SQA Advanced Unit Specification

General information for centres

Unit title: Engineering Systems Analysis: System Modelling and Control

Unit code: HV5E 48

Unit purpose: This unit has been designed to allow candidates to develop their knowledge, understanding and skills of modelling engineering systems using an appropriate software modelling package. Candidates will also learn how to use the software models developed to investigate what impact changes in inputs and changes in system parameters have on closed-loop output responses. They will further learn how to insert a three term controller into an engineering system's model and tune the controller to allow the system's closed-loop response to meet specified conditions.

On completion of the unit the candidate should be able to:

1 model engineering systems using appropriate software
2 evaluate the response of a system to changes in input signals and changes in system parameters
3 tune a three term controller for a single loop system

Credit points and level: 1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

Recommended prior knowledge and skills: Candidates should be familiar with block diagram representation of engineering systems, with the concept of a system step response and with the need for controllers to be used to modify a system response to allow a given specification to be met. This knowledge and understanding may be evidenced by possession of the following SQA Advanced Units: HV44 47 *Principles of Engineering Systems*; HV42 47 *Engineering Communication* and HV43 47 *Engineering Measurement and System Monitoring*.

Core Skills: There are opportunities to develop the following core skill component in this unit, although there is no automatic certification of core skills or core skills components:

Using Information Technology	SCQF level 6
Critical Thinking	SCQF level 6

Context for delivery: If this unit is delivered as part of a group award, it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes.

Assessment: The recommended assessment strategy for this unit is as follows:

Outcomes 1 and 2 — a combined software simulation exercise lasting no more than two hours.

Outcome 3 — software simulation exercise undertaken in the candidates own time.

The combined assessment for Outcomes 1 and 2 should be conducted under controlled, supervised and open-book conditions. In both assessment exercises candidates should be able to access software manuals, online help facilities and other appropriate support materials.

SQA Advanced Unit Specification: statement of standards

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Unit code: HV5E 48

The sections of the unit stating the outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Model engineering systems using appropriate software

Knowledge and/or skills

- System elements and their transfer functions
- System model
- Verification

Outcome 2

Evaluate the response of a system to changes in input signals and changes in system parameters

Knowledge and/or skills

- Input signals
- System parameters

Evidence requirements

All knowledge and/or skills items should be assessed.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by the candidate showing she/he is able to:

Outcome 1

- identify typical systems elements and their transfer functions used in electromechanical and process systems
- represent a model of an engineering system using system elements
- simulate an engineering system's response using appropriate software package
- for the system modelled, produce an output time response for a given step input to test the validity of the model
- for the system modelled, produce a frequency response to test the validity of the model

Outcome 2

Evaluate system output response for step and ramp input signals in terms of the following:

- classification of response:
  - underdamped
  - critically damped
  - overdamped

- measures of response:
  - time-to-settle
  - offset/steady-state error
  - time-to-peak
  - percentage overshoot

Evaluate system response to the following changes in system parameters:

- element gain
- element time constant

The assessment for Outcomes 1 and 2 should be combined together in the form of a software simulation exercise lasting no more than 2 hours and conducted under controlled, supervised conditions. The assessment should be conducted under open-book conditions in which candidates should be able to access software manuals, online help facilities and other appropriate support materials. Candidate evidence should be in the form of computer print outs along with appropriate comments.

Assessment guidelines

Typical system elements may include but not be limited to the following:

- Spring/mass/damper
- R-L-C
- Actuators
- Transducers

Typical engineering systems may include, but not be limited to:

- position
- speed
- flow
- temperature
- pressure
- level

While the assessment for these outcomes require the modelling of only one system centres are strongly recommended to allow candidates to model a number of engineering systems so that they can gain experience and confidence in the software modelling of engineering systems. Centres may wish to develop an appropriate checklist to confirm candidates have satisfied the evidence requirements above.

Outcome 3

Tune a three term controller for a single loop system

Knowledge and/or skills

- Empirical tuning methods

Evidence requirements

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by the candidate showing she/he is able to:

- insert a three term controller into the software-based engineering system model and tune the controller using the Ziegler–Nichols Open-Loop method and the Ziegler–Nichols Closed-Loop method so that the system's closed-loop response meets a set of specified conditions

The assessment of Outcome 3 should be in the form of a software simulation exercise done in the candidate's own time. Candidates should be able to access software manuals, online help facilities and other appropriate support materials. Candidate evidence should be in the form of computer printouts along with appropriate comments.

Centres should make every reasonable effort to ensure the assignment solution is the candidate's own work. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter. A checklist should be used to record oral evidence of the candidate's knowledge and understanding.

Assessment guidelines

Centres may find it advantageous to use the same engineering system as used in the combined assessment of Outcomes 1 and 2 in the assessment for Outcome 3 so that candidates experience a continuity of learning from initial systems modelling to the tuning of controllers. Centres may wish to develop an appropriate checklist to confirm candidates have satisfied the evidence requirements above.

Administrative information

Unit code: HV5E 48

Unit title: Engineering Systems Analysis: System Modelling and Control

Superclass category: VF

Original date of publication: November 2017

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

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SQA Advanced Unit Specification: support notes

Unit title: Engineering Systems Analysis: System Modelling and Control

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this unit

This one-credit unit is a mandatory unit within the SQA Advanced Diploma in Engineering Systems. The unit has been designed to take a non-mathematical, software based approach to the modelling of engineering systems. This approach allows candidates to investigate the effects of changes in input and changes in system parameters on overall system output responses without the need for a heavy mathematical approach. This non-mathematical approach is also used when candidates use the software engineering systems models to insert and tune a three term controller.

In designing this unit, the unit writer has identified the range of topics expected to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each outcome. This has been done to help lecturers decide what depth of treatment should be given to the topics attached to each of the outcomes. While it is not mandatory for centres to use this list of topics it is strongly recommended that they do so to ensure continuity of teaching and learning, and because the assessment exemplar pack for this unit is based on the knowledge and/or skills and list of topics in each of the outcomes.

A list of topics is given below. Lecturers are advised to study this list of topics in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this unit.

1 Model engineering systems using appropriate software (20 hours)

In this first outcome engineering system modelling approaches should be explored. One approach could commence by developing the output/input relationships for a range of system elements (eg mass, spring, damper, resistor, capacitor and inductor) using mechanical and electrical principles. The equations developed for the output/input relationships could be converted into transfer functions using the Laplace operator in preparation for software modelling exercises. However, it is advised that no attempt should be made to solve equations in the s-domain using Laplace tables.

The principle of superposition should also be introduced in preparation for the modelling of overall engineering systems from individual elements. Candidates should also be introduced to the differences between time and frequency domain responses.

It can readily be shown that the general behaviour of different elements is similar, regardless of the nature of the element. Individual elements are generally first order, with combinations of elements producing higher order systems. It should be explained to candidates how first and second order systems can be represented in appropriate simulation software. Lecturers should then go on to demonstrate the way in which the output response of a full-scale engineering system can be generated using such simulation software in which various system elements form the basic building blocks of the engineering system.

It can be explained, and demonstrated, that in higher order systems it may be possible for some elements to have negligible effect on the overall system response.

2 Evaluate the response of a system to changes in input signals and changes in system parameters (12 hours)

In this outcome changes in the output response of an engineering system to changes in input signal and changes in system parameters should be investigated using appropriate simulation software. System parameters should be limited to changes in element gains and time constants.

3 Tune a three term controller for single loop system (8 hours)

In this outcome candidates should insert a three term controller into an engineering system and tune the controller to modify system output performance to meet specified conditions.

Guidance on the delivery and assessment of this unit

Centres will require to possess appropriate simulation and modelling software to deliver this unit. Candidates should be provided with sufficient opportunities to become familiar with the use of this software. They should be able to access software manuals, online help facilities and other appropriate support materials while using the software.

This unit may be delivered by a combination of lecturing, software simulation demonstrations and software simulation modelling exercises.

Formative assessment exercises will play a particularly important role in building candidates' knowledge, skills and confidence before they tackle summative assessment exercises

Details on the approaches to assessment are given under Evidence requirements and Assessment guidelines after Outcomes 2 and 3 in the SQA Advanced Unit Specification: statement of standards section. It is recommended that these sections be read carefully before proceeding with assessment of candidates.

Opportunities for developing core skills

During the delivery of this unit candidates will have opportunities to enhance their Information Technology core skills by using the various features of the simulation and modelling software package.

Candidates will have opportunities to develop their Critical Thinking skills while analysing changes in the behaviour of engineering systems due to changes in inputs, system parameters and the introduction of the three term controllers using the simulation and modelling software.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of online delivery and/or support. However, with regards to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence.

For information on normal open leaning arrangements, please refer to the SQA guide *Assessment and Quality Assurance of Open and Distance Learning (SQA 2000).*

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

General information for candidates

Unit title: Engineering Systems Analysis: System Modelling and Control

Formerly engineering systems would normally have been modelled using sophisticated mathematical techniques. However, with the introduction of modern computer simulation software it is now possible to model very precisely the behaviour of engineering systems using such software.

In this unit you will learn how to use computer simulation software to model complex engineering systems. You will also explore what happens to the outputs of such engineering systems when the inputs or parameters within the system are changed.

In the unit you will also consider the influence of control actions on engineering systems. For example, you will insert a three term controller into an engineering system with a view to ensuring that the system's closed-loop response meets a set of specified conditions.

Unit delivery will be principally by a combination of lecturing, software simulation modelling demonstrations and software simulation modelling exercises.

Formal assessment in the unit will comprise of two software simulation modelling exercises. The first exercise will last two hours and be conducted under controlled, supervised conditions. The second assessment exercise will be done in your own time. You will be able to access software manuals, online help facilities and other appropriate support materials in both exercises.