas of study for candidates

Engineering contexts and challenges

The systems approach should be introduced and then reinforced by developing system and then sub-system diagrams for a number of familiar products. Simple everyday products are ideal for the purpose and candidates should be encouraged to identify inputs and outputs (the sub-system diagram should identify the main input devices and output devices). Feedback loops providing closed-loop control should also be identified, where appropriate.

An introduction to energy can be undertaken using the same products used for the systems approach. Candidates could draw up energy transformation block diagrams showing the energy changes and losses, and carry out simple calculations on the efficiency of the process.

Candidates could identify sub-systems and draw diagrams to show the relationship between these within the overall system. Through a number of tasks of increasing complexity, candidates should learn to distinguish between open- and closed-loop control.

For some of the products analysed, candidates could identify the energy inputs and outputs, and consider the energy transformation function of the transducers. Candidates could then draw block diagrams to show the energy transformations in a product and the main energy losses. For example, the diagrams could show the inputs of light, heat and/or kinetic energy going into their respective input, electrical energy feeding the output transducers to produce light, sound, heat and/or kinetic energy, as appropriate.

Candidates could be given input and output energy values for a few example energy transformation systems and asked to calculate the losses. They should also be able to identify the form that these 'lost' energies would take and be able to put these values into a block diagram showing the type and amount of each of the input and output energies. By using these values, a simple energy audit could be carried out and the overall efficiency of the system determined.

Throughout the course, candidates will be developing their understanding of the main branches of engineering (civil, mechanical, electrical and chemical) and some other sub-branches. They may also discover that many hybrid types of engineering roles have developed in recent years. This can be achieved by involving candidates in guided research and case studies.

Once a basic understanding has been developed, candidates could be given the opportunity to study contemporary and, possibly, local projects involving engineers from a number of the different branches. At least one project should be studied that involves the use of a renewable energy source in order to improve sustainability.

The systems approach should be applied to the project and its main component parts. The roles of engineers within parts of the project can be considered, as well as the contribution of different branches of engineering.

It is likely that as candidates research a number of these projects, they will develop a broad understanding of the varied roles of engineers. There should be some discussion of how emerging technology could be used in the project to improve it in some way. Current online news items might be a useful resource for this area of study.

It is important that candidates see the relevance of any design, simulation and modelling that they do. As such, activities should be chosen that replicate, albeit in a simplified way, the function of a sub-system of the project. Groups within the class could be given different aspects of the same engineering project to model or simulate. This could be done using simulation packages such as Yenka, or by building electronic control systems using modular boards such as Erhardt+Leimer (E&L) or ALPHA, or mechanical aspects using LEGO, fischertechnik or craft materials.

Class discussion, group research and presentation could be used to develop an awareness of the pervasive impact of engineering, bringing advantages and disadvantages to society as a whole, as well as to local communities. Candidates should be able to describe these advantages and disadvantages under the broad headings of society, the economy and the environment.

Electronics and control

Centres wishing to build circuits will need a stock of components, eg resistors, motors, breadboards (prototype board), from one of the many commercial suppliers. Multimeters and logic probes will also be required for measurement exercises and fault finding.

Candidates should be introduced to the requirement for input, process and output sub-systems in an electronic circuit and the function of each. This may involve studying existing systems and identifying, where possible, the components that may be required.

Using Ohm's law, candidates should gain experience of calculating voltage, current and resistance in both series and parallel circuits. This can be introduced by, or consolidated with, practical experience and simulation software.

Voltage dividers should be considered in their capacity as both fixed voltage dividers and as providing input signals for a control system. This will involve the use of LDRs, thermistors, and both fixed and variable resistors. Candidates should also gain experience of interpreting information on LDRs and thermistors from given tables. Incorporating their understanding of Ohm's law, candidates should perform calculations to determine output voltages from voltage dividers under different input conditions.

Transistors should be considered in their capacity as switching devices. Candidates should gain experience of connecting them to output devices such as lamps, motors, buzzers and relays. The use of diodes for circuit protection should also be covered.

Candidates should investigate logic circuits using AND, OR and NOT gates with up to three inputs. Systems should be analysed and described using truth tables and Boolean expressions.

Microcontrollers should be investigated with respect to their use in commercial and industrial applications. This could be an investigative group task, followed by a presentation to the class. Candidates should consider their advantage over hard-wired electronic equivalent circuits.

Candidates should develop their use of flowchart programming to control systems requiring time delays, fixed and continuous loops, and up to three inputs and outputs. High-level programming of microcontroller systems should progress from the use of flowcharts. Candidates should gain experience of using standard commands such as those to switch output devices, create time delays, test conditions, and generate fixed and continuous loops. Candidates will be expected to generate a flowchart from a given problem specification and a program from a given flowchart.

Problem-solving activities provide excellent opportunities to integrate delivery across topic areas. For example, electronic solutions can be used to control mechanical systems (either using pre-built models or allowing candidates the opportunity to construct them for themselves). The resulting models could then be analysed to find out their implications on energy use and the environment.

Mechanisms and structures

Structures, pneumatic systems and mechanical drive systems can be covered in sequence, or a thematic approach may be used. The range of systems is undefined, allowing personalisation and choice. These can be explored in a variety of ways, including:

- reverse engineering of real devices
- studying diagrams of existing systems
- using simulation software
- building small models from kits

As each system is explored, candidates can produce diagrams, drawings and reports (spoken or written) explaining how these systems work.

Relevant calculations involving energy, work, power and efficiency could be applied to the systems. This may be best achieved through a problem-solving challenge or a series of challenges. This can be demonstrated through either mechanical or pneumatic systems (not necessarily both) and the system can be constructed or simulated. A series of increasingly-complex systems could be developed, building candidates' skills and understanding.

Two examples of possible challenges are:

- Design and model/simulate a system to collect fresh farm produce directly from a field and package it. Candidates can decide whether to use pneumatics and/or mechanisms. This will require a knowledge of belt and chain drives to choose the most suitable, and application of knowledge of rotary and linear motion in a conveyor system. Calculations of speed reductions will also be required.
- Design and build a system for a cheese press in a factory situation. This will require a basic knowledge of pressure and logic control in pneumatics.

Much of this area of study could also be delivered through the context of cycling and bike design, for example:

- Motion can be delivered easily in the context of drive systems, as well as calculating speed.
- A bicycle can be used to demonstrate velocity ratios and the changes in motion that take place during cycling.
- Frame design relates to structures, including shape and properties of materials.
- Forces and moments can be taught through the operation of the brake lever.
- Energy can be studied through the discussion and investigation of cyclists in and during the Tour de France. This would involve looking at forms of energy, energy transfer and transformations during the race, and calculations of work done.

Other contexts (or combinations of contexts), such as automotive design, alternative energy devices or building bridges, could equally be used as a theme.

Useful resources for course delivery

A programmable control system which uses PICAXE BASIC is suitable. Hardware and free software downloads for Windows, macOS and Linux are available from Revolution Education.

A range of mechanical components can be obtained from Rapid Education or other suppliers.

Construction kits such as those from LEGO, fischertechnik and Meccano are ideal though not essential. They provide structures as well as a range of mechanisms, motors and interfaces, however, the same results can be obtained using craft materials.

The ‘Engineering Daily’ website provides a range of resources, including an interesting list of what they consider to be the top 10 most impressive engineering projects.

There is good information about canals designed by some of Scotland’s most famous engineers, and projects such as The Falkirk Wheel, on the Scottish Canals website.

Where possible, centres should source or produce modelled systems to enhance candidates’ ability to contextualise the course content. This may take the form of pre-built models that can be use directly or connect to the programmed systems or circuits candidates create.

Yenka or Electronics Workbench, offer electronic circuit simulation, and measurement in analogue and digital circuits. Yenka also provides suitable flowchart simulations that can be linked to microcontroller-based circuits within the package. These flowcharts can be downloaded directly to many commercially available microcontroller-based kits without the requirement for candidates to learn any other programming language. LogicLab is useful logic simulation software, available free from the neuroproductions website.

Programs can be downloaded to various commercially available products, such as those from PICAXE, LEGO Mindstorms or BASIC Stamp microcontrollers. Candidates should become familiar with standard flowchart symbols and conventions, even if particular types of hardware do not use them.

There are a number of different high-level programming languages available that may be suitable to deliver this area of study, including PBASIC. There is no particular language specified for this course and the course assessment will not assume knowledge of any specific language. However, the language used should be able to deliver the constructs listed in the course specification, ie start, stop, input, output, branch and loop.

Modular electronic systems produced by manufacturers, such as Unilab or Erhardt+Leimer (E&L), can provide a suitable method of developing some of the required concepts. Control Studio by New Wave Concepts offers similar functions in a simulated environment.

Possible electronic simulation packages include:

- Yenka
- CircuitLogix student version, produced by Logic Design Inc

Although not a definitive list, the following resources may support the delivery of the mechanisms and structures area of study:

- online videos (eg YouTube)
- Technology Enhancement Programme (TEP) on the STEM website
- STEM Central website
- various energy/pneumatic/mechanism kits available from Technology Supplies Ltd, TEP, Rapid Education, etc

Sequence of teaching areas of study

There is no prescribed order to deliver the areas of study of the course. Resources and techniques will vary between centres and so it is likely that a preferred approach could emerge or that a centre might follow an existing, tested strategy.

Suggested activities for candidates

During the course, it is expected that candidates will develop the skills, knowledge and understanding required to complete the course assessments. Teachers and lecturers should ensure that the following activities are covered:

Investigate engineered objects by:

- describing (using the systems approach) how some engineered objects work
- identifying sub-systems and describing the function of each and how they interact
- producing system diagrams to show sub-systems
- carrying out energy audits

Investigate engineering challenges and relating these to key engineering concepts by:

- identifying and describing how several different branches of engineering contribute to solving an engineering challenge
- describing examples of the varied roles of engineers in designing, implementing, testing and controlling complex systems
- modelling some aspect of a solution to an engineering challenge — this should be related to one branch of engineering
- explaining how emerging technologies may provide improved solutions to engineering challenges

Describe some aspects of the impact of engineering by:

- describing examples of social, economic and environmental impacts of engineering
- describing ways in which engineering solutions contribute to tackling climate change

Develop analogue electronic control systems by:

- describing a range of analogue components, and their functions and purpose within a circuit
- producing circuit diagrams of analogue electronic circuits

- using simple formulae to calculate appropriate component values
- simulating or constructing analogue electronic control systems
- testing and evaluating analogue electronic solutions against a specification

Develop digital electronic control systems by:

- describing a range of digital components and their functions
- producing flowcharts and programs for digital control systems
- simulating or constructing digital control systems
- testing and evaluating digital electronic solutions against a specification

Investigate a range of mechanical and pneumatic systems by:

- describing or producing diagrams of a range of
  - structures
  - pneumatic systems
  - mechanical drive systems
- carrying out calculations involving energy, work, power and efficiency using given formulae

Develop mechanical or pneumatic solutions to solve problems by:

- identifying key aspects of a problem
- applying knowledge and understanding of structures, pneumatics and/or mechanical drive systems
- designing, and simulating or building, mechanical or pneumatic systems
- testing and evaluating solutions against a specification

Preparing for course assessment

Candidates should be given opportunities to practise activities similar to those expected in the course assessment. For example, teachers and lecturers could develop questions and tasks similar to those exemplified in the specimen question paper and specimen coursework assessment task.

In addition, the course has time which can be used at the discretion of teachers or lecturers to prepare for course assessment. This time may be used at various points throughout the course for consolidation and support.

For the question paper, time is required for:

- revision and consolidation of learning
- question paper techniques
- familiarisation with past, specimen and sample question papers
- practice question paper(s) — eg prelim examination

For the assignment, time is required for:

- revision and consolidation of learning
- assignment techniques
- familiarisation with past, specimen and sample assignments
- practice assignment(s)

Developing skills for learning, skills for life and skills for work

Course planners should identify opportunities throughout the course for candidates to develop skills for learning, skills for life and skills for work.

Candidates should be aware of the skills they are developing, and teachers and lecturers can provide advice on opportunities to practise and improve them.

SQA does not formally assess skills for learning, skills for life and skills for work.

There may also be opportunities to develop additional skills depending on approaches being used to deliver the course in each centre. This is for individual teachers and lecturers to manage.

Some examples of potential opportunities to practise or improve these skills are provided in the following table:

Skill	How to develop
2 Numeracy	
2.1 Number processes	♦ applying Ohm's Law ♦ using meters to measure voltage, current and resistance ♦ applying correct units to results ♦ problem-solving questions applying Ohm's Law to calculate values of resistance, current and voltage ♦ using formulae involving energy, power, work done and efficiency ♦ calculating efficiency (%) ♦ applying correct units to results ♦ using calculated results during the design of systems
2.3 Information handling	♦ constructing electronic circuits by interpreting circuit and layout diagrams ♦ producing circuit diagrams ♦ producing flowcharts and control programs ♦ producing and interpreting truth tables ♦ drawing and interpreting system and sub-system diagrams ♦ interpreting online and other data sources ♦ studying diagrams of mechanisms ♦ building pneumatic systems from diagrams ♦ drawing diagrams of structures, mechanisms and pneumatic systems

Skill	How to develop
4 Employability, enterprise and citizenship	
4.2 Information and communication technology (ICT)	♦ researching engineering applications using online resources ♦ using circuit simulation software ♦ using flowcharting software ♦ researching the commercial uses of microcontrollers ♦ storing evidence (notes, reports and diagrams) in digital format ♦ using simulation packages ♦ researching mechanisms using online resources
5 Thinking skills	
5.3 Applying	♦ producing system diagrams to show sub-systems ♦ modelling aspects of a solution to an engineering challenge ♦ explaining how emerging technologies may provide improved solutions to engineering challenges ♦ applying knowledge of structures, pneumatics and drive systems to solve practical problems ♦ practical problem-solving in designing analogue and digital control systems ♦ applying electronic control concepts to real-life examples and situations
5.4 Analysing and evaluating	♦ identifying key aspects of a problem ♦ evaluating mechanical and pneumatic solutions against a specification ♦ choosing mechanical or pneumatic devices to solve a problem ♦ testing and evaluating analogue and digital control systems

Administrative information

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History of changes to course specification

Version	Description of change	Date
2.0	Course support notes added as appendix.	September 2017

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