OCR
Oxford Cambridge and RSA

Cambridge **NATIONALS LEVEL 1/2**

SYSTEMS CONTROL IN ENGINEERING

R116 Process control systems

J833/J843

Schemes of work

Version 1

www.ocr.org.uk/subjects/engineering

CONTENTS

INTRODUCTION

This teaching resource, which we've developed with Nationals Engineering teachers, contains two types of schemes of work.

- A **longer term** plan which covers the whole academic year over three terms and suggests the order in which each Learning Outcome (LO) could be taught. Links to other units and LOs within Nationals Engineering are also shown.
- A **medium term** plan which also covers the whole academic year over three terms and suggests the order in which each LO could taught but also provides classroom activities and any links to other resources which might be useful. We've also included 'Have they got it?' linking to activities other LOs in this unit and/or other units and LOs within Nationals Engineering. This includes performing practical activities by which learners confirm their understanding.

Link to qualification

https://www.ocr.org.uk/qualifications/cambridge-nationals/systems-control-in-engineering-level-1-2-award-certificate-j833-j843/

See our range of planning and teaching resources on the link below (including delivery guides, project approaches, teaching activities, teacher guides and resources lists).
https://www.ocr.org.uk/qualifications/cambridge-nationals/systems-control-in-engineering-level-1-2-award-certificate-j833-j843/planning-and-teaching/

See our range of assessment resources on the link below (including past paper, mark schemes, examiners' reports, candidate exemplars and set assignments).
https://www.ocr.org.uk/qualifications/cambridge-nationals/systems-control-in-engineering-level-1-2-award-certificate-j833-j843/assessment/

Scheme of work (longer term plan – academic year)

	Learning Outcome	Topic area/theme (from R116 specification)	Links to other Cambridge Nationals Engineering units and LOs
Autumn Term	**LO1**	System layouts – part 1.	**R113 LO2** – Understand the operating principles of electronic components.
	LO1	System layouts – part 2.	**R113 LO2** – Understand the operating principles of electronic components.
	LO1	Applications of microprocessors and microcontrollers – part 1.	**R113 LO2** – Understand the operating principles of electronic components.
	LO1	Applications of microprocessors and microcontrollers – part 2.	**R113 LO2** – Understand the operating principles of electronic components.
	LO1	Basic function of components in a control system – input devices.	**R113 LO2** – Understand the operating principles of electronic components.
	LO1	Basic function of components in a control system – output devices.	**R113 LO2** – Understand the operating principles of electronic components.
	LO1	Basic function of components in a control system – control devices.	**R113 LO2** – Understand the operating principles of electronic components.
	LO1	Operation of control systems in products and systems – part 1.	**R113 LO2** – Understand the operating principles of electronic components.
	LO1	Operation of control systems in products and systems – part 2.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	Introduction to designing and programming control systems.	**R113 LO2** – Understand the operating principles of electronic components.

	Learning Outcome	Topic area/theme (from R116 specification)	Links to other Cambridge Nationals Engineering units and LOs
Spring Term	**LO2**	System design – hardware requirements.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	System design – input and output devices – part 1.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	System design – input and output devices – part 2.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	System design – using system diagrams – part 1.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	System design – using system diagrams – part 2.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	System design – introduction to programming and simulation tools.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	Practical system design and programming activity.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	Practical system design and programming activity.	**R113 LO2** – Understand the operating principles of electronic components.
	LO3	Practical system design and programming activity.	**R113 LO2** – Understand the operating principles of electronic components.
	LO3	Practical system design and programming activity.	**R113 LO2** – Understand the operating principles of electronic components.

	Learning Outcome	Topic area/theme (from R116 specification)	Links to other Cambridge Nationals Engineering units and LOs
Summer Term	**LO2**	Practical system design and programming activity.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	Practical system design and programming activity.	**R113 LO2** – Understand the operating principles of electronic components.
	LO2	Synoptic links to other units.	**R113 LO2** – Understand the operating principles of electronic components.
	LO3	Developing control system test plans – part 1.	**R113 LO2** – Understand the operating principles of electronic components. **R113 LO3** – Know test methods for electronic circuit. **R112 LO2** – Be able to assess product quality from inspection and quality control techniques.
	LO3	IDeveloping control system test plans – part 2.	**R113 LO2** – Understand the operating principles of electronic components. **R113 LO3** – Know test methods for electronic circuit. **R112 LO2** – Be able to assess product quality from inspection and quality control techniques.
	LO3	Practical control system testing.	**R113 LO2** – Understand the operating principles of electronic components. **R113 LO3** – Know test methods for electronic circuit. **R112 LO2** – Be able to assess product quality from inspection and quality control techniques.
	LO3	Practical control system testing.	**R112 LO3** – Know how modern technologies can be used in quality control.
	LO3	Interpreting test results and practical system refinement.	**R113 LO2** – Understand the operating principles of electronic components. **R113 LO3** – Know test methods for electronic circuit. **R112 LO2** – Be able to assess product quality from inspection and quality control techniques.
	LO3	Interpreting test results and practical system refinement.	**R113 LO2** – Understand the operating principles of electronic components. **R113 LO3** – Know test methods for electronic circuit. **R112 LO2** – Be able to assess product quality from inspection and quality control techniques.
	LO3	Interpreting test results and practical system refinement.	**R113 LO2** – Understand the operating principles of electronic components. **R113 LO3** – Know test methods for electronic circuit. **R112 LO2** – Be able to assess product quality from inspection and quality control techniques.

Scheme of work (medium term plan – more detailed by academic term)

	Event	Learning Outcome	Topic area/subtopic Area (from R116 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Autumn Term	**1**	**LO1**	System layouts – part 1.	Teachers could begin with an introduction to why microprocessors and microcontrollers are used to automate systems. This could include consumer systems (e.g. domestic appliances, toys, mobile phones, engine management systems) and commercial systems (e.g. production/assembly lines). This can be extended to the basic layout of systems i.e. relationship of processing devices to inputs and outputs.		The following shows the system layout for a simple washing machine. It is possible in the diagram to identify the control devices, and input and output devices https://www.renesas.com/br/en/solutions/home-appliance/major-home-appliance/washing-machine-low.html The following is for a microwave oven https://www.cypress.com/applications/microcontrollers-microwave-ovens
	2	**LO1**	System layouts – part 2.	Teachers could continue to explain the layout of microprocessor/microcontroller systems by considering block diagrams showing system layout. This could relate the processing device to how it interacts with input devices (e.g. sensors, switches, keypads etc.) and output devices (e.g. actuators, light emitting diodes, displays, sounders etc.). Simple layout block diagrams could be used (e.g. microwave oven, washing machine, ABS braking system etc.). It should be noted that the internal layout of the programmable device (i.e. the internal architecture) need not be considered.	**R116 LO1** – Learners will be able to present system layouts for a range of different systems, clearly showing the relative relationship between processing devices and input and output devices.	
	3	**LO1**	Applications of microprocessors and microcontrollers – part 1.	Teachers could focus on the applications of microprocessors and microcontrollers in various systems in this lesson. They could highlight the benefits they bring to different applications. Teachers could differentiate between the microprocessor and microcontroller. Video case studies could be used.		Internet sources could be useful to investigate a range of microprocessor and microcontroller applications. The following provides a basic list of applications of microcontrollers https://www.vlsifacts.com/different-applications-microcontroller/

	Event	Learning Outcome	Topic area/subtopic Area (from R116 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Autumn Term	**4**	**LO1**	Applications of microprocessors and microcontrollers – part 2.	Learners could independently investigate applications of microprocessors and microcontrollers in automating systems. They could summaries a range of examples, including benefits. This could be appended with simple block diagrams showing the system layout (i.e. relationship of the microprocessor/microcontroller to input and output devices).	**R116 LO1** – Learners will be able to present evidence of the application of microprocessors and microcontrollers in a range of different applications.	
	5	**LO1**	Basic function of components in a control system – input devices.	In the next two lessons, teachers could focus in more detail on the function of basic input and output devices in microprocessor/microcontroller applications. In this lesson they could illustrate how switches, temperature, position, light, flow, and pressure devices function. Practical devices could be used if available, along with data sheets and videos.	**R116 LO1** – Learners will be able to identify and explain the function of a range of different input devices.	Internet sources explaining sensors, transducers, and actuators, including their use in programmable control systems, could be useful such as https://www.electronics-tutorials.ws/io/io_1.html
	6	**LO1**	Basic function of components in a control system – output devices.	In this lesson, teachers could continue by looking at how output devices function, including lamps, sounders, solenoids, and relays. Again, physical devices could be used along with datasheets and videos.	**R116 LO1** – Learners will be able to identify and explain the function of a range of different output devices.	
	7	**LO1**	Basic function of components in a control system – control devices.	Teachers could focus in more detail in this lesson about how the microprocessor or microcontroller functions to interact with input and output devices. It is not necessary to concentrate on the internal architecture of the device, rather how it reads inputs and makes decisions to control outputs.	**R116 LO1** – Learners will be able to identify and explain the function of a range of different control devices (e.g. microprocessor, microcontroller).	Websites explaining the features of and differences between the microprocessor and microcontroller could be useful https://www.electronicsforu.com/resources/difference-between-microprocessor-and-microcontroller

	Event	Learning Outcome	Topic area/subtopic Area (from R116 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Autumn Term	**8**	**LO1**	Operation of control systems in products and systems – part 1.	Teachers could begin with an explanation of the operation of a complete system, and how the microprocessor or microcontroller interacts with inputs and outputs to provide control. An example is a washing machine which reads input sensors (e.g. door closed switch, water temperature) and controls outputs (e.g. spin motor and heater). Different examples could be used.		
	9	**LO1**	Operation of control systems in products and systems – part 2.	Learners could independently investigate a range of different microprocessor or microcontroller systems and produce a summary of how each operates.	**R116 LO1** – Learners will be able to explain how a microprocessor/ microcontroller operates in conjunction with input devices, output devices and using feedback in control systems.	Internet sources explaining the operation of products containing programmable devices could be used. The following explains the operation of a computer-controlled antilock braking (ABS) system https://auto.howstuffworks.com/auto-parts/brakes/brake-types/anti-lock-brake1.htm
	10	**LO2**	Introduction to designing and programming control systems.	In this lesson, teachers could introduce learners to the process for designing a practical microprocessor or microcontroller control system solution. This could include defining the control problem, selecting hardware, and methods for programming the system. It could also include advance detail of how system operation will be tested.		

	Event	Learning Outcome	Topic area/subtopic Area (from R116 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Spring Term	1	LO2	System design – hardware requirements.	In the following series of lessons, learners will develop skills in designing, developing, simulating, and ultimately implementing a control system solution. Teachers could begin by defining the control problem including a brief overview of the hardware requirements for the system.	**R116 LO2** – Learners will be able to identify and specify hardware requirements (i.e. programmable device) for a practical control system design problem.	There are many microcontroller systems which are suitable for developing, simulating, and implementing control systems, such as https://beagleboard.org/bone https://www.arduino.cc/ https://www.raspberrypi.org/ https://www.microchip.com/design-centers/microcontrollers
	2	LO2	System design – input and output devices – part 1.	Learners could independently select and investigate input devices to implement the selected control system problem. They could undertake a basic investigation of the input devices required including how they function, the type of signals they produce, and how they will be connected to the programmable device.		
	3	LO2	System design – input and output devices – part 2.	In this lesson, learners could continue to independently investigate suitable output devices required to implement the selected control system problem. They could find out how the devices operate, and the type of signal they require to enable them to function correctly. They could investigate how they can be connected to the programmable device. By the end of this lesson, learners should have completely defined the hardware requirements for the system.	**R116 LO2** – Learners will be able to identify and specify suitable input and output devices for a practical control system design problem. They will also be able to identify any other peripheral requirements (e.g. mechanical construction, interconnections etc).	
	4	LO2	System design – using system diagrams – part 1.	In these two lesson, learners could be introduced to the use of diagrams to help with planning and programming of their control system. This could include the use of block diagrams to represent the overall system, and the use of flow diagrams and charts to aid with programming.		Free software for creating flowcharts to assist programming could be useful, such as https://www.edrawsoft.com/create-programming-flowchart.html

	Event	Learning Outcome	Topic area/subtopic Area (from R116 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Spring Term	**5**	**LO2**	System design – using system diagrams – part 2.	Learners could continue to produce block diagrams which represent their whole system (e.g. input, outputs, process devices and any feedback), and more detailed flow charts to represent system operation in preparation for programming and testing.	**R116 LO2** – Learners will be able to start developing system diagrams showing layout of their control system solution, and flowcharts in preparation for programming.	
	6	**LO2**	System design – introduction to programming and simulation tools.	Teachers could provide a more detailed introduction to the programmable device (hardware) selected for the control system, including software tools for programming and simulation. Learners could begin to undertake simple programming activities using the selected programmable hardware and software, including how to transfer/download and operate software code to the device.		Websites and video tutorials could be useful to show how to setup and program systems, such as https://www.adafruit.com/
	7	**LO2**	Practical system design and programming activity.	In the following series of six lessons, learners will, with guidance, construct and program a complete control system solution. This will include the use of software simulation tools before transferring working code to a physical programmable device. Learners will already have decided upon input and output devices required for the system.		
	8	**LO2**	Practical system design and programming activity.	Learners will continue to write and simulate software for a given control system problem. They could use system diagrams and flow charts to help with the task, and record step by step progress using annotated screen shots and photographs.		
	9	**LO3**	Practical system design and programming activity.	Learners will continue to program and simulate the given control system problem. Evidence of simulation could be presented as annotated screen shots clearly showing simulation taking place.		
	10	**LO2**	Practical system design and programming activity.	Learners could continue by downloading part-completed software to their control system hardware for initial review and testing. Rework and reprogramming will undoubtedly be required throughout the activity.		

	Event	Learning Outcome	Topic area/subtopic Area (from R116 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Summer Term	**1**	**LO2**	Practical system design and programming activity.	Learners should be working to conclude the activity by having completed software ready to download and test on a physical system.		
	2	**LO2**	Practical system design and programming activity.	In the final lesson on programming, simulation and constructing a working control system solution, learners could draw together evidence. This could include step by step evidence including screen shots and photos showing development of the programming activity. It could also show how the program has been downloaded and operated on physical hardware and could show a video of the control system functioning.	**R116 LO2** – Learners will be able to show well documented evidence of design, development, and simulation of a control system solution, including transfer to physical hardware.	
	3	**LO2**	Synoptic links to other units.	In this lesson, learners could review work completed in LO2 of this unit and make links to other units in the specification (especially unit R113). They could produce a simple table documenting links from content covered in LO2 to R113, and other units.	**R113 LO2** – Learners will be able to relate to the systems approach, process devices and input and output devices.	
	4	**LO3**	Developing control system test plans – part 1.	Learners may have already been undertaking testing of their control system solution throughout the development stage. In this lesson, teachers could introduce the formal requirements for system testing to ensure correct and safe operation, and to comply with any customer or regulatory requirements. This could begin with the development of structured test plans to test parts of the system (sub system tests) and the complete system (full system test).		Templates could be used to develop test plans, such as the following which is a tabulated planning template with: step, date, expected outcome, actual outcome and pass/fail https://www.smartsheet.com/test-case-templates-examples

	Event	Learning Outcome	Topic area/subtopic Area (from R116 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Summer Term	**5**	**LO3**	Developing control system test plans – part 2.	Learners could develop a complete test plan for their own control system solution, including the testing of any sub-systems separately as required. The test plan could include expected outcomes for given conditions and should also account for unexpected combinations of conditions.	**R116 LO3** – Learners will be able to produce a detailed test plan in preparation to test their own control system.	
	6	**LO3**	Practical control system testing.	In the following two lessons learners will use their test plans to functionally test their own control system solution, confirming correct operation or otherwise.		
	7	**LO3**	Practical control system testing.	Learners will complete and record functional testing of their own control system solution. This could include testing of hardware devices, and correct operation of software. Results could be recorded in tabulated form using a test template provided. Evidence of testing taking place could also be recorded using annotated photographs or a short video.	**R116 LO3** – Learners will be able to use their test plan to perform testing of their own test system, recording findings.	
	8	**LO3**	Interpreting test results and practical system refinement.	In the final series of lessons learners could interpret the results of testing and make suggestions for refinement to the system to ensure correct and enhanced operation.		Internet resources related to 'functional testing' and refinement of control systems could be useful, such as http://softwaretestingfundamentals.com/functional-testing/
	9	**LO3**	Interpreting test results and practical system refinement.	Learners could implement system refinements (hardware and/or software) to ensure that their system functions correctly. They could also make enhancements to refine system operation to make it more efficient.		

	Event	Learning Outcome	Topic area/subtopic Area (from R116 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Summer Term	**10**	**LO3**	Interpreting test results and practical system refinement.	In this final lesson, learners could conclude by summarising their test results, and clearly identifying refinements made to their own system. Evidence of refinements made could be shown using annotated screen shots or photographs. Refinements that could be made (but which have not been implemented) could be summarised in a brief write-up or presentation.	**R116 LO3** – Learners will be able to use the outcomes of their test plan, and other evidence, to make refinements to their control system. This could include refinements to both hardware and software.	

Did you know?

OCR Resources: *the small print*

OCR's resources are provided to support the delivery of OCR qualifications, but in no way constitute an endorsed teaching method that is required by OCR. Whilst every effort is made to ensure the accuracy of the content, OCR cannot be held responsible for any errors or omissions within these resources. We update our resources on a regular basis, so please check the OCR website to ensure you have the most up to date version.

This resource may be freely copied and distributed, as long as the OCR logo and this small print remain intact and OCR is acknowledged as the originator of this work.

Our documents are updated over time. Whilst every effort is made to check all documents, there may be contradictions between published support and the specification, therefore please use the information on the latest specification at all times. Where changes are made to specifications these will be indicated within the document, there will be a new version number indicated, and a summary of the changes. If you do notice a discrepancy between the specification and a resource please contact us at: resources.feedback@ocr.org.uk.

OCR acknowledges the use of the following content: N/A

Whether you already offer OCR qualifications, are new to OCR, or are considering switching from your current provider/awarding organisation, you can request more information by completing the Expression of Interest form which can be found here: www.ocr.org.uk/expression-of-interest

Please get in touch if you want to discuss the accessibility of resources we offer to support delivery of our qualifications: resources.feedback@ocr.org.uk

Looking for a resource?

There is now a quick and easy search tool to help find **free** resources for your qualification:

www.ocr.org.uk/i-want-to/find-resources/

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our **Customer Support Centre**.

Vocational qualifications

Telephone 02476 851509
Facsimile 02476 851633
Email vocational.qualifications@ocr.org.uk

www.ocr.org.uk

Cambridge Assessment

CERTIFIED ISO 9001 UKAS MANAGEMENT SYSTEMS 001