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: September 2018 (version 2.0)

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: $E_w = Fd$ $P = E/t$ $E_k = \frac{1}{2} mv^2$ $E_p = mgh$ $E_e = VIt$ $E_h = cm\Delta T$ Efficiency $\eta = E_{out}/E_{in} = P_{out}/P_{in}$
Calculations	♦ manipulating 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 π 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 = ½ 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.

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. You should read these in conjunction with this course specification and the specimen question paper and coursework.

Approaches to learning and teaching

The Higher Engineering Science course reflects Curriculum for Excellence values, purposes and principles. The approaches to learning and teaching developed by individual centres should reflect these principles.

At Higher, candidates analyse, investigate, debate, and evaluate engineering systems and solutions. Candidates should take more responsibility for their own learning, with teachers and lecturers increasingly taking the role of facilitator.

You should use an appropriate balance of teaching methodologies to deliver the course. Whole-class, direct teaching opportunities should be balanced by activity-based learning using practical tasks. An investigatory approach encourages candidates to become actively involved in developing their skills, knowledge and understanding by investigating a range of real and relevant engineering systems, problems and solutions.

You should also use a variety of active learning approaches, including group work, peer-to-peer teaching, individual and group presentations, role play, and game-based learning with candidate-generated questions. However, candidates cannot use group work for course assessment.

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

Learning and teaching strategies

You should use a broad range of learning and teaching strategies to enrich candidates' experiences.

Co-operative and collaborative learning supports, encourages and enables candidates to reach their full potential. By adopting these approaches, candidates can learn from each other, through sharing information, evaluating each other's ideas and monitoring the group's work.

Practical activities and investigations lend themselves to group work. Although candidates are not assessed while 'working in a group', it is a fundamental aspect of working in the engineering industry. You should encourage and develop this.

Problem-based learning develops candidates' problem solving, decision making, investigative skills, creative thinking, team working and evaluative skills. It prepares candidates for problem-based assessment activities and is useful at the end of an area of study, where you may need additional challenge to ensure candidates are secure in their knowledge and understanding, and can apply them in less familiar contexts.

Throughout the course, a prime objective should be to stimulate candidates' interest and curiosity. Where possible, you should include locally relevant contexts and educational visits.

You can enrich the learning experience with guest speakers from industry and further or higher education. Where this is not possible, online resources can be valuable alternatives. Computer-based simulations also encourage learning, as candidates can manipulate and investigate systems without requiring expensive equipment.

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

Areas of study for candidates

Engineering contexts and challenges

Initially, you could guide candidates through analysing a chosen engineering system, developing a broad overview of the need it fulfils, the type of technologies and the engineering disciplines involved.

The system should be more complex than a system for National 5, involving multiple disciplines and several interacting sub-systems. You can find information using videos, printed information and online resources. Candidates could then carry out further research, focusing on aspects of particular interest to them. Applying energy audit techniques (introduced at National 5) to this more complex system, candidates can build up skills and knowledge so they can carry out their own research project into a system of their own choice.

Candidates should model aspects of a complex engineered solution by constructing or simulating a model of the control system and constructing or simulating a model of a mechanical or structural aspect of the solution. Learning should relate to real engineered solutions, including electronics and control, and mechanisms and structures. Where possible, candidates should use information from their own studies to identify a control sub-system, and a mechanical or structural aspect of the system they have researched, and develop a model of this. Their models can be constructed or simulated.

Able candidates can consolidate learning from across the course by developing complex models, using calculated values. For example:

- Designing sensor voltage dividers — candidates could look up the resistance of a light or temperature sensor, and then calculate the value of a fixed or variable resistor to produce the desired output signal.
- Signal conditioning — candidates could calculate suitable inverting and non-inverting operational amplifier resistor values.
- Using comparators or difference amplifiers to provide two-state or proportional control respectively — candidates could calculate the requisite resistor value.

You could carry out investigations and calculations to determine suitable designs of mechanical or structural elements. This could involve determining a suitable material for a particular application and calculating the required section. Once candidates have identified the need for power transmission, motion conversion and/or mechanical advantage, they could select and design suitable mechanisms.

You should encourage candidates to keep records of their models, for example photographs and screenshots. They should supplement these with information on how the models relate to the engineering system studied.

Electronics and control

You should link tasks and activities throughout this area of study to relevant contexts, for example manufacturing, consumer electronics, security systems, health or medicine, scientific research, transportation and construction. To help understanding, candidates could analyse aspects of existing engineered solutions to real problems. They should do this mathematically where possible. Suitable examples include:

- security alarm systems
- electrical kitchen utensils
- manufacturing assembly lines
- mobile phones
- motorsport
- scientific research
- astronomical observation
- medical instrumentation
- consumer electronics

Candidates should expect to develop a number of control systems as part of their learning.

Individual, paired or group problem-solving tasks should relate to authentic contexts. For example, candidates could write a program to control the braking system of a sports car or build an electronic circuit to control an air conditioning system.

It is important to give scope for problem-solving activities that require candidates to apply their skills and knowledge. You should encourage candidates to investigate electronic circuits using the systems approach.

You should consider voltage dividers in their capacity of providing input signals for a control system. This involves using light and temperature sensors, and both fixed and variable resistors. Candidates should experience interpreting information on light and temperature sensors from given tables. By incorporating their understanding of Ohm’s Law, candidates could perform calculations to determine output voltages from voltage dividers under different input conditions.

You should consider bipolar junction transistors in their capacity as current amplifiers. Candidates should experience calculating gain, based on input and output currents, and could design and construct circuits involving input sensors, transistor driver circuits and output devices such as lamps, motors, buzzers and relays. You should also highlight using diodes for circuit protection.

Candidates should experience designing and constructing operational amplifiers in inverting, non-inverting, comparator, difference, and summing configurations. To do this effectively, they must practise calculating gain, and input and output voltages. Reference values should generally be set using fixed voltage dividers or potentiometers and input voltages generated from sensing circuits. Candidates should:

- monitor circuits using voltmeters, oscilloscopes or connected to appropriate output devices or models
- investigate MOSFETs in n-channel enhancement mode, in their capacity as voltage-operated switching devices, and their operating characteristics contrasted with bipolar transistors
- develop their understanding of combinational logic circuits using AND, OR, NOT, NAND, NOR and EOR gates with up to four inputs
- understand and experience developing NAND equivalent circuits and the relative advantage over circuits containing a number of different logic gates
- design or develop logic diagrams and truth tables from written specifications
- develop Boolean expressions from written specifications and truth tables
- construct logic circuits using 7400 family integrated circuits with digital input devices

Candidates should use high-level programming to control systems requiring up to four inputs and outputs. You should develop their experience by using standard commands (for example, those to switch output devices, create time delays, test conditions, and generate fixed and continuous loops) to incorporate both logic and arithmetic operations in decision-making processes. Candidates could investigate pulse-width modulation as a method for controlling the speed of a DC motor and incorporate this in problem-solving activities.

Problem-solving activities provide excellent opportunities to make links across the course, for example using electronic solutions to control mechanical systems. You could use pre-built models or allow candidates to construct them. Candidates could analyse the resulting models with respect to their implications on energy use and the environment.

Mechanisms and structures

You should link individual, paired or group problem-solving tasks and activities throughout this area to relevant and motivating contexts. The skills, knowledge and understanding tables show what is required, but you can select interesting contexts for candidates to develop them, providing scope for personalisation and choice. To help understanding, candidates could analyse aspects of existing engineered solutions to real problems. Suitable examples include:

- bicycle design
- automotive design
- wind turbine design
- bridge design

To develop analysis and evaluation skills, you may find it helpful to plan learning using a problem-based or experiential learning approach. Alternatively, when developing knowledge and understanding, an outcome-focused or co-operative learning approach could help candidates progress.

An integrated approach combines investigation and developing solutions, and develops knowledge and skills using one or more contexts. It is possible to deliver much of this through the context of wind turbine and renewable energy, for example:

- couplings can form the basis for exploring drive systems, with debate and discussion around bearings and friction
- calculating torque on the propeller shaft
- relating Young's modulus and factor of safety to the structure design
- calculating energy and efficiency for the wind turbine
- studying energy conversion by discussing and investigating wind calculations of energy transfers, work done and power

You can use other contexts (or combinations of contexts) as a theme, for example automotive design, alternative energy devices or bridge building. You can cover structures, pneumatic systems and mechanical drive systems in sequence, or using a thematic approach. There is an undefined range of systems, allowing personalisation and choice, and you can explore these 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 candidates explore each system, they can produce diagrams, drawings and reports (oral or written) explaining how these systems work. This produces naturally occurring evidence that they can use formatively. Candidates can apply relevant calculations involving energy, work, power and efficiency to the systems.

You could develop mechanical or structural solutions to complex problems through a problem-solving challenge or a series of challenges, building on the knowledge developed through the investigation of existing solutions. The system could be constructed or simulated. By developing a series of increasingly complex systems, you can build skills and understanding, for example:

- Design and model or simulate a tidal farm to supply renewable energy to a remote community and the national grid.
  - candidates need to know and understand factor of safety and to be able to use Young's modulus of elasticity when designing
  - candidates need to carry out calculations of energy generation from the tidal turbines
- Design a temporary structure to host a concert at a festival.
  - candidates need a basic knowledge of structural design and material properties

Sequence of teaching areas of study

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

Suggested activities for candidates

During the course, candidates should develop the skills, knowledge and understanding required to complete the course assessments. You should ensure that the following activities are covered:

Research and describe a complex engineering system by:

- analysing the needs being met by the system
- identifying sub-systems, and describing the function of each and how they interact
- producing system and sub-system diagrams
- explaining the role of feedback in the system
- carrying out an energy audit of the system

Model aspects of a complex engineered solution by:

- constructing or simulating a model of its control system
- constructing or simulating a model of a mechanical or structural aspect of the solution

Present a critical analysis of an engineered solution to a contemporary problem by:

- describing clearly the nature of the problem
- describing some social and economic impacts of the solution
- describing some environmental impacts of the solution
- identifying and describing emerging technologies which may impact future developments

Develop analogue electronic control systems by:

- designing and constructing circuits using sensor inputs and BJT drivers
- designing and constructing circuits using sensor inputs and MOSFET drivers
- designing and constructing operational amplifier circuits
- testing and evaluating analogue electronic solutions against a specification

Develop digital electronic control systems by:

- designing and constructing complex combinational logic circuits
- describing logic functions using Boolean operators
- simplifying logic circuits using NAND equivalents
- testing and evaluating combinational logic circuits against a specification

Develop programmable control systems for mechatronic systems by:

- designing and simulating high-level programs to monitor inputs and initiate digital outputs
- designing and simulating high-level programs to make decisions using arithmetic and logic functions
- testing and evaluating programs against a specification

Investigate a range of complex mechanisms and structures by:

- using the systems approach to analyse mechanisms and structures
- describing or producing diagrams of a range of complex structures
- describing or producing diagrams of a range of complex mechanisms
- investigating the properties of a range of materials used in mechanisms and structures

Develop mechanical or structural solutions to solve complex problems by:

- identifying key aspects of the problem
- applying knowledge and understanding of structures, materials and/or mechanisms
- carrying out calculations to assist the selection of materials or component sizes
- designing structures and/or mechanisms
- simulating or building mechanisms and/or structures
- testing and evaluating solutions

Preparing for course assessment

You should give candidates opportunities to practise activities similar to those expected in the course assessment. For example, you could develop questions and tasks similar to those in the specimen question paper and specimen coursework.

In addition, the course has time built in to prepare for course assessment. You can use this at your discretion, at various points throughout the course for consolidation and support.

For the question paper, time is required for:

- revision and to consolidate learning
- question paper techniques
- familiarisation with past, specimen and sample question papers
- practice question paper(s) — for example prelim examination

For the assignment, time is required for:

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

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

You 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 you 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	♦ using meters to measure voltage, current and resistance ♦ setting problem-solving questions applying Ohm's Law to calculate values of resistance, current and voltage ♦ using variables in arithmetic processes as part of control programming ♦ using formulae involving torque ♦ calculating efficiency, work done and power ♦ calculating forces in frames and reaction forces ♦ calculating Young's modulus and factor of safety ♦ applying correct units to results
2.3 Information handling	♦ using Boolean algebra when analysing and designing logic circuits ♦ interpreting information on operating characteristics of electronic components from logarithmic graphs ♦ producing flowcharts and control programs ♦ producing and interpreting truth tables ♦ drawing and interpreting system, and sub-system diagrams ♦ interpreting online and other data sources, and using these to design sub-systems ♦ calculating values to produce devices with particular characteristics ♦ studying diagrams of mechanisms (couplings and bearings)

Skill		How to develop
		♦ building pneumatic systems from diagrams ♦ drawing diagrams of structures, mechanisms and pneumatic systems ♦ drawing stress-strain graphs for different materials
4	**Employability, enterprise and citizenship**	
4.2	Information and communication technology (ICT)	♦ using circuit simulation software ♦ programming microcontroller systems ♦ storing evidence (notes, reports and diagrams) in digital format ♦ researching engineering applications using online resources ♦ preparing, delivering and reflecting on a presentation of research findings ♦ using simulation packages ♦ researching mechanisms using online resources
5	**Thinking skills**	
5.3	Applying	♦ carrying out practical problem solving in designing analogue, digital, and programmed control systems ♦ applying electronic control concepts to real examples and situations ♦ using knowledge previously gained to design sub-systems which will function in a predetermined way ♦ testing, reflecting on and modifying sub-systems to perform in the desired way ♦ applying knowledge of structures, pneumatics and drive systems to solve practical problems ♦ using calculated results when designing systems
5.4	Analysing and evaluating	♦ testing and evaluating analogue, digital, and programmed control systems ♦ identifying key aspects of a problem ♦ evaluating mechanical and pneumatic solutions against a specification ♦ choosing mechanical or pneumatic devices to solve a problem

Administrative information

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History of changes

Version	Description of change	Date
2.0	Course support notes added as appendix.	September 2018

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