## SQA Advanced Unit Specification

## General information for centres

**Unit title:** Engineering Systems Analysis: Non-Linearities and Control Strategies

**Unit code:** HV5F 48

**Unit purpose:** This unit has been designed to allow candidates to enhance their knowledge, understanding and skills of modelling engineering systems using an appropriate software modelling package. In addition candidates will learn how to use software models to explore the effects of non-linearities on system responses. Candidates will also be introduced to different control strategies used in engineering systems and will demonstrate appropriate control actions to minimise interaction and control multi-loop systems.

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

1 evaluate the effects of non-linearities on system responses
2 explain different control strategies used in control systems
3 demonstrate control actions for both interactive and multi-loop systems

**Credit points and level:** 1 SQA Credit(s) 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 use of controllers to modify a system response to allow a given specification to be met. Candidates should also be able to model engineering systems using appropriate modelling software. This may be evidenced by possession of the following SQA Advanced Units: HV44 47 *Principles of Engineering Systems*; HV42 47 *Engineering Communication*, HV43 47 *Engineering Measurement and System Monitoring*, and HV5F 48 *Engineering Systems Analysis: System Modelling and Control*.

**Core skills:** There are opportunities to develop the following core skills 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:

Outcome 1 — software simulation exercise lasting one hour.

Outcome 2 — assessment paper taken under controlled, supervised, closed-book conditions lasting 1 hour.

Outcome 3 — software simulation exercise undertaken in the candidate's own time.

The software simulation exercises for Outcome 1 should be conducted under controlled, supervised, open-book conditions. With regard to both simulation exercises candidates should be able to access software manuals, online help facilities and other appropriate support materials.

# SQA Advanced Unit Specification: statement of standards

## Unit title: Engineering Systems Analysis: Non-Linearities and Control Strategies

## Unit code: HV5F 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

Evaluate the effects of non-linearities on system responses

### Knowledge and/or skills

- Transfer lag
- Hysteresis
- Saturation

### 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 can:

Evaluate separately the effects of the following non-linearities within any single element on the overall engineering system's output response:

- Transfer lag
- Hysteresis
- Saturation

The assessment of Outcome 1 should be in the form of a software simulation exercise lasting one hour 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

Centres may find it advantageous to use the same engineering system as used in the assessment of Outcomes 1 and 2 of the Unit, HV5F 48 *Engineering Systems Analysis: System Modelling and Control* so that candidates can easily compare the influence of introducing non-linear effects on system responses. Centres may wish to develop an appropriate checklist to confirm candidates have satisfied the evidence requirements above.

## Outcome 2

Explain different control strategies used in control systems

### Knowledge and/or skills

- Three term control
- Gain scheduling
- Adaptive
- Predictive

### 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:

- explain the need for and the key characteristics of the following control methods:
  - three term control
  - gain scheduling
  - adaptive
  - predictive

The assessment of Outcome 2 should be in the form of an assessment paper lasting one hour and conducted under controlled, supervised conditions. The assessment should be conducted under closed-book conditions in which candidates should not be able to bring any notes, textbooks or handouts into the assessment event.

### Assessment guidelines

The assessment paper could be composed of restricted-response questions.

## Outcome 3

Demonstrate control actions for both interactive and multi-loop systems

### Knowledge and/or skills

- Gain alterations only (interactive systems only)
- Cascade control (multi-loop system)
- Feedforward control (multi-loop system)

### 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 that she/he is able to:

- demonstrate, using modelling software, minimising interaction by the use of gain alterations
- demonstrate, using modelling software, how system output response improves with the use of cascade control

- demonstrate, using modelling software, how system output response improves with the use of feed forward control

The assessment of Outcome 3 should be in the form of a software simulation exercise done in the candidates 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 print outs 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 wish to develop an appropriate checklist to confirm candidates have satisfied the evidence requirements above.

## Administrative information

**Unit code:** HV5F 48

**Unit title:** Engineering Systems Analysis: Non-Linearities and Control Strategies

**Superclass category:** VF

**Original date of publication:**

**Version:** 01

**History of changes:**

| Version | Description of change | Date |
|---|---|---|
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**Source:** SQA



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# SQA Advanced Unit Specification: support notes

## Unit title: Engineering Systems Analysis: Non-Linearities and Control Strategies

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 an optional 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 non-linear effects on system output responses without the need for a heavy mathematical treatment. Candidates can also demonstrate control actions for both interactive and multi-loop systems using such software modelling techniques.

This unit identifies the range of topics expected to be covered by lecturers. There are also 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.

**1 Evaluate the effects of non-linearities on system responses (15 hours)**

'Real' systems include non-linearities, which tend to destabilise a system. The following three types of non-linearity should be studied in this outcome: transfer lag; hysteresis and saturation.

Each non-linearity should be introduced into the software model separately and its effect on overall system output response evaluated.

**2 Explain different control strategies used in control systems (10 hours)**

In this outcome candidates should investigate the need for and the key features of the following control strategies: three term control (P+I+D), gain scheduling, adaptive and predictive.

**3 Demonstrate control actions for both interactive and multi-loop systems (15 hours)**

Many industrial systems are multi-loop and these loops can be interactive (in that altering one setpoint may cause more than one output to vary). In this outcome candidates should investigate, using appropriate simulation software, gain alteration techniques for reducing interaction. Candidates should also examine multi-loop systems where there are large differences in the time-constants between major and minor loops in a system and the means of providing satisfactory control of such systems.

## 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 1, 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 investigating the effects of non-linearities on system responses and when demonstrating control actions on interactive and multi-loop systems.

## 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.

Arrangements would be required to be put in place to ensure that the assessment paper for Outcome 2 was conducted under controlled, supervised conditions. Likewise centres would require to ensure that the summative software simulation modelling exercise for Outcome 1 was conducted under controlled, supervised conditions.

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: Non-Linearities and Control Strategies

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. Most practical engineering systems have elements that have non-linear characteristics. You will examine what happens to system responses when such effects are introduced into a system. You will also consider the influence of control actions on engineering systems, and examine a range of strategies to control complex engineering systems For example, you will consider control actions that minimise interaction and control actions in multi-loop engineering systems.

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 one assessment paper lasting one hour and conducted under controlled, supervised conditions and two software simulation modelling exercises one, lasting one hour, and conducted under controlled, supervised conditions and the other done in your own time. You will be able to access software manuals, online help facilities and other appropriate support materials while undertaking the two software simulation modelling exercises.