General information for centres

Unit title: Mechatronic Systems Elements

Unit code: HV46 47

Unit purpose: This Unit is designed to enable candidates to develop knowledge and understanding of a range of Mechatronic Systems.

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

1   Analyse a range of mechatronic systems
2   Describe the characteristics of typical output responses to a step change input to open loop and closed loop control systems
3   Describe the operation of a range of controllers used in mechatronic systems
4   Determine the appropriate Analogue to Digital and Digital to Analogue interfacing requirements for a particular mechatronic system.
5   Analyse calibration results of transducers and actuators for mechatronic systems.

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 would be an advantage for candidates to have a basic knowledge and understanding of the design and operation of mechanical mechanisms, electronic circuits and computer programming for engineering systems. However entry requirements are at the discretion of the centre.

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 Skills components.

Problem Solving   SCQF level 6
Numeracy   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: This Unit lends itself to holistic assessment. The assessment for Outcomes 1, 2, 3, 4 and 5 could be combined together into one assessment paper. This paper should be taken by candidates at a single assessment event that should last 2 hours. Assessment should be conducted under closed booked controlled, supervised conditions.

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.

SQA Advanced Unit specification: statement of standards

Unit title: Mechatronic Systems Elements

Unit code: HV46 47

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

Analyse a range of mechatronic systems.

Knowledge and/or skills

- Block Diagrams
- System Elements
- Process Parameters
- System Function

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **three out of four** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of three from four knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

Where sampling takes place, a candidate's response can be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:-

- Produce a block diagram of two mechatronic systems
- Describe the function of the system elements in a mechatronic system with the aid of a block diagram
- Determine the process parameters of a particular mechatronic system
- Describe the mechatronic system's function

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and/or structured questions.

The assessment of this Outcome should be combined with that for Outcome 2, 3, 4 and 5 to form a single assessment paper, details of which are given under Outcome 5.

Outcome 2

Describe the characteristics of typical output responses to a step change input to open loop and closed loop control systems.

Knowledge and/or skills

◆ Open loop response
◆ Closed loop response

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly on **all** knowledge and/or skills items.

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

Describe with the aid of diagrams a typical output response to a step change:

◆ in an open loop system (1st order system)
◆ in a closed loop system (2nd order system)

For the above open and closed loop systems, the aspects of system response that should be covered are:

◆ Set point (desired value, reference point)
◆ Steady state error (offset)
◆ Settling time
◆ Setting zone
◆ Gain
◆ Peak overshoot
◆ Underdamped, overdamped and critically damped
◆ Rise time
◆ Steady state and transient state
◆ Hunting
◆ Stable and unstable

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and/or structured questions.

The assessment of this Outcome should be combined with that for Outcome 1, 3, 4 and 5 to form a single assessment paper, details of which are given under Outcome 5.

Outcome 3

Describe the operation of a range of controllers used in mechatronic systems.

Knowledge and/or skills

- Programmable Logic Controllers
- Microcontrollers
- Personal Computers

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **two out of three** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of two from three knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all two items.

Where sampling takes place, a candidate's response can be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to: -

- Describe the features of a programmable logic controller in mechatronic systems and give a typical application
- Describe the features of a microcontroller in mechatronic systems and give a typical application
- Describe the features of a personal computer in mechatronic systems and give a typical application

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and/or structured questions.

The assessment of this Outcome should be combined with that for Outcome 1, 2, 4 and 5 to form a single assessment paper, details of which are given under Outcome 5.

Outcome 4

Determine the appropriate Analogue to Digital and Digital to Analogue interfacing requirements for a particular mechatronic system.

Knowledge and/or skills

- Analogue to Digital
- Digital to Analogue
- Signal conditioning

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **two out of three** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of two from three knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all two items.

Where sampling takes place, a candidate's response can be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to: -

For Analogue to Digital interfacing
- Select suitable input interface cards (Analogue to Digital) for two transducers connected to a system using standardised signal

For Digital to Analogue interfacing
- Select suitable Output interface cards (Digital to Analogue) for two actuators connected to a system using standardised signal.

For Signal conditioning answer one from three of the following evidence questions
- Describe the effects of aliasing (Shannon's Theorem) on digital process signals
- Describe signal conditioning necessary to convert from analogue to digital and also signal improvements
- Describe signal conditioning necessary to convert from digital to analogue and also signal improvements

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and/or structured questions.

The assessment of this Outcome should be combined with that for Outcome 1, 2, 3 and 5 to form a single assessment paper, details of which are given under Outcome 5.

Outcome 5

Analyse calibration results of transducers and actuators for mechatronic systems.

Knowledge and/or skills

◆   Transducers Calibration
◆   Actuators Calibration

Evidence Requirements

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **one out of two** knowledge and/or skills items should be sampled.

Where sampling takes place, a candidate's response can be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

◆   Evaluate the types and magnitude of major errors from the results of a transducer calibration (span, zero, linearity and hysteresis)
◆   Evaluate the types and magnitude of major errors from the results of an actuator calibration (span, zero, linearity and hysteresis)

Assessment guidelines

The assessment of this Outcome should be combined with that of Outcome 1, 2, 3 and 4 to form one assessment paper for the Unit. This single assessment paper should be taken at a single assessment event lasting two hours and carried out under closed book controlled, supervised conditions. Such a paper should compose of an appropriate balance of short answer, restricted response and structured questions.

Administrative Information

Unit code: HV46 47

Unit title: Mechatronic Systems Elements

Superclass category: XL

Date of publication: November 2017

Version: 01

Source: SQA

SQA Advanced Unit specification: support notes

Unit title: Mechatronic Systems Elements

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

The purpose of this Unit is to provide candidates with an opportunity to acquire knowledge and understanding of a variety of Mechatronic Systems.

Allocated delivery times are for guidance purposes only.

Outcome 1 (8 hours) – The aim of this Outcome is to analyse a range of mechatronic systems in terms of Block diagrams, System Elements, Process Parameters and the Overall System Function. The Outcome commences with the production of block diagrams of a range of Mechatronic systems. (it is expected at least five systems are covered during delivery of this Unit). Each block represents system elements with a particular function (eg control, input, output or signal conditioning). The individual system elements are identified and described with regard to their function in the mechatronic system. The overall process parameters of mechatronic systems are determined. Process parameters will vary depending upon function of the system and the system range, maximum and minimum process variables this could be pressure, temperature, flow, voltage current, heat, PH value or any other process variable that requires to be controlled within limits. The overall function of a mechatronic system is then analysed in term of its operation and process variables and the function it carries out in a system or process. (Note: mechatronic systems are produced for industrial, commercial or household systems.)

Outcome 2 (4 hours) – The aim of this Outcome is to develop knowledge and understanding of the characteristics of a typical output response to a step change on open loop and closed loop control systems

Typical output responses to a step change are to be examined:

◆   in an open loop system (1st order system)
◆   in a closed loop system (2nd order system)

Use of a control system or simulated software would benefit the understanding of output responses by comparing for a system:

◆   Set point (desired value, reference point)
◆   Steady state error (offset)
◆   Settling time
◆   Setting zone
◆   Gain
◆   Peak overshoot
◆   Underdamped, overdamped and critically damped
◆   Rise time
◆   Steady state and transient state
◆   Hunting
◆   Stable and unstable

SQA Advanced Unit Specification

System responses that are to be considered are open and closed loop responses to a step input change to show the difference between open and closed loop responses.

The need for continuous control is discussed, although continuous control is examined using proportional action only.

It is not intended to cover the topic of the PID control algorithm in this Unit; it will be covered in the SQA Advanced Unit *Mechatronic Systems*.

Outcome 3 (4 hours) – controller features of controllers used in mechatronic systems are compared and typical applications are outlined. Controllers included Programmable Logic Controllers, microcontrollers and personal computers.

The features of a controller in mechatronic systems that are to be covered include methods of programming, ease of programming, size of memory, input and output capabilities, programme functions (timers, counters and logic) that can be performed, operating environmental considerations, physical size and weight.

The above factors can be taken into account when selecting suitable controllers for particular applications

Outcome 4 (10 hours) – The appropriate Analogue to Digital and Digital to Analogue interfacing requirements for a particular mechatronic system are to be determined along with the appropriate signal conditioning.

The need for standardised signals should be covered including live zero and true zero signals live zero and true zero.

Live zero signals (4 to 20mA, 1- 5Volts, 0.2 to 1.0 bar)
True zero signals (0- 20mA, 0- 5Volts, 0-10V)

Other signalling methods and signal conditioning should include band-pass filters, amplifiers, signal converters (I/P, P/I, E/I, I/E), RS485, RS232 and fibre optics, USB, parallel and serial ports and ongoing improvements in signal conditioning.

Analogue to Digital interfacing should cover the selection of suitable input interface cards for transducers connected to a system using standardised signals.

Digital to Analogue interfacing should cover the selection of suitable output interface cards for actuators connected to a system using standardised signals.

The effects of aliasing on digital process signals should be covered and Shannon's Theorem discussed in terms of method of resolving alias problems.

Outcome 5 (10 hours) – The calibration process for a range of variable transducers and actuators should be covered and evaluated in terms of the types and magnitude of major errors from a transducer calibration results (span, zero, linearity and hysteresis).

Calibration processes can be a process of:

a   Taking reading and adjusting a transducer or actuator (eg a Bourdon tube pressure or temperature device) or

b   Taking reading and accepting or rejecting the transducer or actuator as fit for purpose. This is where there is no adjustment possible eg a resistance temperature detector (RTD)

Minimisation of the major errors and recalibration should be discussed along with the fundamental interval (0˚C to 100˚C) and fixed points of reference (melting points of pure metals).

Guidance on the delivery and assessment of this Unit

This Unit should be delivered by a combination of lecturing to a whole class and group discussions. In order to make the subject as interesting as possible centres are encouraged to carry out formative practical assignments on mechatronic systems and system elements, and also use practical examples, manufacturers' data sheets and videos. Candidates should also be encouraged to explore the Internet for information on mechatronic systems and system elements.

Information on Evidence requirements and Assessment guidelines is given after Outcomes 5 in the SQA Advanced Unit specification: statement of standards section. The written assessment should take place after completion of all Outcomes of this Unit.

An assessment exemplar will be available for this unit.

Opportunities for developing Core Skills

Elements of the Core Skill of Problem Solving, that is, critical thinking, reviewing and evaluating, will be developed and enhanced in the Unit, which requires an examination of the application of theoretical knowledge to a practical task. Candidates are assessed on their ability to determine the appropriate Analogue to Digital and Digital to Analogue interfacing requirements for a particular mechatronic system. In formative work they should be encouraged to identify and examine the relevance of all factors in various stages of a process and to develop critical and creative thinking on all aspects of mechatronic systems and applications.

During formative work group discussion of the significance of calibration results of transducers and actuators for mechatronic systems may support analytical approaches although candidates should be independently able to identify and evaluate the types and magnitude of major errors. Individual discussions with the assessor to reinforce analytical evaluation could enhance problem solving skills.

Accuracy and confidence in interpreting and applying complex numerical and graphic information underpins the competencies developed in the unit. Candidates could be provided with ongoing support to enhance skills in the interpretation and presentation of data in practical contexts. The emphasis of formative work should be on Numeracy as a tool to be used and applied efficiently and critically in design solutions. Access to technology and appropriate software packages could provide useful support.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of online 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 assessment, whether done at a single or multiple events, was conducted under controlled, supervised conditions.

For information on normal open learning arrangements, please refer to the SQA guide *Assessment and Quality 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: Mechatronic Systems Elements

This Unit has been designed to allow you to develop knowledge and understanding of a variety of mechatronic systems and their system elements.

The functions of the system elements are examined along with the function of the overall mechatronic system and process parameters are determined or stated.

The Unit will also provide you with an opportunity to examine typical output responses to a step change input to open loop and closed loop control systems. This will cover the aspects of set point, steady state error, settling time, setting zone, gain, overshoot damping, rise time, steady state and transient state.

This Unit also provides you with an opportunity to develop knowledge and understanding of controllers used to achieve control of mechatronic systems.

You will study the Analogue to Digital and Digital to Analogue interfacing requirements for mechatronic systems along with the appropriate signal conditioning, the need for standardised signals and the effects of aliasing. Other signalling methods and signal conditioning will be covered including band-pass filters, amplifiers, signal converters, fibre optics, USB, parallel and serial ports and ongoing improvements in signal conditioning.

The calibration of transducers and actuators to minimise the major errors is carried out and the results are analysed to determine whether the transducer or actuator is within tolerance.

The formal assessments for this Unit consist of a single assessment paper covering all Outcomes lasting 2 hours. The assessment paper for all Outcomes will be conducted under closed book conditions, which you will not be allowed to take notes, textbooks etc. into the assessment. However you will be allowed to use a scientific calculator. You will sit this assessment paper at the end of the Unit.