SCOTTISH QUALIFICATIONS AUTHORITY

MECHATRONICS
Higher

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SCOTTISH QUALIFICATIONS AUTHORITY

NOTE OF CHANGES TO ARRANGEMENTS - CD-ROM DECEMBER 1999

COURSE TITLE: Mechatronics (Higher)

COURSE NUMBER: C028 12

National Course Specification

Course Details: Core skills statements expanded

National Unit Specification

All Units: Core skills statements expanded

SCOTTISH QUALIFICATIONS AUTHORITY

National Course Specification

MECHATRONICS (Higher)

COURSE NUMBER C028 12

COURSE STRUCTURE

The course comprises of four mandatory units as follows:

D146 12	***Mechatronic Systems: An Introduction (H)***	***1 credit (40 hours)***
D147 12	***Programmable Control Systems (H))***	***0.5 credit (20 hours)***
D148 12	***Robotic and Automated Systems (H)***	***1 credit (40 hours)***
D149 12	***Mechatronics Case Study (H)***	***0.5 credit (20 hours)***

All courses include 40 hours over and above the 120 hours for the component units. This may be used for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for external assessment.

Whilst the course is integrative in nature some sequential teaching is recommended. To this end it is advised that the units are approached in the sequence listed above.

This will ensure that concepts are encountered at the appropriate stage of the course and can thus be reviewed, reinforced and further developed through application within later units. Every opportunity should be taken to integrate concepts.

Administrative Information

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Course Specification: general information (cont)

COURSE Mechatronics (Higher)

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade Technological Studies or Physics at grade 2 or above or equivalent National units
- Intermediate 2 Electronic and Electrical Fundamentals or Technological Studies
- a Scottish Group Award at Intermediate 2 in an appropriate area.

Note: It is recommended that all candidates should have attained a minimum of Standard Grade Mathematics at grade 3 or equivalent National units.

CORE SKILLS

This course gives automatic certification of the following:

Complete core skills for the course	Problem Solving	H
	IT	Int 2
Additional core skills components for the course	None	

For more information about automatic certification of core skills for any individual unit in this course, please refer to the general information section at the beginning of the unit.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Course Specification: course details

COURSE Mechatronics (Higher)

RATIONALE

Higher Mechatronics aims to provide candidates with knowledge and understanding of this new approach to integrated multi-disciplinary systems. Mechatronics integrates electronic, mechanical, control and computing principles and technologies and applies these to the design, manufacture and maintenance of complex products and processes. The course contributes to the candidate's personal development and further study and serves as an interest topic which will contribute positively to his or her technological capability.

The emphasis of Higher Mechatronics is on understanding electronic, mechanical, control and computing principles and applying them in an integrated way. The integration of these technologies allows candidates to develop the evaluative and investigative skills which need to be employed when working with many types of modern technological products and processes. The resulting assessable elements of knowledge, understanding and evaluation form the basis of the Higher course.

The study of mechatronics at Higher level provides an increasingly sophisticated development of skills through a range of challenging experiences. In addition, there is emphasis on developing skills of co-operative learning through the use of investigations and case studies. These studies are intended to develop the ability to communicate views clearly and confidently. Skills will be developed throughout the course in order to provide candidates with a sound base from which to pursue further studies.

The principal aim of Higher Mechatronics is that, by using the concepts and practical aspects of technology, candidates should develop a detailed understanding of the discipline necessary for the integration of 'system thinking' in the design of products and processes. In addition, the course should enable candidates to develop progressively:

- a knowledge and understanding of the necessary skills and techniques to meet the challenge of the new integrated approach to technology
- an appreciation of the interaction of people and their environments and the ways they effect and are affected by technology
- skills of investigating and evaluating through practical activities and providing accurate and objective descriptions and analyses of processes. The development of these skills should include the use of computers to gather, process, and communicate information.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

The course fulfils the following aims:

- the development of an understanding of key technologies which are used in mechatronic systems
- the development of a knowledge of principles and processes of engineering, and their application in solving problems or in meeting specifications
- the development of skills in communication, presentation and co-operation
- the development of a receptive attitude towards technological progress and its implementation in a mechatronic system
- the development of the ability to seek out, research and apply such information as is necessary in the field of engineering applications.

Within these aims, the study of Higher Mechatronics should cultivate a positive attitude towards new technology and the nature of future continuous developments in technology. Through this knowledge and understanding candidates should be better prepared to accept the resultant changes experienced throughout their working lives.

COURSE CONTENT

Whilst the units in the course can be taught independently, the synergistic nature of mechatronics lends itself to the integration of the technologies covered within the individual units chosen for the course content. This approach will enable candidates to develop a 'systems thinking' philosophy to the design of systems and processes.

All of the course content will be subject to sampling in the external assessment.

A brief description of the content and outcomes of each of the four units which constitute the course follows.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

SUMMARY OF COURSE CONTENT

Mechatronic Systems: An Introduction (H)

Candidates will be introduced to the concepts of mechatronics by having practical experience in operating typical examples of mechatronic systems. Candidates will gain insights into the component sub-systems of a mechatronic system by investigating the overall operation of the system and the implementation of the sensor and actuator sub-systems.

Candidates will be exposed to a variety of software used to write control programs for mechatronic systems. They will be instructed in the design and coding of a typical control program. They will demonstrate their understanding by firstly using a preprepared program to exercise a mechatronic system, then secondly modifying the program to alter the operation of a target system.

CONTENT STATEMENTS

Mechatronic Systems: An Introduction (H)

The content statements given in the left-hand column of the table overleaf describe in detail what the candidate should be able to do in demonstrating knowledge and understanding associated with mechatronic systems.

The right-hand column gives suggested contexts, applications, illustrations and activities associated within the content statements.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

Knowledge and Understanding	*Contexts, applications, illustrations and activities*
1 Mechatronic systems.	Products, processes.
2 Common elements.	Sub-system being controlled, microprocessor based controller, sensors, actuators, inter-facing, bus structure, software.
3 Controllers.	Hardwired logic, ASIC, microcontroller, PC, PLC.
4 Architecture.	Microprocessor, memory elements, buses, I/O interface.
5 Software.	Operating system, high and low level programming.
6 Input Signal.	Digital, analogue.
7 Sensor.	Switch, proximity, temperature, pressure, flow.
8 Actuator.	Rotational, linear. Electrical, pneumatic, hydraulic.
9 Programming levels.	Machine code, assembly, high level.
10 Comparisons.	Compiler, interpreter, linker, usage of memory, speed of operation.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

SUMMARY OF COURSE CONTENT

Programmable Control Systems (H)

This unit will expand and deepen the knowledge of programmable systems gained in the introduction to the course. Candidates will learn about the main types of controller systems and should be able to distinguish between these types. They will then specialise in one type, the programmable logic controller, and will be taught how to program this type at an operational level.

Problem solving skills will be developed and enhanced in this unit by the candidate engaging in solving a control problem using a chosen programmable system. The candidate will apply the specification, design, implementation and verification process in full, thereby gaining valuable practical experience in this type of activity.

CONTENT STATEMENTS

Programmable Control Systems (H)

The content statements given in the left-hand column of the table below describe in detail what the candidate should be able to do in demonstrating knowledge and understanding associated with programmable control systems.

The right-hand column gives suggested contexts, applications, illustrations and activities associated within the content statements.

Knowledge and Understanding	***Contexts, applications, illustrations and activities***
1 Programmable sub–systems.	Microcontroller-based systems, PC-based systems, programmable logic controllers.
2 Key features.	Ease of use, ease of change, expansion, maintenance, cost, physical attributes.
3 PLC software.	Ladder logic.
4 Software development environment.	Editor, emulator, simulator.
5 Analysis tool.	Flowchart.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

SUMMARY OF COURSE CONTENT

Robotic and Automated Systems (H)

Candidates will develop an integrated understanding of typical robotic and automated systems which can be viewed as restricted subsets of mechatronic systems. Candidates will also develop an understanding of the function and operation of some of the technologies resident in typical robotic manipulators.

Candidates will be expected to carry out simple analysis on certain manipulator anatomies, to assess drive and transmission systems, to analyse simple encoder output and to compare control strategies suitable for robotic manipulators. In addition, candidates will program a robotic system to carry out a repeatable pick and place task.

CONTENT STATEMENTS

Robotic and Automated Systems (H)

The content statements given in the left-hand column of the table below describe in detail what the candidate should be able to do in demonstrating knowledge and understanding associated with robotic and automated systems.

The right-hand column gives suggested contexts, applications, illustrations and activities associated within the content statements.

Knowledge and Understanding	***Contexts, applications, illustrations and activities***
1 Anatomy.	Revolute, cartesian, cylindrical, polar, SCARA geometries.
2 Degrees of freedom.	Robotic joints, work envelope volume, safety.
3 End-effector grippers.	Mechanical, electromagnetic, pneumatic.
4 Comparison.	Range of movement, position control, safety, cost, force, torque, speed, power.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

Knowledge and Understanding (cont'd)	*Contexts, applications, illustrations and activities*
5 Encoders.	Linear, rotary.
6 Positional accuracy.	Resolution, effective bit length.
7 Tactile sensing.	End-effector application.
8 Sequential control strategy.	Time based, event based.
9 Comparisons.	Ease of application, cost, stability, accuracy.
10 Responses.	Time domain plots.
11 PID control.	Speed of response, stability, accuracy.
12 Methods.	Lead-by-nose, point-to-point.
13 Analysis of task.	Sequential description, flowchart.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

SUMMARY OF COURSE CONTENT

Mechatronics Case Study (H)

The purpose of the case study is to allow candidates the opportunity to develop investigative capabilities and to apply knowledge and understanding encountered at earlier stages of the course to the solution of a technological problem set within an industrial or commercial context.

The case study should provide a logical conclusion to the course and offer the opportunity for consolidation and review. It is envisaged that candidates will initially be provided with an industrial design brief. The problem will require candidates to carry out research and investigation into possible solutions and, based on technological and commercial feasibility, justify the selection of a particular solution. A technical report will be produced by the candidate and presented to assessors and peers.

The case study should reflect knowledge and understanding in the following areas:

- key technologies which are used in mechatronic systems
- principles and processes of engineering
- skills in communication, presentation and co-operation
- developing a receptive attitude towards technological progress and its implementation in a mechatronic system
- the ability to seek out, research and apply information as is necessary to solve the problem presented in the mechatronics case study
- the wider implications arising from the use of technology.

ASSESSMENT

To gain the award of the course the candidate must pass all the unit assessments as well as the external assessment. External assessment will provide the basis for grading attainment in the course award.

When units are taken as component parts of a course, candidates will have the opportunity to achieve a level beyond that required to attain each of the unit outcomes. This attainment may, where appropriate, be recorded and used to contribute towards course estimates, and to provide evidence for appeals. Additional details are provided, where appropriate, with the exemplar assessment materials. Further information on the key principles of assessment is provided in the paper *Assessment* (HSDU, 1996), and in *Managing Assessment* (HSDU, 1998).

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

DETAILS OF THE INSTRUMENTS FOR EXTERNAL ASSESSMENT

The external assessment will comprise a written examination paper. The time allocation for the question paper will be 3 hours. The paper will be worth 100 marks and will be in two parts as follows:

Section A - 50 marks
This section will contain short answer questions. Candidates should attempt **all** questions in this section.

Section B - 50 marks
This section will contain three structured questions which will assess the candidate's ability to deal with the integrated course content. Candidates should attempt **two** questions in this section. Each question will carry 25 marks.

GRADE DESCRIPTIONS

The grade of award A, B or C will be based on the total score obtained from both sections of the question paper. The descriptions below indicate the nature of the achievement which is required for the award of a grade C and a grade A in the course assessment. They are intended to assist candidates, teachers, lecturers and users of the certificate and to help establish standards when question papers are being set.

GRADE C	GRADE A
Use the appropriate knowledge, understanding and skills acquired through the study of the course with regularity.	Use knowledge, understanding and skills which have been developed well in advance of those required for the basic study of the component units of this course.
Demonstrate the ability to integrate skills acquired in component units to solve problems of both a theoretical and practical nature.	Demonstrate the ability to integrate advanced skills acquired in the course to solve problems of both a theoretical and practical nature.
Apply knowledge and understanding to solve problems presented in less familiar contexts.	Apply advanced knowledge and understanding to solve complex and sometimes unstructured problems presented in a variety of contexts.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

APPROACHES TO LEARNING AND TEACHING

It is recommended that the outcomes of the units *Mechatronic Systems: An Introduction (H)*, *Programmable Control Systems (H)*, and *Robotic and Automated Systems (H)* be undertaken in the context of a series of practical assignments. These would allow candidates initially to develop their understanding of the systems approach to mechatronic systems, then to gain more detailed knowledge and understanding of such systems by the specialist activities carried out in the second and third units.

The integrative nature of the course is best addressed by initial practical experience of mechatronic systems to understand their common elements. The knowledge gained in the initial stages is examined in the context of the principles taught as the course unfolds. Once candidates have grasped the identity and function of the sub-systems of a mechatronic system, they can proceed to synthesise new systems from their knowledge and understanding of the component parts.

The specialist unit *Programmable Control Systems (H)* builds on the concepts advanced in the introductory unit and is therefore ideally suited to an integrated laboratory teaching environment. The candidate should gain practical experience in using a PLC.

The specialist unit *Robotic and Automated Systems (H)* exemplifies the mechatronic approach to complex program-controlled electromechanical systems. It is recommended that the candidate is encouraged to integrate across all the outcomes through using typical robotic systems.

The purpose of the unit *Mechatronics Case Study (H)* is to develop in candidates practical capability in applying knowledge and understanding encountered at earlier stages of the course to the solution of a technical problem. The case study should provide a logical conclusion to the course and offer the opportunity to consolidate and integrate the material covered in the other three units.

The case study should reflect knowledge and understanding in the following areas:

- key technologies which are used in mechatronic systems
- principles and processes of engineering
- skills in communication, presentation and co-operation
- developing a receptive attitude towards technological progress and its implementation in a mechatronics system
- the ability to seek out, research and apply information as is necessary to solve the problem presented in the case study.

It is envisaged that candidates will be provided with a problem-solving activity set in an industrial or commercial context. The problem will require candidates to carry out research and investigation into possible solutions and, based on their results, justify the selection of a particular solution. A technical report will be produced by the candidate as evidence of the investigative work undertaken.

The procedures and regulations pertaining to health and safety issues should be addressed at all times throughout the delivery of the course. Candidates should also be encouraged to discuss and take responsibility for all environmental issues arising from activities undertaken and connected with the course.

National Course Specification: course details (cont)

COURSE Mechatronics (Higher)

SUBJECT GUIDES

A Subject Guide to accompany the Arrangements Documents has been produced by the Higher Still Development Unit (HSDU) in partnership with the Scottish Consultative Council on the Curriculum (SCCC) and Scottish Further Education Unit (SFEU). The Guide provides further advice and information about:

- support materials for each course
- learning and teaching approaches in addition to the information provided in the Arrangements document
- assessment
- ensuring appropriate access for candidates with special educational needs.

The Subject Guide is intended to support the information contained in the Arrangements document. The SQA Arrangements documents contain the standards against which candidates are assessed.

SPECIAL NEEDS

This course specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Mechatronic Systems: An Introduction (Higher)

NUMBER D146 12

COURSE Mechatronics (Higher)

SUMMARY

The purpose of the unit is to develop an understanding of the integration of electronics, mechanics and computer technology in mechatronic systems.

OUTCOMES

1 Compare and operate a selection of mechatronic systems.
2 Compare the variations of controllers used in typical mechatronic systems.
3 Specify and select sensor and actuator sub-systems for a mechatronic system.
4 Investigate and modify software to control a mechatronic system.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade in Technological Studies or Physics at grade 2 or above
- equivalent National units
- Intermediate 2 Electronic and Electrical Fundamentals or Technological Studies
- Scottish Group Award at Intermediate 2 in an appropriate area.

Note: It is recommended that all candidates should have attained a minimum of Standard Grade Mathematics at Grade 3 or equivalent National units.

Administrative Information

Superclass: XL

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Mechatronic Systems: An Introduction (Higher)

CREDIT VALUE

1 credit at Higher.

CORE SKILLS

There is no automatic certification of core skills or core skills components in this unit.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Mechatronic Systems: An Introduction (Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Compare and operate a selection of mechatronic systems.

Performance criteria

(a) The function of a mechatronic system is correctly explained.
(b) The common elements of a mechatronic system are correctly identified.
(c) A given task on a mechatronic system is implemented successfully.
(d) Examples of mechatronic systems are accurately described.

Note on range for the outcome

Mechatronic system: products, processes.
Common elements: subsystem being controlled, microprocessor based controller, sensors, actuators, interfacing, bus structure, software.

Evidence requirements

Performance evidence, as well as written and graphical evidence of the candidate's ability to compare and operate a selection of mechatronic systems.

For PC (d) a minimum of two examples should be described which could include the following:

- automatic camera
- automatic washing machine
- pick and place robot
- automatic assembly machine
- automotive engine management system
- computer controlled fitness equipment
- vending machine.

National Unit Specification: statement of standards (cont)

UNIT Mechatronic Systems: An Introduction (Higher)

OUTCOME 2

Compare the variations of controllers used in typical mechatronic systems.

Performance criteria

(a) The flexibility of a range of controllers is correctly identified.
(b) The architecture of a microprocessor based controller sub-system found in a mechatronic system is correctly described.
(c) The types of software used by programmable controllers are correctly identified.

Note on range for the outcome

Controllers: hardwired logic, ASIC, microcontroller, PC, PLC.
Architecture: microprocessor, memory elements, buses, I/O interface.
Software: operating system; high and low level programming.

Evidence requirements

Written and graphical evidence of the candidate's ability to compare the variation of controllers used in typical mechatronic systems.

OUTCOME 3

Specify and select sensor and actuator sub-systems for a mechatronic system.

Performance criteria

(a) The type of sensor required to process input signals is correctly specified.
(b) An appropriate sensor for a particular input signal is correctly selected.
(c) A type of actuator required to deliver output action is correctly specified.
(d) An appropriate actuator for a particular output action is correctly selected.

Note on range for the outcome

Input signal: digital, analogue.
Sensor: switch, proximity, temperature, pressure; flow.
Action: rotational, linear.
Actuator: electrical, pneumatic, hydraulic.

Evidence requirements

Written and graphical evidence of the candidate's ability to specify and select sensor and actuator subsystems for a mechatronic system, as specified in PCs (a) to (d).

National Unit Specification: statement of standards (cont)

UNIT Mechatronic Systems: An Introduction (Higher)

OUTCOME 4

Investigate and modify software to control a mechatronic system.

Performance criteria

(a) Different programming levels are correctly identified.
(b) Compiled and interpreted high level languages are correctly compared.
(c) A preprepared software program to control a mechatronic system is correctly used.
(d) Software code is effectively modified to alter the operation of a mechatronic system.

Note on range for the outcome

Programming levels: machine code, assembly, high level.
Comparisons: compiler, interpreter, linker, usage of memory, speed of operation.

Evidence requirements

Written evidence of the candidate's ability to distinguish between programming languages and levels.
Performance evidence of the correct operation of the mechatronic system.

National Unit Specification: support notes

UNIT Mechatronic Systems: An Introduction (Higher)

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

It is recommended that you refer to the SQA Arrangements document for Higher Mechatronics before delivering this unit.

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

The purpose of this unit is to develop an understanding of the integration of electronics, mechanics and computer technology in mechatronic systems.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

This unit should be taught, wherever possible, in a practical or laboratory context. There should be a variety of technologies available, i.e. electro-pneumatic, electro-hydraulic, advanced manufacturing, CNC, robotic, computer/microcontroller/PLC-controlled systems. Candidates should be allowed ample access time to suitably equipped laboratories to enable them to become thoroughly conversant with the equipment.

Suitable mechatronic systems might include: automatic camera; automatic washing machine; automatic assembly machine; automotive engine management system; computer controlled fitness equipment; program-controlled conveyor systems, electro-pneumatic sorters, pick and place robots, vending machine.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

It is recommended that you refer to the Subject Guide for additional information. The Subject Guide is intended to support the information contained in the Arrangements document. The SQA Arrangements documents contain the standards against which candidates are assessed.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Examples of instruments of assessment which could be used are as follows:

- practical assignments
- restricted response questions
- extended response questions
- laboratory investigations
- mini-projects
- case studies.

A candidate-centred resource-based approach to learning should be adopted in which candidates are encouraged to work both individually and co-operatively as team members.

National Unit Specification: support notes

UNIT Mechatronic Systems: An Introduction (Higher)

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Programmable Control Systems (Higher)

NUMBER D147 12

COURSE Mechatronics (Higher)

SUMMARY

The purpose of this unit is to develop an understanding of a range of Programmable Control Systems as applied to a mechatronic system. It will also develop an appreciation of the role that software plays in the behaviour of a mechatronic system.

OUTCOMES

1 Evaluate and operate a programmable system.
2 Solve a control problem using a PLC.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade Technological Studies or Physics at grade 2 or above
- equivalent National units
- Intermediate 2 Electronic and Electrical Fundamentals or Technological Studies
- Scottish Group Award at Intermediate 2 in an appropriate area.

Note: It is recommended that all candidates should have attained a minimum of Standard Grade Mathematics at grade 3 or equivalent National units.

Administrative Information

Superclass: VE

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Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Programmable Control Systems (Higher)

CREDIT VALUE

0.5 credit at Higher.

CORE SKILLS

There is no automatic certification of core skills or core skills components in this unit.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Programmable Control Systems (Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Evaluate and operate a programmable system.

Performance criteria

(a) The key features of various programmable sub-systems used in control systems are correctly identified.
(b) The functions of a software development environment are clearly described.
(c) Pre-prepared PLC software is correctly used to operate a mechatronic system.
(d) PLC software is successfully modified to perform an alternative task on a system.

Note on range for the outcome

Programmable sub-systems: microcontroller-based systems, PC-based systems, programmable logic controllers.
Key features: ease of use, ease of change, expansion, maintenance, cost, physical attributes.
PLC software: ladder logic.
Software development environment: editor, emulator, simulator.

Evidence requirements

Written and graphical evidence that the candidate can:

- evaluate the key features of various types of programmable control systems
- describe the key functions of a software development environment with specific reference to the editor, emulator and simulator.

In addition, performance evidence that the candidate can correctly operate and successfully modify the program sequence for the chosen system.

National Unit Specification: statement of standards

UNIT Programmable Control Systems (Higher)

OUTCOME 2

Solve a control problem using a PLC.

Performance criteria

(a) The given task is correctly analysed.
(b) The I/O assignments for the chosen control systems are clearly identified.
(c) Software for the chosen PLC is used effectively.
(d) The operation of the selected system is successfully verified.

Note on range for the outcome

Analysis tool: flowchart.

Evidence requirements

Written evidence regarding the correct analysis of the problem and identification of the input/output sub-systems. Performance evidence of the correct operation of the system.

National Unit Specification: support notes

UNIT Programmable Control Systems (Higher)

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

It is recommended that you refer to the SQA Arrangements document for Higher Mechatronics before delivering this unit.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 20 hours.

The purpose of this unit is to develop an understanding of a range of Programmable Control Systems as applied to a mechatronic system. The candidate will appreciate the role that software plays in the behaviour of a mechatronic system.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

This unit should be taught, wherever possible, in a practical context, although simulation may be used to enhance the candidate's learning experience.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

A candidate-centred resource-based approach to learning should be adopted in which candidates are encouraged to work both individually and co-operatively as team members.

It is recommended that you refer to the Subject Guide for additional information. The Subject Guide is intended to support the information contained in the Arrangements document. The SQA Arrangements documents contain the standards against which candidates are assessed.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Examples of instruments of assessment which could be used are as follows:

- practical assignments
- restricted response questions
- extended response questions
- laboratory investigations
- mini-projects
- case studies.

National Unit Specification: support notes (cont)

UNIT Programmable Control Systems (Higher)

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Robotic and Automated Systems (Higher)

NUMBER D148 12

COURSE Mechatronics (Higher)

SUMMARY

The purpose of this unit is to develop an understanding of the anatomy, senses and control mechanisms of a typical industrial robot.

OUTCOMES

1 Compare the anatomy of typical robotic devices.
2 Analyse the sensory systems used in typical robotic devices.
3 Describe the control strategies used in typical automation systems.
4 Program a typical robotic system to carry out repeatable actions.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Standard Grade Technological Studies or Physics at grade 2 or above
- equivalent National units
- Intermediate 2 course Electronic and Electrical Fundamentals or Technological Studies
- Scottish Group Award at Intermediate 2 in an appropriate area.

Note: It is recommended that all candidates should have attained a minimum of Standard Grade Mathematics at grade 3 or equivalent National units.

Administrative Information

Superclass: VE

Publication date: December 1999

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Version: 03

National Unit Specification: general information (cont)

UNIT Robotic and Automated Systems (Higher)

CREDIT VALUE

1 credit at Higher.

CORE SKILLS

There is no automatic certification of core skills or core skills components in this unit.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Robotic and Automated Systems (Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Compare the anatomy of typical robotic devices.

Performance criteria

(a) The axes of motion and degrees of freedom of a typical robot are correctly described.
(b) Operation of end-effector grippers is correctly described.
(c) Pneumatic, hydraulic and electrical drive systems are critically compared for a specified application.

Note on range for the outcome

Anatomy: revolute, cartesian, cylindrical, polar, SCARA geometries.
Degrees of freedom: robotic joints, work envelope volume; safety.
End-effector grippers: mechanical, electromagnetic, pneumatic.
Comparison: range of movement, position control, safety, cost, force, torque, speed, power.

Evidence requirements

Written and graphical evidence of the candidate's ability to compare the anatomy of typical robotic devices, as specified in PCs (a) to (c).

National Unit Specification: statement of standards (cont)

UNIT Robotic and Automated Systems (Higher)

OUTCOME 2

Analyse the sensory systems used in typical robotic devices.

Performance criteria

(a) Description of incremental and absolute encoders is accurate.
(b) Pure Binary Codes, (PBC), Binary Coded Decimal (BCD) and Gray codes are accurately compared.
(c) Positional accuracy is accurately calculated.
(d) Tactile sensing is correctly explained.

Note on range for the outcome

Encoders: linear, rotary.
Positional accuracy: resolution, effective bit length.
Tactile sensing: end-effector application.

Evidence requirements

Written and graphical evidence of the candidate's ability to analyse the sensory systems used in typical robotic devices, as specified in PCs (a) to (d).

OUTCOME 3

Describe the control strategies used in typical automation systems.

Performance criteria

(a) Sequential control strategy is correctly described.
(b) Open-loop and closed-loop control systems are accurately compared.
(c) The output responses of proportional control are accurately described.
(d) The influence of the constituent elements of a PID control strategy is accurately described.

Note on range for the outcome

Sequential control strategy: time based, event based.
Comparisons: ease of application, cost, stability, accuracy.
Responses: time domain plots.
PID control: speed of response, stability, accuracy.

Evidence requirements

Written and graphical evidence of the candidate's ability to describe the control strategies used in typical automation systems, as specified in PCs (a) to (d).

National Unit Specification: statement of standards (cont)

UNIT Robotic and Automated Systems (Higher)

OUTCOME 4

Program a typical robotic system to carry out repeatable actions.

Performance criteria

(a) Programming methods are correctly described.
(b) Analysis of task for a given pick and place sequential operation is correct.
(c) Translation of task analysis into functional software is correct.
(d) Verification of software operation on hardware is correct.

Note on range for the outcome

Methods: lead-by-nose, walkthrough (point-to-point).
Analysis of task: sequential description, flowchart.

Evidence requirements

Written and performance evidence of the candidate's ability to program a typical robotic system to carry out repeatable actions, as specified in PCs (a) to (d).

National Unit Specification: support notes

UNIT Robotic and Automated Systems (Higher)

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

It is recommended that you refer to the SQA Arrangements document for Higher Mechatronics before delivering this unit.

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

The purpose of this unit is to develop an integrated understanding of typical robotic and automated systems.

Safety should be emphasised throughout the delivery of this unit. In particular, safety in the application of robotic and automated systems should be reviewed prior to their use.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

The candidate should achieve the level of competence of someone who understands the functions and operation of robotic and automated systems. This unit is part of Higher Mechatronics and would be best delivered in an integrated manner in conjunction with the other units of the course.

The outcomes would be best undertaken in the context of assignments which embed the principles within an industrial context. The work undertaken by candidates in Outcome 1 should allow them to differentiate between differing robotic anatomies. The candidates would be expected to distinguish between cartesian and polar geometries.

The candidate will be introduced in a qualitative manner to pneumatic, hydraulic and electric drive systems. This will be considered in the unit Mechatronics Systems: An Introduction (H); however, a contextualised approach within this unit will be required. The candidates will be expected to be able to critically assess differing drive systems for specific situations. Typical criteria will be range of movement, position control, power, torque, force, speed, safety and cost.

Outcome 2 introduces the candidate to the sensory systems employed in typical robotic manipulators and end-effectors, with a focus on the linear and rotary encoders. The candidate will be expected to be able to differentiate between incremental and absolute encoders. The candidate will be expected to be able to use PBC, BCD and Gray codes in calculating angles of rotations. The calculation of resolution from a given bit length will also be required.

Outcome 3 introduces the candidate to the concepts of sequential, open-loop and closed-loop control. The candidates will be expected to be able to compare open-loop and closed-loop responses.

The strategies of proportional control and the effects of error and gain will be introduced to the candidates. The candidates will be expected to reproduce block diagrams and use these to describe a proportional control strategy.

Derivative and integral control will be introduced to the candidates in a qualitative manner. Candidates should have an understanding of the constituent parts of a PID control strategy which will enable them to choose the most suitable strategy for a robotic application.

Outcome 4 is the culmination of the unit. The candidate will be given a specific repetitive pick and place task and will be required to break down the task into the constituent robotic movements and thus derive a sequence for the task. Once the sequence has been derived and proven, the candidate will convert it into the functional code of the particular robotic system available at the centre. Verification will consist of ensuring the robotic system performs the original task given to the candidate.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

It is recommended that you refer to the Subject Guide for additional information. The Subject Guide is intended to support the information contained in the Arrangements document. The SQA Arrangements documents contain the standards against which candidates are assessed.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1, 2 and 3 could consist of written questions with Outcome 4 consisting of a practical exercise.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Mechatronics Case Study (Higher)

NUMBER D149 12

COURSE Mechatronics (Higher)

SUMMARY

The purpose of this unit is to develop the capability in applying knowledge and understanding encountered throughout the course to the solution of a technical problem. It will also develop skills in producing and presenting a technical report.

OUTCOMES

1 Propose a solution to a mechatronics problem.
2 Produce a technical report.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained the other units in Higher Mechatronics, ie:

- Programmable Control Systems (H)
- Mechatronic Systems: An Introduction (H)
- Robotic and Automated Systems (H).

Administrative Information

Superclass: XL

Publication date: December 1999

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Mechatronics Case Study (Higher)

CREDIT VALUE

0.5 credit at Higher.

CORE SKILLS

This unit gives automatic certification of the following:

Complete core skills for the unit	Problem Solving H
Additional core skills components for the unit	None

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Mechatronics Case Study (Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Propose a solution to a mechatronics problem.

Performance criteria

(a) A given problem is correctly analysed in system terms.
(b) Technical data is correctly used in the analysis of the problem.
(c) Possible solutions are identified taking due account of appropriate safety considerations.
(d) The final solution is evaluated and justified correctly with respect to the given problem.

Evidence requirements

Written and graphical evidence of the candidate's ability to evaluate and justify a solution to a mechatronics problem as specified in PCs (a) to (d).

OUTCOME 2

Produce a technical report.

Performance criteria

(a) The report clearly identifies the given problem.
(b) Evidence of the analysis is thorough.
(c) The proposed solution is fully justified.
(d) The effectiveness of the approach taken is critically reviewed.
(e) The wider implications of the technical solution are given due consideration.
(f) Conclusions drawn are soundly based and well argued.
(g) The report is clear, concise, suitably structured and well presented.

Evidence requirements

Written and graphical evidence of the candidate's ability to produce and present a technical report, which may be hand-written or typed.

National Unit Specification: support notes

UNIT Mechatronics Case Study (Higher)

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

It is recommended that you refer to the SQA Arrangements document for Higher Mechatronics before delivering this unit.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 20 hours.

The purpose of this unit is to develop capability in applying knowledge and understanding to solving a practical problem and the ability to produce and present a technical report.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

It is envisaged that candidates will be provided with a problem-solving activity set in an industrial or commercial context. The problem will require candidates to carry out research and investigation into possible solutions and, based on results, justify the selection of a particular solution. A technical report will be produced by the candidate as evidence of the investigative work undertaken.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

This unit is part of Higher Mechatronics and would be best delivered in an integrated manner in conjunction with the other units of the course. Outcomes 1 and 2 would be best undertaken in the context of an integrated project set in an industrial situation, in which candidates would be required to apply knowledge of a range of technical devices and systems and demonstrate practical capability in their use.

A typical case study would involve candidates in interpreting a given specification to analyse a problem in systems terms. Sub-systems would include those typically found in mechatronic systems. Candidates would be expected to research ideas for solutions to each sub-system using data which could be in the form of a resource file. The operation of a sub-system would be analysed and described, if appropriate. Results achieved would be recorded, along with the solution to the sub-system, in the case-study report. A critical evaluation of the effectiveness of the solution in meeting the specification would be produced.

National Unit Specification: support notes (cont)

UNIT Mechatronics Case Study (Higher)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Examples of instruments of assessment which could be used for each outcome are given below.

Outcome 1

The candidate could investigate practical systems which would model the operation of the identified solution.

Outcome 2

The candidate would produce a case study report containing evidence of the work undertaken in meeting the outcome.

The teacher or lecturer would be expected to keep an observation checklist to verify work undertaken by the candidate at each stage of the case study. A candidate-centred, resource-based approach to problem solving should be adopted in which candidates are encouraged to work in an independent manner.

The candidate would be given a practical problem to solve, the solution to which would be based on work previously undertaken in Higher Mechatronics.

Guidance would be given to candidates on the approach to be taken in generating a solution to the problem in the form of a case study report booklet. The booklet would indicate to candidates the research work to be undertaken at each stage and the depth of treatment to be given in recording evidence. Candidates would be required to access information, including technical data, from resource files whilst investigating a solution.

The solution should demonstrate capability in applying concepts developed on the course in an integrated manner.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).