Further information on Higher Engineering Science Course Assessment
(November 2013)

Key messages

SQA is currently developing Course and Unit assessments. This document outlines our progress in Course Assessment for the Higher Course in Engineering Science.

Higher Engineering Science is a new course which provides progression from National 5 Engineering Science. The Course provides a broad and challenging exploration of engineering. Learners extend and apply knowledge and understanding of key engineering concepts, principles and practice; understand the relationships between engineering, mathematics and science; and apply skills of analysis, design, construction and evaluation to a range of engineering problems with some complex features.

The Course assessment will be out of 150 marks and will have two components: a question paper and an assignment.

The question paper requires candidates to demonstrate aspects of breadth and application in theoretical contexts. Candidates will apply breadth of knowledge from across the Course, and depth of understanding, to answer appropriately challenging questions in engineering contexts.

The assignment requires candidates to demonstrate aspects of challenge and application in a practical context. Candidates will apply knowledge and skills from the Units to solve an appropriately challenging engineering problem.

Higher specimen question paper (publication by 28 February 2014)

The question paper will have 90 marks and two sections. Candidates will have 2 hours in which to complete it. It will give candidates an opportunity to demonstrate the following skills, knowledge and understanding:

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

Section 1 will have 20 marks and will consist of short-answer questions. This section will give candidates an opportunity to demonstrate breadth of knowledge from across the Course. Most questions will be subdivided into smaller parts. Some calculations, but only involving direct substitution into formulae, will be required.

Section 2 will have 70 marks and will consist of structured questions. This section will give candidates an opportunity to demonstrate application of knowledge and understanding to answer appropriately challenging context-based questions by drawing on and applying knowledge from across the Course. Section 2 will contain some questions or question parts that are particularly challenging and could be integrative (requiring a combination of understanding from two topics within one question or question part). These questions will require detailed descriptions or explanations, the design of solutions or the substitution of a result from one formula or part of a calculation into other parts.

Approximately 25-35% of the marks overall will be awarded for questions related to engineering contexts and challenges, and broad course themes.

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

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

Within each of these broad areas, questions will sample across the main topics, so that each question paper will have some marks related to each of the following sub-topics:

- course themes (systems approach, energy and efficiency)
- engineering roles and disciplines, impacts of engineering
- analogue electronic control systems
- digital and programmable electronic control systems
- drive systems and pneumatics
- structures and forces
- materials

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

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

(For sample questions from the current draft of the Specimen Question paper, please see Appendix 1)

Higher Assignment (publication by 31 March 2014)

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

The assignment should clearly demonstrate application of knowledge and skills, at an appropriate level, from across the Course. It will have 60 marks, which will be awarded for:

- Analysing the problem 10 marks
- Designing a solution 20 marks
- Constructing/simulating a solution 10 marks
- Testing the solution 10 marks
- Reporting on the solution 10 marks

A bank of assignments will be provided by SQA and there will be a choice from the bank.

Evidence should include:

- the completed solution (model or photograph and/or hard copy from simulation software)
- a record of progress through the assignment, including all items of evidence specified within the assessment task
- a short report on the testing of the solution (in written, electronic and/or oral form)
- evidence of candidate's degree of independence and safe working (detailed assessor observation notes)

Evidence will be internally marked by centre staff in line with SQA marking instructions.

(For further information from the current draft of the Assignment, please see Appendix 2)

Appendix 1

Examples of types of questions which may be used in the Higher Engineering Science Question Paper

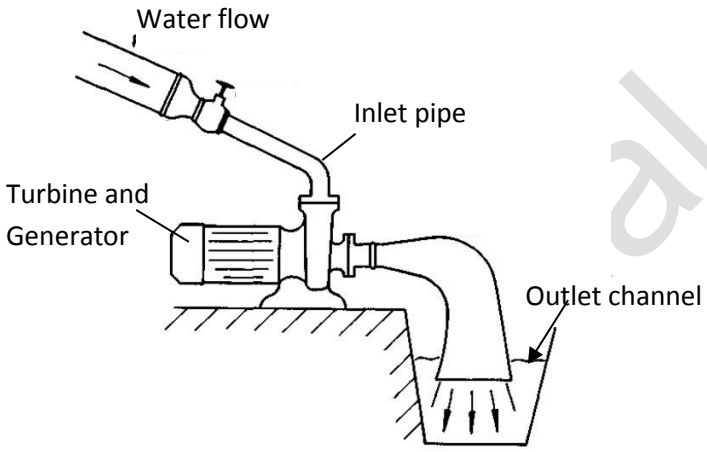
Section 1

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

A possible Section 1 question is shown in example 1.

Example 1

An Engineer is carrying out an audit on the micro-hydro system shown.



The Engineer measured the electrical output from the generator to be 22A at 230 V. The mass of water flowing through the inlet pipe into the generator was 2500 kg every second at an average flow rate of 3.2 ms^{-1}.

(a) Calculate the efficiency of the system. **3**

(b) (i) Explain why it is impossible to achieve 100% efficiency in any system **1**

(b) (ii) Describe one modification that could be made to this system to improve its efficiency. **1**

Section 2

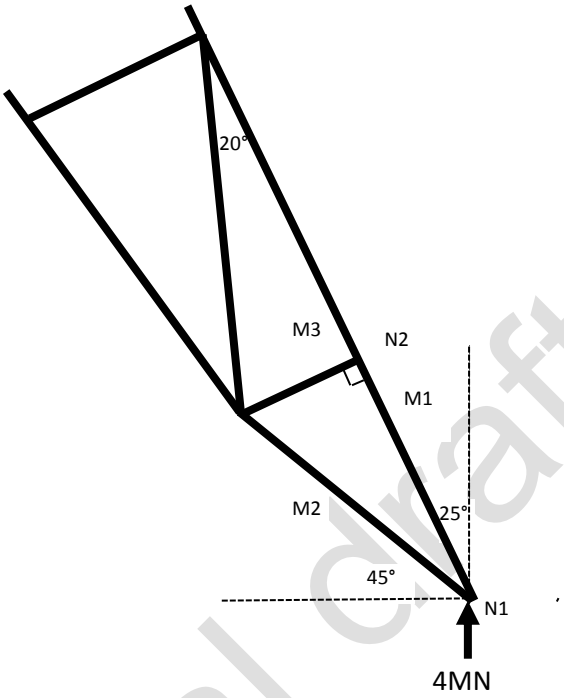
Section 2 will have 70 marks, and will consist of structured questions.

Possible parts of Section 2 questions are shown in examples 2, 3 and 4.

Example 2

A new railway station is being built. A Structural Engineering company has been asked to produce detailed information about a possible station roof.

A proposed design for one of the roof's support legs is shown:



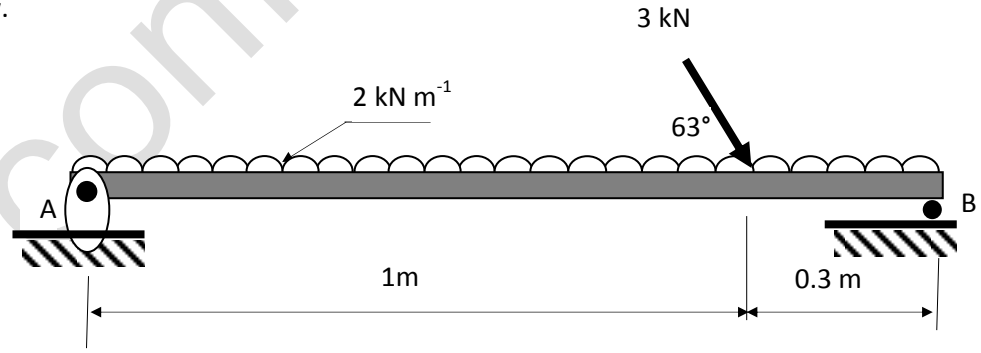
(a) The structure is in static equilibrium. M2 is a tie.

Calculate the magnitude of the forces in members M1 and M2. 5

(b) Describe three examples of how a Structural Engineer would **apply** knowledge of materials, and/or skills in carrying out calculations, in the design of the structure shown above. **3**

(c) Describe two positive and one negative **economic** impacts that the station project might have on the local community during the construction phase. **3**

During the design phase a scale model of a particular loading condition was made as shown below.



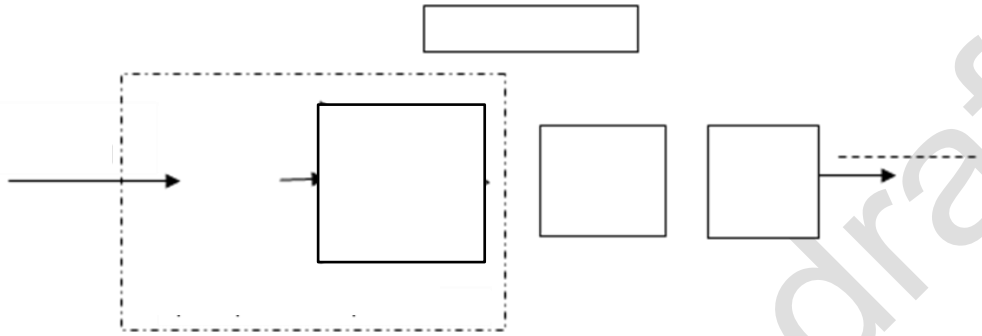
(d) Determine the magnitude and direction of the reaction at A. **4**

Example 3

The laser level device shown has an automatic electronic control system. The system uses an accelerometer to sense whether the laser beam is horizontal. If it is not horizontal, a motor adjusts the laser levelling platform position.

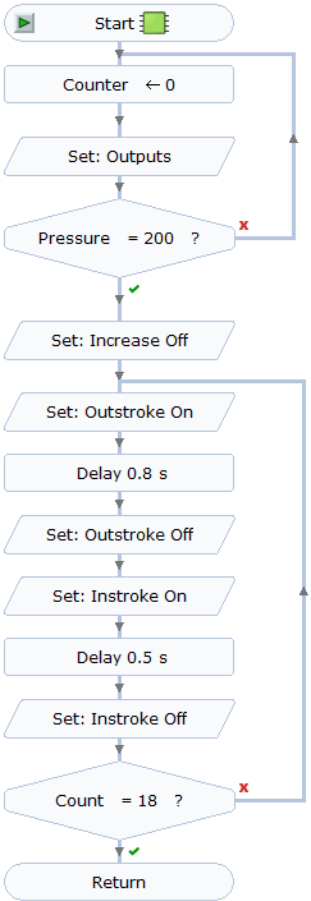
photo of camera on tripod

(a) Complete the control diagram for the device: **4**



Example 4

A punch press is controlled by a microcontroller which provides the sequence of operations required to punch out the can shape. Part of the program sequence is the sub-procedure *cycle*, as detailed by the flowchart and input/output table shown:



Input	Pin	Output
	7	Air pressure increase
	6	Outstroke actuator
	5	Instroke actuator
Pressure sensor	1	

(c) Using a high level language appropriate for programming microcontrollers, write a program which will carry out the sequence required.

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Appendix 2:

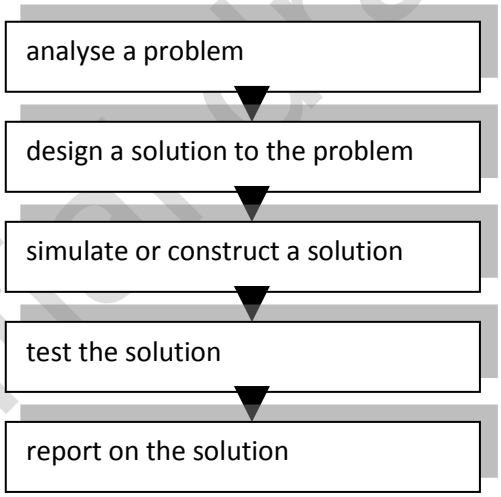
Example extracts from a draft Engineering Science Assignment

Engineering Science assignment

This assessment applies to the assignment for Higher Engineering Science.

This assignment is worth 60 marks out of the total of 150 marks. This is 40% of the overall marks for the Course assessment. The Course will be graded A–D.

Your assessor will let you know how the assessment will be carried out and any required conditions for doing it. In this assessment, you will have to:



Marks will be awarded for each stage.

You will be provided with:

- a description of the problem you must solve
- descriptions of what you must produce for each stage of the assignment

Throughout the task, you are required to keep a record of progress. This could be an informal log or diary, and could be handwritten or kept electronically. It should explain what you have done, describing any help you required and listing any evidence you have produced (printouts, sketches, photographs).

You should update your record of progress after each stage of the assignment.

Make sure you date and label all evidence, and store it in a safe place. All items below in **bold text** are evidence that you must retain for assessment.

After each stage of the task, get your assessor to check your work before moving on to the next stage.

household appliance: the problem

Many household appliances (e.g. smoothie makers, vacuum cleaners, washing machines, cooling fans, lawnmowers, hair dryers) are based on a similar overall design.

generic design features described here: e.g.

- *use pulse width modulation to control speed / heat output*
- *use proportional feedback*
- *involve programmable control*
- *use a MOSFET to drive a motor*

Your task is to choose any appliance that could be controlled using a setup similar to this. You must

- analyse the needs of the system, in terms of realistic speed and conditions;
- design the electronic, control and any mechanical or structural sub-systems required;
- construct (and/or simulate) the programmable control system and at least one other sub-system, and describe how a fully integrated solution could be constructed;
- test and report on your solution.

household appliance: the task

Stage 1: Analysing the problem
During this stage, you should produce the following:

a. complete and detailed specification for your chosen appliance

b. system and sub-system diagrams, showing all inputs, processes and outputs **(with numerical values where appropriate),** and interactions between sub-systems

c. up-to-date record of progress, checked by your assessor.

Stage 2a: Designing the electronic and control sub-systems
During this stage, you should produce the following:

a. complete and correct flowchart **and program** for control system

b. detailed circuit diagrams for electronic sub-systems

c. evidence of calculations or reasoned estimates to support all numerical values of components

d. up-to-date record of progress, checked by your assessor.

additional requirements at Higher compared to N5 are highlighted in bold text

Stage 2b: Designing the mechanical and/or structural sub-systems

During this stage, you should produce the following:

a. detailed design and sketches for mechanical and/or structural sub-systems, including **evidence of calculations or reasoned estimates to support all numerical values of components**

b. up-to-date record of progress, checked by your assessor.

Stage 3: Simulating and/or constructing a solution

During this stage, you should produce the following evidence:

a. a programmable control sub-system fully simulated or constructed

b. at least one electronic, mechanical and/or structural sub-system fully simulated or constructed

c. decisions on materials and components fully justified

d. **evidence of integration of the programmable control sub-system with at least one other sub-system**

e. **brief outline description of how a complete solution could be constructed by integrating all sub-systems**

f. up-to-date record of progress, checked by your assessor.

Stage 4: Testing the solution

During this stage, you should produce the following evidence:

a. a test plan for your system, listing all the tests which should be carried out, with reasons for each test.

b. evidence of testing the control sub-system to ensure it responds correctly to all possible inputs

c. evidence of testing at least one of the electronic, mechanical and/or structural sub-systems

d. notes on any discrepancies between predicted and measured numerical values

e. notes describing and justifying any changes you made as a result of testing

f. up-to-date record of progress, checked by your assessor.

Stage 5: Reporting on the solution ….

Extract from Assignment Assessment Conditions

Assessors must exercise their professional responsibility in ensuring that evidence submitted by a candidate is the candidate's own work.

This assessment is a single assessment event. **Candidates should undertake the assessment at an appropriate point in the Course. This will normally be when they have completed most of the work on the Units in the Course.**

This is an open-book assessment. There are no restrictions on the resources to which candidates may have access.

Candidates must undertake the assessment independently. However, reasonable assistance may be provided prior to the formal assessment process taking place. The term 'reasonable assistance' is used to try to balance the need for support with the need to avoid giving too much assistance. If any candidates require more than what is deemed to be 'reasonable assistance', they may not be ready for assessment or it may be that they have been entered for the wrong level of qualification.

Reasonable assistance may be given on a generic basis to a class or group of candidates, for example, advice on how to develop a project plan. It may also be given to candidates on an individual basis. When reasonable assistance is given on a one-to-one basis in the context of something the candidate has already produced or demonstrated, there is a danger that it becomes support for assessment and assessors need to be aware that this may be going beyond reasonable assistance.

Clarification may be sought by candidates regarding the wording of a brief or specification or instructions for the assessment if they find them unclear. In this case, the clarification should normally be given to the whole class.

Some guidance may be provided during the analysis and design stages, but the candidate should work independently throughout the implementation, testing and evaluation stages.

Assessor input and advice on the candidate's analysis and design is acceptable in order to allow the candidate to progress to the next stages of the assessment. The assistance provided must be recorded so that the candidate's own analysis and design work can be marked/judged fairly.

As this assignment is a summative assessment, support and guidance during implementation, testing and evaluation stages should be limited to minimal prompts and questioning, referring the candidate to the instructions provided in the assessment task.

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

Extract from draft marking instructions

Assessors should allocate a mark out of 10 for each of the six subsections, by applying the instructions given below to the evidence gathered, and record this mark on the candidate assessment record, **with a comment justifying why each mark was awarded.**

For each of the sections, the assessor should select the band descriptor which most closely describes the evidence gathered.

Once the best fit has been selected, follow this guidance:

- if the evidence almost matches the level above, the highest available mark from the range should be awarded
- if the candidate's work just meets the standard described, the lowest mark from the range should be awarded
- otherwise the mark from the middle of the range should be awarded

Band descriptors for section 1:
Analysing the problem: system specification, system and sub-system diagrams

Complete and detailed specification, system and sub-system diagrams, showing all inputs, processes and outputs, and interactions between sub-systems, **and including numeric values where appropriate,** produced by the candidate working independently.	9-10
Partially complete specification and system and sub-system diagrams, showing most inputs, processes and outputs, produced by the candidate working independently.	6-8
Incomplete specification and system/sub-system diagrams, omitting several significant inputs, processes or outputs, produced by the candidate working independently; or, completed, but requiring significant advice and guidance	3-5
Incomplete, despite significant advice and guidance	0-2

Band descriptors for section 4:
Testing the solution

Test plan is logical and thorough, **covers all sub-systems**, and is well justified; all faults in control sub-system and one other sub-system diagnosed independently, and all required adjustments carried out, working safely and independently	9-10
Test plan partially developed, **covering some sub-systems**, with some justification; most faults diagnosed independently, and most required adjustments carried out, working safely and independently	6-8
Poor test plan, incomplete testing, incomplete fault diagnosis and/or adjustments, working safely and independently	3-5
No test plan (tests carried out, but without planning); or requiring supervision to ensure safe working	0-2