SQA Advanced Unit Specification

General information for centres

Unit title: Mechatronic Systems

Unit code: HV3J 48

Unit purpose: This Unit is designed to further develop the candidates' knowledge and understanding of mechatronic systems. The Unit also provides candidates with the opportunity to programme mechatronic systems and perform a research on a mechatronic system.

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

1   Describe the operation and characteristics of mechanisms used in mechatronic systems
2   Describe and calculate the effects of control algorithms used in mechatronic systems.
3   Programme to operate a mechatronic system
4   Analyse, evaluate and research a mechatronic system to justify the selection of system elements.

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: It would be an advantage for candidates to have a good knowledge and understanding of the design and operation of mechanical mechanisms, electronic circuits and computer programming for engineering systems. This could be evidenced by prior achievement of the SQA Advanced Unit HV46 47 Mechatronic Systems Elements. 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
Using Information Technology	SCQF level 6
Communication	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 and 2 should be combined together into one written assessment paper. This paper should be taken by candidates at a single assessment event that should last 1 hour. The assessment should be conducted under closed booked controlled, supervised conditions.

The assessment of Outcome 3 should take the form of a practical assignment, which summarises the steps taken by the candidate to complete the knowledge and/or skills items. The time that may be allocated for the assignment is 1 hour 30 minutes in total. It is recommended that centres develop checklists to support the assessment requirements for each of the knowledge and/or skills items.

Outcome 4 is a case study of 500 words minimum and should be the culmination of the learning that takes place in Outcomes 1 to 3. It would be beneficial for it to be introduced to the students as soon as possible to encourage research as the Unit progresses. The Case Study will be open book with access to learning resource facilities, manufacturer's data and the Internet to carry out research. However, it is expected that the report will be written up in the candidates' own time

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

Unit code: HV3J 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

Describe the operation and characteristics of mechanisms used in mechatronic systems.

Knowledge and/or skills

- Gear Trains
- Four Bar Mechanisms
- Belt Drive Systems
- Chain Drive Systems
- Pawl and Ratchet Systems
- Rack and Pinion
- Pneumatic and Hydraulic actuators
- Lever Systems

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 **five out of eight** 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 five out of eight knowledge and/or skills items is required each time the Outcome is assessed.

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:-

- Calculate the input, output variables of gear train mechanisms
- Describe the operation of a four bar mechanism
- Calculate the input, output variables of belt drive systems
- Describe the operation of chain drive systems
- Describe the operation of pawl and ratchet systems
- Describe the operation of rack and pinion
- Calculate the input, output variables of pneumatic and hydraulic actuators
- Calculate the input, output variables of lever systems

Assessment guidelines

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

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

Outcome 2

Describe and calculate the effects of control algorithms used in mechatronic systems.

Knowledge and/or skills

- Control Algorithms
    - Proportional Action
    - Integral Action
    - Derivative Action
    - Two Step Control
    - Dead zone

- Control loop Tuning Methods
    - Ultimate Cycle Method
    - Process reaction Curve

Evidence Requirements

Each candidate will need to demonstrate that she/he can answer questions based on **all** knowledge and/or skills items.

In any assessment of this Outcome **all** knowledge and/or skills items should be assessed.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of the control actions and control loop tuning methods within in the two knowledge and/or skills items is required each time the Outcome is assessed.

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 the effects of three control algorithms on a Mechatronic system. (3 from 5 control algorithms below)
    - Proportional Action
    - Integral Action
    - Derivative Action
    - Action of Two Step Control
    - Dead zone setting on a controller system

♦   Calculate the PID values to optimise the control of a Mechatronic System using 1 from 2 control loop tuning methods (Using the given Ziegler and Nichols empirical formulae for P, PI and PID)
—   Ultimate Cycle Method or
—   Process Reaction Curve

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

Assessment guidelines

The assessment of this Outcome should be combined with that of Outcome 1 to form one assessment paper for the Unit. This single assessment paper should be taken at a single assessment event lasting 1 hour 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.

Outcome 3

Programme to operate a mechatronic system.

Knowledge and/or skills

♦   PLC Programming
♦   Microcontrollers Programming
♦   High Level Language Programming

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 a practical programming exercise. Each candidate will need to demonstrate that she/he can produce a programme for a given task 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** out of **three** knowledge and/or skills items is required each time the Outcome is assessed.

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: -

♦   Programme a PLC to operate a mechatronic system
♦   Programme a microcontroller to operate a mechatronic system
♦   Programme a computer with a high level language to operate a mechatronic system

For the practical assignment evidence of completed tasks must include:

♦   Correct programme printout with date of generation and student's name on it.
♦   A checklist of completed programmes that correctly perform the given tasks and signed by the assessor as completed.

Assessment guidelines

The assessment of this Outcome should take the form of a practical assignment, which summarises the steps taken by the candidate to complete the knowledge and/or skills items. The time that may be allocated for the assignment is 1 hour 30 minutes in total. It is recommended that centres develop checklists to support the assessment requirements for each of the knowledge and/or skills items.

Outcome 4

Analyse, evaluate and research a mechatronic system to justify the selection of system elements.

Knowledge and/or skills

♦   Mechatronic system case study

Evidence Requirements

Evidence for this Outcome will be provided by a candidate undertaking a case study based on **all** knowledge and skills items.

For the case study the candidates must produce a report that must include:

♦   Analysis of a given system
♦   Research on system elements
♦   Justifications of selection of system elements (quality, accuracy, precision, resolution), which may include appropriate sketches of system mechanisms and calculations.

Candidates should be supplied with a given mechatronic system. Candidates should complete written reports in their own time. It is important that candidates' progress is closely monitored to ensure the work is their own. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter

Assessment guidelines

Outcome 4 is a case study of 500 words minimum and should be the culmination of the learning that takes place in Outcomes 1 to 3. It would be beneficial if it were introduced to the students as soon as possible to encourage research as the Unit progresses. The case study will be open book with access to learning resource facilities, manufacturer's data and the Internet to carry out research. However, it is expected that the report will be written up in the candidates' own time

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.

Administrative Information

Unit code: HV3J 48

Unit title: Mechatronic Systems

Superclass category: XL

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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: Mechatronic Systems

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 mechatronic systems. The Unit also provides candidates with the opportunity to programme mechatronic systems and perform a research on a mechatronic system.

Allocated delivery times are for guidance purposes only.

Outcome 1 (8 hours) The aim of this Outcome is to analyse a range of mechanisms to develop knowledge and understanding of the operation and characteristics of mechanisms used in mechatronic systems.

Typical mechanisms to be analysed are as follows:

◆   Gear Trains
◆   Four Bar Mechanisms
◆   Belt Drive Systems
◆   Chain Drive Systems
◆   Pawl and ratchet Systems
◆   Rack and Pinion
◆   Pneumatic and hydraulic actuators
◆   Lever Systems

Learning of the operation of the mechanisms, calculations of the input to output variables and characteristics should be covered by classroom lecturer, group discussions, and use of practical apparatus to justify calculation on mechanisms.

Outcome 2 (8 hours) The aim of this Outcome is to study the effects of control algorithms used in mechatronic systems.

The Control Algorithms include Proportional Action, Integral Action, Derivative Action (P, PI and PID control) of mechatronic systems. Class lecturers and group discussions along with appropriate simulation software of control algorithms and practical control loop that the proportional band (or gain) can be adjusted to should the change in output response. Two Step Control should be studied and overlap put into two Step Control to compare the effects of Dead zone on the output response. The optimising of Control loop using the following Tuning Methods should be described and carried out using: -
◆   Ultimate Cycle Method
◆   Process reaction Curve

Calculation of the PID values to optimise the control of a Mechatronic System would be carried out using the Ziegler and Nichols empirical formulae for P, PI and PID. Optimising of practical system where available would reinforce the students' learning.

Outcome 3 (10 hours) The aim of this Outcome is to develop knowledge and skills in the programming of mechatronic systems.

The methods programming will need to be cover by class lecturer explaining programme commands. The candidate will develop their skill by initially programming controllers with pre-written programmes and discussing their operation.

As skill develops the candidates will be expected to write the programmes themselves for given systems.

The methods of programming mechatronic systems will include:
- PLC Programming
- Microcontrollers Programming
- High Level Language Programming on personal computers

A prior knowledge of programming is not expected for this Outcome as the study of programming in this Outcome is intended to develop the candidates' understanding and knowledge of a range of programming methods and controllers in mechatronic systems. It is not intended to gain a depth of knowledge of one particular method of programming.

The programmes that are to be developed by candidates should be modelled on the depth of knowledge covered in the prewritten programmes already programmed into controllers by the students in the formative learning.

The programmes should be limited to sequential control, counters and timers/delays.

It is intended that Outcome 3 will bring together the knowledge of a range of programming methods, along with the knowledge of a range of controllers used in mechatronic systems, previously covered in the SQA Advanced Unit Mechatronic Systems Elements.

Outcome 4 (10 hours) In this Outcome the candidates are each given a specification for a mechatronic system and set the task of carrying out a case study on that system.

It would be preferable that centres have access to a range of mechatronic systems available for the case study in Outcome 4 to ensure that not all of the candidates are engaged in researching the same mechatronic system. This case study could be achieved by use of simulation packages. It is acceptable of the candidate to research a mechatronic system within their industrial placement. However it is important that candidates' progress is closely monitored to ensure work is their own.

The students have to analyse, evaluate and research the mechatronic system to justify the selection of system elements (input transducers, D/A and D/A interfaces, actuators controllers and signal conditioning).

For the case study the candidates must produce a report that must includes:
- Analysis of a given system
- Research on system elements
- Justifications of selection of system elements (quality, accuracy, precision, resolution), which may include appropriate sketches of system mechanisms and calculations.

The use of manufacturers' manuals the Internet and other sources of information to select system elements in line with the requirements of the given system will need to be made available.

Candidates should complete written reports in their own time. It is important that candidates' progress is closely monitored to ensure work is their own.

Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter

Candidates should be supplied with the required report format. Candidates should complete written reports in their own time. It is important that candidates' progress is closely monitored to ensure work is their own. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter

Guidance on the delivery and assessment of this Unit

This Unit should be delivered by a combination of lecturing and group discussions along with practical activities on mechatronic systems. 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 various transducers, actuators, controllers and interface devices.

Information on Evidence requirements and Assessment guidelines is given after Outcomes 3 and 4 in the SQA Advanced Unit specification: statement of standards section. The written assessment should take place after Outcomes 1 to 3 have been completed and the Assignment would normally be undertaken following the written test.

Opportunities for developing Core Skills

Accuracy in interpreting complex numerical and graphic information and the ability to calculate, apply and present complex data underpins the competencies developed in the Unit. Candidates could be provided with formative opportunities to enhance skills in the interpretation of numerical, statistical and graphic data in practical contexts before being assessed on their ability to describe and calculate the effects of control algorithms used in mechatronic systems. The emphasis of formative work should be on Numeracy as a tool to be used and applied efficiently and critically in the selection of systems elements. Calculations and effective presentation of report data could be supported and enhanced by the use of appropriate technology.

All elements of the core skill of Problem Solving, namely planning and organising, critical thinking, and reviewing and evaluating will be naturally developed and enhanced as candidates apply theoretical knowledge to programming requirements for the operation of the system. Researching, identifying and examining the relevance of all factors in various stages of the process before deciding on and implementing a strategic approach will involve a high level of critical thinking. Group discussion of issues may be useful although candidates should be independently able to justify the selection of systems elements, and identify and evaluate effective programming solutions which allow for review and modification.

Candidates could be encouraged to access and analyse a range of complex information in paper based and electronic format as part of research prior to writing up a case study. Feedback on formative practical assignments could develop evaluative approaches. The formal written report should express essential ideas and information accurately and coherently. It should be formally structured, use correct spelling and punctuation and be effectively presented to industry standard. Graphic data should be accurate and correctly annotated. Use of current software to check technical accuracy is good practice.

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

This Unit has been designed to allow you to develop knowledge and understanding of a range of Mechatronic systems

The early part of the Unit allows you to examine the operation and characteristics of mechanisms used in mechatronic systems including, gear trains, four bar mechanisms, belt drive systems, chain drive systems, pawl and ratchet systems, rack and pinion, pneumatic and hydraulic actuators, lever systems.

The Unit will also provide you with an opportunity to examine the effects of control algorithms used in mechatronic systems covering proportional, integral and derivative actions (PID) along with two step control and dead zone. Control loop tuning methods covered are ultimate cycle method and the process reaction curve.

This Unit also provides you with an opportunity to programme controllers used in mechatronic systems with a range of software programmes. This entails Programmable Logic Controller programming methods, microcontroller programming methods and personal computers programming using high level language programming.

You will carry out a mechatronic system case study to analyse, evaluate and research a mechatronic system to justify the selection of system elements.

The formal assessments for this unit consist of the following:
The assessment for Outcomes 1 and 2 will be combined together into one written assessment paper lasting 1 hour, and will be conducted under closed booked controlled, supervised conditions.
The assessment of Outcome 3 will be a practical assignment the time allocated for the assignment is 1 hour 30 minutes.

The assessment of Outcome 4 is a case study of 500 words minimum. The case study will be open book with access to learning resource facilities, manufacturer's data and the Internet to carry out research. However, it is expected that the report will be written up in your own time.