SQA Advanced Unit Specification

General information for centres

Unit title: Engineering Measurement and System Monitoring

Unit code: HV43 47

Unit purpose: This Unit has been designed to introduce candidates to the measurement of electrical and mechanical quantities. Candidates will also be provided with opportunities to develop a knowledge and understanding of the principles of operation and applications of a range of electrical and mechanical transducers. They will also have opportunities to learn about typical responses produced by engineering systems subject to step external disturbances and the actions required to be taken to restore normal system operation following a disturbance.

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

1 Verify by measurement a range of electrical and mechanical quantities.
2 Explain the principle of operation and application of sensors/transducers used in engineering systems.
3 Analyse engineering system responses and corrective actions required to allow an engineering system to operate within its normal range.

Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*).

**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: It is recommended that candidates have a knowledge and understanding of physics and/or technological studies and mathematical concepts and theorems. This may be evidenced by possession of a Higher in Physics and/or Technological Studies and/or Mechatronics and a National Certificate Unit in Core Mathematics 4 or SCE Standard Grade Mathematics at 1 or 2, or an equivalent level of experience.

Core Skills: There may be opportunities to gather evidence towards the following listed Core Skill components in this Unit, although there is no automatic certification of Core Skills or Core Skill components.

Written Communication	SCQF level 6
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 assessment strategy for this Unit is as follows:

Outcome 1 should be assessed by candidates undertaking an assignment in which they take and record measurements of engineering quantities and produce a single short report which contains details of the instruments used for measurements, the calculated and recorded measurements, a comparison of the calculated and recorded measurement and identification of sources of error. The taking and recording of measurements should be done under supervised, controlled conditions.

Outcome 2 should be assessed by candidates producing a report in which they describe the principles of operation and applications of two electrical transducers and one mechanical transducer. The report should also include details of the procedures used to calibrate one electrical and one mechanical transducer.

Outcome 3 should be assessed by candidates undertaking an assignment involving practical work and/or computer simulation on a mechanical and an equivalent electrical system and preparing a report. This practical work/computer simulation should be conducted under controlled, supervised conditions.

Candidates should write up their reports in their own time. Centres should make every reasonable effort to ensure that reports are candidates' 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.

To consolidate knowledge and understanding of engineering systems approaches it is recommended that centres use the same engineering systems, or sub-systems, as are used in the *Principles of Engineering Systems* and *Engineering Communication* units.

SQA Advanced Unit specification: statement of standards

Unit title: Engineering Measurement and System Monitoring

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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

Verify by measurement a range of electrical and mechanical quantities

Knowledge and/or skills

Category A

- voltage
- current
- resistance
- power
- energy

Category B

- force
- pressure
- temperature
- position
- velocity
- flow
- strain
- power

Evidence Requirements

Evidence for the knowledge and /or skills items in this Outcome should be provided on a sample basis. Each candidate will need to demonstrate that she/he can provide correct responses based on a sample of the items shown under the knowledge and skills items in the Outcome. Each quantity should be measured at least once. In any assessment of Outcome 1 **four out of five** knowledge and/or skills items from Category A and **five out of eight** knowledge and/or skills items from Category B should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be assessed on, a different sample of four out of five knowledge and/or skills items from Category A and five out of eight knowledge and/or skills items from Category B should be sampled each time the Outcome is assessed. Candidates must provide a satisfactory response to all sampled items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to calculate each quantity sampled and verify this by measurement. All measurements must

- be conducted in a safe and practical manner;
- be accurate within the limitations of tolerance and
- take account of sources of error

Evidence should be generated by candidates undertaking an assignment in which they take and record measurements and produce a single short report which contains details of the instruments used for measurements, the calculated and recorded measurements, a comparison of the calculated and recorded measurement and identification of sources of error. The taking and recording of measurements should be done under supervised, controlled conditions. Candidates should write up their reports in their own time.

Centres should make every reasonable effort to ensure the report 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

Candidate reports would not normally be between 750–1,000 words and may contain appropriate diagrams of instruments, instrument specifications etc. Centres may wish to provide candidates with details of how to structure their report or leave it to the candidates to structure their own report.

Outcome 2

Explain the principle of operation and application of sensors/transducers used in engineering systems

Knowledge and/or skills

- Electrical Transducers
- Mechanical Transducer
- Accuracy and resolution
- Calibration Techniques
- Application of feedback

Evidence Requirements

All knowledge and/or skills items in this Outcome should be assessed.

Candidates will need to provide evidence to demonstrate their knowledge and/or skills by explaining the principle of operation and applications of:

- two principal electrical transducer types
- one principal mechanical transducer type

Candidates must comment on the accuracy and resolution of these transducer types.

In addition candidates will need to demonstrate an ability to calibrate:

- one electrical transducer;
- one mechanical transducer

Evidence should be generated by candidates producing a report in which they describe the principle of operation and applications of two electrical transducers and one mechanical transducer. The report should also include details of the procedures used to calibrate one electrical and one mechanical transducer. Candidates should also comment on how the output signal from the transducer can be applied in a system via appropriate feedback. Candidates should write up their reports in their own time.

Centres should make every reasonable effort to ensure the report 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

This Outcome may provide an appropriate opportunity to introduce current standards (eg S.I. standards). The report would normally be between 750-1,000 words and contain appropriate diagrams, instrument specification etc. Centres may wish to provide candidates with details of how to structure their report or leave it to the candidate to structure their own report.

Outcome 3

Analyse engineering system responses and corrective actions required to allow an engineering system to operate within its normal range

Knowledge and/or skills

- Normal operating range
- Nature of external disturbance
- System response
- Corrective actions
- Controller actions (P, P+I, P+D and P+I+D)

Evidence Requirements

All knowledge and/or skills items in this Outcome should be assessed.

Candidates will need to provide evidence to demonstrate their knowledge and/or skills by explaining for a mechanical system and a comparable electrical system (any comparison should highlight the differences between first and second order responses):

- normal operating range of the system
- nature of system response to step
- comparison of the responses of the two systems to external disturbances
- identification of corrective actions to restore normal operating conditions

Evidence should be generated by candidates undertaking an assignment involving practical work and/or computer simulation on a mechanical and equivalent electrical system and preparing a report. This practical work and/or computer simulation should be conducted under controlled, supervised conditions. Candidates should write up the report in their own time.

Centres should make every reasonable effort to ensure the report 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 choose their own mechanical and electrical systems but examples of suitable systems are a mass, spring, damper mechanical system and a resistor, inductor, capacitor electrical system.

Centre may choose to approach this Outcome from the perspective of initially examining the response of an open loop system and then add a controller and feedback to create a closed loop system. It is recommended that if this approach is taken that centres do not simply focus on the action of the controller in restoring normal operating conditions but also consider the influence of changing parameters in the system being controlled and the influence of different external disturbances.

The report would normally be between 750-1,000 words and contain appropriate diagrams and graphs of system responses. Centres may wish to provide candidates with details of how to structure their report or leave it to the candidate to structure their own report.

Administrative Information

Unit code: HV43 47

Unit title: Engineering Measurement and System Monitoring

Superclass category: XJ

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History of changes:

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

SQA Advanced Unit specification: support notes

Unit title: Engineering Measurement and System Monitoring

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 1-credit, SCQF Level 7 Unit has been written as one of the four mandatory Principles/Technology units within the SQA Advanced Certificate in Engineering. The other three mandatory units are *Principles of Engineering Systems, Engineering Communication* and *Mathematics for Engineering 1: Mechanical and Manufacturing*. The *Principles of Engineering Systems* unit is a 2 credit SQA Advanced unit while the *Engineering Communication* and the *Mathematics for Engineering 1: Mechanical and Manufacturing* units are 1 credit SQA Advanced units. All three units are at SCQF Level 7. It is important that all four units are seen as providing an integrated programme of study covering a systems approach to the analysis of engineering processes and systems. As such every opportunity should be sought to combine the delivery and assessment of the three units.

The emphasis in the four units should be on allowing candidates to develop knowledge and understanding of basic ideas and concepts involved in engineering systems rather than on any mathematical treatment of systems. Equal emphasis should be given to mechanical and electrical concepts, ideas and quantities.

In designing this Unit, the unit writers have identified the range of topics expected to be covered by lecturers. The writers have 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. Whilst 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 Verify by measurement a range of electrical and mechanical quantities (15 hours)

Centres may wish to deliver this Outcome in tandem with Outcomes 2 and 3 in the Principles of Engineering Systems: describing the mechanical and electrical quantities to be measured first and then allowing candidates to undertake measurements.

2 Explain the principle of operation and application of sensors/transducers used in engineering systems (15 hours)

Electrical transducers could include:

- hall effect probe
- light Emitting Diode
- linear and rotatory potentiometers

- linear variable differential transformer
- photodiode and phototransistor
- piezoelectric crystal
- strain gauge (including bridge circuit)
- thermocouple
- thermistor

Mechanical transducer could include:

- bourdon tube
- diaphragm
- pitot tube
- manometer
- proximity switch

Principles of operation and applications should be related directly to the quantities the transducer is able to measure. Candidates should also be provided with details of each transducer's performance characteristics in terms of such factors as size, cost, input/output range (including signal conditioning requirements), accuracy, resolution, response time, linearity and hysteresis.

Candidates should be introduced to the factors involved in calibrating transducers and the correct procedures to perform calibration.

Candidates should also be introduced to the role transducers play in providing feedback in closed loop control systems.

3 Analyse engineering system responses and corrective actions required to allow an engineering system to operate within its normal range (10 hours)

The delivery of this Outcome could be linked in with the delivery of Outcome 8 in the Principles of Engineering Systems units (eg teach Outcome 8 first and follow up with the practical work in this Outcome). During the delivery of this Outcome candidates should be made aware that while mechanical and electrical systems are physically different and operate in quite different ways there response to external stimuli are very similar. Candidates should also explore the natural responses of electrical and mechanical systems (eg resonance in an electrical system compared with critical frequencies in a vibrating mechanical system).

Guidance on the delivery and assessment of this Unit

This Unit may be delivered by a combination of lecturing, group work, investigation (including the use of the Internet), practical investigation and computer simulation.

It is important that emphasis throughout the Unit is placed on a systems approach to engineering processes and systems with equal weighting being given to mechanical and electrical engineering concepts, ideas and quantities.

Furthermore, every opportunity should be used during the delivery of the Unit to compare mechanical and electrical concepts, ideas and quantities with a view to identifying similarities between the concepts, ideas and quantities.

The Internet contains a rich and varied source of information about transducers and candidates should be encouraged to use this source of information to find out more about transducers. The use of the Internet for this purpose will also help to develop candidates search skills which is a very important part of the Using Information Technology Core Skill.

Centres are encouraged to make use of computer simulation software to represent the responses of mechanical and electrical systems in Outcome 3. The use of this software will also help to develop candidates Using Information Technology Core Skill.

Candidates will have opportunities to develop their written communication skills through the preparation of assignment reports. Critical thinking skills should be developed through the analysis of measured and calculated results and identification of sources of error in Outcome 1, the investigation of transducer operation and applications in Outcome 2 and the analysis and comparison of mechanical and electrical system responses in Outcome 3.

Details on the approaches to assessment are given under Evidence requirements and Assessment guidelines under each Outcome 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. Given the range of assessment in this Unit it is strongly recommended that candidates are provided with clear details about assessment at the beginning of the Unit (eg submission dates for assignments).

Opportunities for developing Core Skills

There may be opportunities to gather evidence towards the following listed Core Skill components in this Unit, although there is no automatic certification of Core Skills or Core Skill components.

Written Communication	SCQF level 6
Using Information Technology	SCQF level 6
Critical Thinking	SCQF level 6

Open learning

Outcomes 1 and 3 involve practical laboratory work and high levels of tutor/candidate interaction and support which may limit opportunities for delivery of these outcomes by distance learning. Outcome 2 may be delivered by distance learning including on-line support apart from the calibration of transducers which is likely to involve practical laboratory work at a centre.

Where open learning is considered due regard to assessment planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence.

For information on normal open learning 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 Measurement and System Monitoring

The ability to take and record accurately engineering measurements is a very important skill for the engineering technician and incorporated engineer to develop. How an engineering system responds to external stimuli and what actions are required to bring the system back into its normally operating mode is also something that it is important for engineering technicians and incorporated engineers to understand.

In this Unit you will learn how to measure, record and interpret a range of mechanical and electrical engineering quantities. You will also learn about a range of devices that are used in engineering systems to convert one form of signal into another form of signal: namely transducers. You will also be provided with opportunities to study how different engineering systems respond to external stimuli and what corrective actions are required to get a system to work within its normal operating range.

The Unit is likely to be delivered by a combination of lecturing, group work, investigation (including the use of the Internet), practical investigation and computer simulation.

Assessment will comprise of three assignments: a practical laboratory in Outcome 1 involving the measurement of various mechanical and electrical quantities, the preparation of a report for Outcome 2 on transducers plus the calibration of an electrical and mechanical transducer and a practical investigation and/or computer simulation in Outcome 3 involving the response of a mechanical system and its corresponding electrical system to external stimuli. Both Outcomes 1 and 3 will also require a short report.