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Cambridge **NATIONALS LEVEL 1/2**

SYSTEMS CONTROL IN ENGINEERING

Cambridge NATIONALS

Specification
OCR Level 1/2 Cambridge National Award in Systems Control in Engineering (60 glh)
OCR Level 1/2 Cambridge National Certificate in Systems Control in Engineering (120 glh)

Version 5 - December 2019

ocr.org.uk/cambridgenationals

Summary of key changes to this specification

Section	Title of section and change	Version and date issued
3.3 Grading and awarding grades	Additional text added to clarify the potential for grade thresholds to change.	Version 5 December 2019
All	New format for the specification, however with the exception of the changes highlighted below, the content remains unchanged.	Version 4 September 2019
Throughout	The term 'model assignment' has been replaced with 'set assignment' throughout.	
4.5 Authentication	Updated information on the use of Centre authentication forms.	
6.2 Accessibility	Updated information on approval requirements and permissible access arrangements.	
7 Administration	Updated information	
8.2 Progression from these qualifications	Updated information	
8 Other information	The following information has been removed: Key Skills Functional Skills	
Appendix B: Marking criteria for centre assessment, Unit R116: Process control systems	LO3 – Minor typographical corrections to MB1 and MB2.	
2.3 Unit R113: Electronic principles	At the end of each unit, updated *Connections between units for synoptic assessment*	Version 3 November 2018
2.4 Unit R114: Simulate, construct and test electronic circuits		
2.5 Unit R115: Engineering applications of computers		
2.6 Unit R116: Process control systems		
3.2 Synoptic assessment	Updated section	
Appendix B Marking criteria for centre assessment	Updated Guidance on synoptic assessment for each unit	
7.4 Unit and qualification resits	Updated information about resits for the externally assessed unit	Version 2 September 2018

OCR Cambridge Nationals in Systems Control in Engineering

Qualification title	Guided Learning Hours (GLH)	Entry Code	Reference
OCR Level 1/2 Cambridge National Award in Systems Control in Engineering	60	J833	601/1406/X
OCR Level 1/2 Cambridge National Certificate in Systems Control in Engineering	120	J843	601/1407/1

Contents

1 Introduction to Cambridge Nationals in Systems Control in Engineering

1.1 Qualification aims

Systems control in engineering uses sensors to measure the output performance of a device being controlled and feedback to operate actuators that constantly adjust for a desired performance. This qualification is aimed at learners who wish to study the range of computer and microprocessor applications in engineering, and learn how systems are used across a range of engineering environments such as product design, automated manufacturing, maintenance and stock control. Learners will use computer-based simulation software to produce printed circuit boards (PCB) and practical skills to test the operation of circuits. Through review, learners will evaluate the completed circuits to suggest improvements in design.

The Cambridge Nationals in Systems Control in Engineering will develop learners' understanding of computer and microprocessor applications in engineering and their knowledge of basic electronic principles, applying these to the manufacture of electronic and electrical circuits. Learners will develop knowledge and understanding of the design, simulation and testing of microprocessor / microcontroller control systems and consider how a systems design problem is best solved through the use of appropriate sensors, transducers and programmable devices. Learners are required to test the performance of their design system and be able to transfer their program to a programmable device such as programmable logic controllers (PLC) or programmable interface controllers (PIC).

A practical approach to teaching and learning will provide learners with knowledge in engineering technology and underpin the assessment of their skills, challenging learners to develop scientific and mathematical techniques, encouraging critical thinking and apply dextrous skills through engaging practical experiences.

The Cambridge Nationals in Systems Control in Engineering can be delivered separately or as part of an engineering curriculum providing useful contextualisation alongside other Cambridge Nationals in Engineering and GCSE Design and Technology subjects as well as the opportunity to apply scientific and mathematic core principles at Level 2.

Centres will need access to engineering production equipment such as Computer Aided Design (CAD) and Computer Numerical Control (CNC) and will benefit from offering this qualification in association with OCR Cambridge Nationals in Principles in Engineering and Engineering Business.

This specification contains OCR's Cambridge National Award/Certificate in Systems Control in Engineering.

1.2 Qualification summary

The Cambridge Nationals in Systems Control in Engineering consists of two qualifications:

The OCR Level 1/2 Cambridge National Award in Systems Control in Engineering consists of two mandatory units.

The OCR Level 1/2 Cambridge National Certificate in Systems Control in Engineering consists of four mandatory units.

1.3 Qualification size (GLH and TQT)

The size of the qualification is described in terms of Guided Learning Hours (GLH) and Total Qualification Time (TQT).

GLH indicates the approximate time (in hours) the teacher will spend supervising or directing study time and assessment activities. We have worked with people who are experienced in delivering related qualifications to determine what content needs to be taught and how long it will take to deliver.

TQT is comprised of two elements: GLH, and an estimate of the number of hours a learner will reasonably spend on any unsupervised learning or assessment activities (including homework) so they can successfully achieve their qualification.

OCR level 1/2 Cambridge National Award in Systems Control in Engineering requires 60 GLH in total. Total qualification time (TQT) is 68.

OCR level 1/2 Cambridge National Certificate in Systems Control in Engineering is 120 GLH in total. TQT is 135.

1.4 Prior learning/attainment

Learners who are taking courses leading to this qualification should normally have followed a corresponding Key Stage 3 Programme of Study within the National Curriculum. There is no requirement for learners to achieve any specific qualifications prior to undertaking this qualification.

1.5 Overview of the qualifications

Units	Assessment method	GLH	J833 Award 60 GLH	J843 Certificate 120 GLH
Mandatory				
R113: *Electronic principles*	Written paper OCR set and marked 1 hour – 60 marks (60 UMS) Learners answer all questions	30	M	M
R114: *Simulate, construct and test electronic circuits*	Centre-assessed tasks OCR-moderated Approx 10–12 hours – 60 marks (60 UMS)	30	M	M
R115: *Engineering applications of computers*	Centre-assessed tasks OCR-moderated Approx 10–12 hours – 60 marks (60 UMS)	30	N/A	M
R116: *Process control systems*	Centre-assessed tasks OCR-moderated Approx 10–12 hours – 60 marks (60 UMS)	30	N/A	M
Key: M = mandatory unit				

A bank of set assignments is available free of charge from the OCR website for the centre-assessed units R114 – R116.

2 Units

2.1 Guidance on unit content

Use of i.e./e.g. in unit content

The unit content describes what has to be taught to ensure that learners are able to access the highest marks.

Anything which follows an i.e. details what must be taught as part of that area of content.

Anything which follows an e.g. is illustrative, it should be noted that where e.g. is used, learners must know and be able to apply relevant examples in their work, though these do not need to be the same ones provided in the unit content.

Teachers will need to ensure that any modifications to tasks from the bank of set assignments for the optional units, do not expect the learner to do more than they have been taught, but they must enable them to access the full range of marks as described in the marking criteria.

For externally assessed units, where the content contains i.e. and e.g. under specific areas of content, the following rules will be adhered to when setting questions:

- a direct question may be asked where the unit content is shown with an i.e.
- where unit content is shown as an e.g., a direct question will not be asked about that example. Any questions relating to the area of content will offer learners the opportunity to provide their own examples, as the unit has not specified with which examples they should be familiar.

2.2 Guidance on practical activity

The specification content includes specific requirements associated with health and safety and provides opportunities to promote safe working practice through developing knowledge and understanding during practical activities.

Care must be taken by individual centres to follow all health and safety requirements and quality assurance procedures specific to each practical activity and ensure they have the appropriate health-and-safety policies in place relating to the use of equipment by learners, even if the equipment is not specified in the unit content.

Throughout practical activities, centres must exercise continuing supervision to ensure essential compliance with Health and Safety requirements.

2.3 Unit R113: *Electronic principles*

Aims

This unit will develop learners' knowledge of basic electronic principles. Learners will consider how these can be applied to the design, maintenance and repair of electrical/electronic systems used within engineering products.

Learners will understand the fundamentals of electronic circuits and be able to design, construct and test a range of electronic circuits. Learners will use techniques to identify potential electrical hazards and apply fault-finding procedures using appropriate test equipment.

On completion of this unit, learners will have knowledge of how basic electronic circuits operate, and understand how to measure and calculate circuits and their component values as well as how to test circuits.

Learners studying for the Certificate will be able to apply knowledge and understanding gained in this unit to help develop their skills further during the completion of Units R115 and R116.

Please refer to section 2.2 for guidance on practical activities.

Learning Outcome 1: Understand basic electronic principles

Learners must be taught:

- principles, units and measurement, i.e.
  - current (amps)
  - Electromotive Force (EMF)
  - Induction/back EMF (henry)
  - potential difference (volts)
  - resistance (ohms)
  - capacitance (farads)
  - power and energy (watts)
  - frequency (hertz)
- values for voltage, current, resistance and power by calculation, i.e.
  - Ohm's Law and power law ($V=IR$, $P=IV$, $P=I^2R$)
- circuit components, symbols and diagrams, i.e.
  - interpretation of simple circuit schematic diagrams
- series and parallel circuits, i.e.
  - uses of series and parallel circuits
  - calculation of resistance within series and parallel circuits
- the operation of a potential divider, i.e.
  - calculation of component values for potential divider circuits
  - calculation of output voltage from a potential divider circuit
- types of power sources available, i.e.
  - battery
  - solar
  - mains
  - combined

- reasons for selection of suitable power sources, i.e.
  - portable, e.g. battery
  - sustainable, e.g. solar
  - continuous, e.g. mains (under normal conditions)
- function and application of voltage regulators in power supply circuits

Learning Outcome 2: Understanding the operating principles of electronic components

Learners must be taught:

- appropriate cable types for specific applications giving reasons for their use, i.e.
  - solid core
  - multi-core
  - ribbon
  - connection devices
- identification and application of resistors used in electronic circuits, i.e.
  - fixed (preferred values E12 series)
  - variable resistors (potentiometers), i.e. negative temperature coefficient (NTC), thermistor, light dependent resistors (LDR)
  - resistor values determined by measurement, calculation and colour code
  - rating/tolerance
- identification and application of capacitors used in electronic circuits, i.e.
  - types of capacitor, i.e.
    - polarised
    - non-polarised
    - rating/tolerance
- application and function of resistor/capacitor circuit and RC time constant
- identification and application and function of switches, i.e.
  - push to break (PTB)
  - push to make (PTM)
  - momentary action
  - latching
  - contact arrangements i.e.
    - Single Pole Single Throw (SPST)
    - Single Pole Double Throw (SPDT)
    - Double Pole Single Throw (DPST)
    - Double Pole Double Throw (DPDT)
  - reed
  - micro
  - toggle
- application, function and benefits of circuit protection, i.e.
  - fuse
  - diode
- systems approach, i.e.
  - open and closed loop
  - input, process, output, feedback
  - system block diagrams

- identification, function and application of input devices, i.e.
  - photodiode
  - phototransistor
  - LDR
  - NTC thermistor
  - switch
  - moisture sensor
  - microphone
  - pressure switch
  - 'touch screen'
- identification, function and application of process devices, i.e.
  - semi-conductors i.e.
    - diodes
    - NPN transistors, i.e.
      - single transistor as amplifier or switch
      - Darlington Pair
      - transistor arrays
  - integrated circuits, i.e.
      - operational amplifiers, i.e. comparator
      - monostable, astable, bistable circuit
      - logic functions/gates, i.e.
        - AND
        - OR
        - NAND
        - NOR
        - NOT
        - XOR
        - application of logic gates singly and in combination
      - single digit counter
- identification, function and application of output devices, i.e.
  - Piezo-electric buzzers/sounders
  - Lamps
  - Light Emitting Diode (LED)
  - LED 7 segment display
  - Liquid Crystal Display (LCD) display module
  - Solenoid
  - Relays
- application and function of DC electric motor control, i.e.
  - forward and reverse motor
- identification of smart and modern materials, i.e.
  - quantum tunnelling composite (QTC)
  - shape memory alloys (SMA)

Learning Outcome 3: Know test methods for electronic circuits

Learners must be taught:

- techniques to identify potential electrical hazards and the reasons for their use, i.e.
  - visual inspection of equipment

- portable appliance testing (PAT) compliance
- use of residual current device (RCD)

- fault-finding procedures, i.e.
  - visual inspection
  - the half split method of fault location
  - testing, i.e.
    - truth tables
    - expected values
- appropriate test equipment, i.e.
  - power supply unit
  - multimeter for voltage, current, resistance and continuity
  - logic probe for logic levels
  - signal generator and oscilloscope (i.e. virtual and physical)

Learning Outcome 4: Understand commercial circuit construction methods

Learners must be taught:

- discrete, through hole and surface mount components
- benefits and drawbacks to the manufacturer of using surface mount components and using alternatives
- the manufacturing processes used within commercial circuit construction, i.e.
  - flow solder process
  - pick and place robot
  - manual component placement
- quality assurance methods used during commercial printed circuit board (PCB) production, i.e.
  - automatic test
  - visual inspection

Connections between units for synoptic assessment

Whilst we do not prescribe the order in which units should be assessed, because of the interdependence between units it is strongly recommended that learners complete the learning for this unit R113 before completing assessment of other units within this qualification, as teaching of this unit will develop key knowledge, skills and understanding which should be applied and assessed in context further throughout the qualification.

Further information regarding synoptic assessment within this qualification can be found under section 3.2 *Synoptic Assessment*.

Assessment guidance

This unit will be assessed through a 1 hour externally assessed examination.

During the external assessment, learners will be expected to demonstrate their understanding through questions that require the skills of analysis and evaluation in particular contexts.

2.4 Unit R114: *Simulate, construct and test electronic circuits*

Aims

This unit covers construction techniques and processes used in the manufacture of electronic and electrical circuits. It uses computer based simulation software to prototype and test the operation of circuits and produce designs for printed circuit boards (PCB).

Learners will develop knowledge and understanding of the construction techniques and processes used in the manufacture of electronic and electrical circuits.

On completion of this unit, learners will understand how to build and evaluate the performance of a simple electronic circuit.

Learners studying for the Certificate will be able to apply knowledge and understanding gained in this unit to help develop their skills further during the completion of Units R115 and R116.

Please refer to section 2.2 for guidance on practical activities.

Learning Outcome 1: Be able to use CAD for circuit simulation and design

Learners must be taught:

- circuit schematic diagram drawing using CAD software
- circuit simulation and test using CAD software
- PCB layout production to include both track and component views (e.g. export of schematic diagrams, use of component libraries)

Learning Outcome 2: Be able to construct circuits

Learners must be taught:

- safe use of manually-operated hand tools, i.e.
  - soldering iron
  - wire cutters
  - wire strippers
  - pliers
  - screwdrivers
  - de-soldering tools
  - manual/PCB drills
  - appropriate PPE
- circuit construction following circuit diagram(s) (e.g. transistor circuits using sensors and switches, alarm circuits, audio circuits, optical circuits, counting circuits, logic circuits)
- safe construction of PCBs (e.g. photoresist methods, etch resist methods, engraving)
- circuit construction using appropriate methods (e.g. component assembly, PCB soldering techniques, heat sinks for delicate components)
- construction techniques for joining external components, i.e.
  - soldering
  - connecting between boards (e.g. ribbon cable, connecting plugs and sockets, PCB to case fittings, sleeves, insulation, heat shrink, screw terminals)

Learning Outcome 3: Be able to test electronic circuits

Learners must be taught:

- techniques for testing electronic circuits, i.e.
  - visual inspection, i.e.
    - fitting of incorrect component
    - mis-placed components
    - dry joint
    - bridged or damaged PCB tracks
  - appropriate testing and fault-finding methods (e.g. continuity testing, test-point voltage, current measurement, signal tracing (e.g. half-split, input to output, output to input)
  - use of physical test equipment (e.g. power supplies, multi-meter, logic probe, oscilloscope, signal generator)

Connections between units for synoptic assessment

Whilst we do not prescribe the order in which units should be assessed, because of the interdependence between units it is strongly recommended that learners complete the learning for unit R113 before completing assessment of this unit as they will have been taught key knowledge, skills and understanding which should be applied and assessed in context further in this unit.

Further information regarding synoptic assessment within this qualification can be found under section 3.2 *Synoptic Assessment.*

2.5 Unit R115: *Engineering applications of computers*

Aims

This unit covers the range of computer and microprocessor applications within engineering and considers how systems are used across a range of engineering activities from product design and development to automated manufacturing, maintenance and stock control.

Learners will develop knowledge and understanding of the range of computer and microprocessor applications within engineering and will consider how computer systems are used across a range of engineering activities.

This unit will explore how computers are used within engineering industries to design and manufacture new products with Computer Aided Design (CAD) and Computer Aided Manufacture (CAM) and the use within automated manufacturing such as Programmable Logic Controllers (PLC), Programmable Interface Controller (PIC).

On completion of this unit, learners will understand the specific processes involved in electronic systems control and have an appreciation of how computers communicate and transfer data in Human Machine Interface (HMI) and expert systems.

Please refer to section 2.2 for guidance on practical activities.

Learning Outcome 1: Understand how computers are used in engineering design, manufacture and process control

Learners must be taught:

- how computers are used within engineering industries to design new products, i.e.
  - how CAD systems and graphical packages are used to design and prototype new products
- how computers are used within engineering industries to manufacture products, monitor production and manage process control, i.e.
  - how CAM systems are used in the manufacturing process
  - how computers are used to automate manufacturing (e.g. PLC, PIC)
  - how computers are used to monitor production/production operations (e.g. automated test systems)
  - how computers are used for stock control (e.g. automatic stock movement, Radio Frequency Identification Devices (RFID))
- features of computer controlled automation (e.g. temperature control, weight control, position sensing, size sensing, workflow, warehousing and product movement, safety systems and machine interlocks).

Learning Outcome 2: Understand how computers are used for maintenance of engineering systems

Learners must be taught:

- how computers are used within engineering systems maintenance, i.e.
  - Human Machine Interface (HMI), i.e.
    - system operation, diagnostics and maintenance
    - use of system operation data
    - modification or correction of system operation

- o expert systems, i.e.
  - use within system operation, diagnostics and maintenance
  - use of system operation data
  - interpretation of results to modify or correct system operation

Learning Outcome 3: Know how computers are used to communicate and use data for production and maintenance

Learners must be taught:

- the use of computers to communicate and exchange data during production operations (e.g. assembly/production recording, efficiency information, cycle times)
- how data from production operations is used in maintenance (e.g. assembly/production recording, efficiency information, cycle times, maintenance planning)
- how computers are used to communicate and exchange data for maintenance operations (e.g. remote monitoring of engineered systems, transmission of service data, monitoring and recording maintenance operations, parts used, control of stock, prediction of failure, work scheduling)
- the use of hand-held computer devices in manufacturing and maintenance systems i.e.
  - o bar code scanning (e.g. monitor stock usage, automatic update of service records)
  - o service information and instructions (e.g. data loggers, data collection and analysis, work scheduling, maintenance checklists)

Connections between units for synoptic assessment

Whilst we do not prescribe the order in which units should be assessed, because of the interdependence between units it is strongly recommended that learners complete the learning for unit R113 before completing assessment of this unit as they will have been taught key knowledge, skills and understanding which should be applied and assessed in context further in this unit.

Further information regarding synoptic assessment within this qualification can be found under section 3.2 *Synoptic Assessment.*

2.6 Unit R116: *Process control systems*

Aims

This unit will develop learners' knowledge of microprocessor/microcontroller control systems in engineering systems such as production, engine control, domestic appliances and office equipment. Learners will study a range of systems designs and consider how each system uses appropriate input and output devices.

Learners will develop knowledge and understanding of the design, simulation and testing of microprocessor/microcontroller control systems and consider how a systems design problem is best solved through the use of appropriate sensor, transducer and programmable logic controllers (PLC)/ programmable interface controllers (PIC) devices. Learners are required to test the performance of their design system and be able to transfer their program to a programmable device.

On completion of this unit, learners will understand how microprocessor/microcontroller control systems are used in engineering systems and be able to design and test a simple control system.

Please refer to section 2.2 for guidance on practical activities.

Learning Outcome 1: Understand the application and operation of microcontrollers and microprocessors in engineered products

Learners must be taught:

- simple layouts of microcontroller/ microprocessor in products or systems
- applications of microcontroller/ microprocessor in products or systems (e.g. production/assembly systems, engine control systems, office machines, domestic appliances, children's toys)
- the basic function of component parts of a control system i.e.
  - input devices (e.g. switch, temperature, position, light, flow, pressure)
  - control device (e.g. microprocessor, microcontroller)
  - output device (e.g. lamp, sounder/speaker, solenoid, relay)
- the operation of a control system within a product or system that use microprocessor, microcontroller control

Learning Outcome 2: Be able to design, develop and simulate a control system solution

Learners must be taught:

- techniques used to produce a control system solution
- the use of resources for a control system solution i.e.
  - use of systems diagrams i.e.
    - input, process (including feedback and variables) and output
    - use of block diagrams to define control systems
    - designs of instructions for control systems, i.e.
    - repeat loops and subroutines
  - use of input and output sensors (e.g. analogue/digital - switch, temperature, position, light, flow, pressure)
  - use of programming tools to create a control system programme (e.g. linear, symbolic, flow-chart)
- use of simulation for a control system solution
- transfer of control programs to programmable devices (e.g. PIC / PLC)

Learning Outcome 3: Be able to test control systems

Learners must be taught:

- development of test plans to ensure functionality of control systems (e.g. sub system test, full system test)
- control system testing using a test plan to evaluate the performance of the system
- interpretation of test results to refine control systems

Connections between units for synoptic assessment

Whilst we do not prescribe the order in which units should be assessed, because of the interdependence between units it is strongly recommended that learners complete the learning for unit R113 before completing assessment of this unit as they will have been taught key knowledge, skills and understanding which should be applied and assessed in context further in this unit.

Further information regarding synoptic assessment within this qualification can be found under section 3.2 *Synoptic Assessment.*

3 Assessment of Cambridge Nationals in Systems Control in Engineering

3.1 Overview of the assessment in the Cambridge Nationals Award and Certificate in Systems Control in Engineering

Entry code	Qualification title	GLH	Reference
J833	OCR Level 1/2 Cambridge National Award in Systems Control in Engineering	60	601/1406/X
Made up of: Units R113 and R114.			
J843	OCR Level 1/2 Cambridge National Certificate in Systems Control in Engineering	120	601/1407/1
Made up of: Units R113, R114, R115 and R116.			

Individual unit details below:

Unit R113: *Electronic principles*	
30 GLH 1 hour written paper 60 marks (60 UMS) OCR set and marked	This question paper: • consists of two sections, comprising short-answer and extended-response questions • assesses the quality of written communication.
Unit R114: *Simulate, construct and test electronic circuits*	
30 GLH Centre-assessed tasks 60 marks (60 UMS) Centre-assessed and OCR-moderated	The centre-assessed tasks: • will be practical tasks in the context of an assignment, selected from the OCR bank of set assignments.
Unit R115: *Engineering applications of computers*	
30 GLH Centre-assessed tasks 60 marks (60 UMS) Centre-assessed and OCR-moderated	The centre-assessed tasks: • will be practical tasks in the context of an assignment, selected from the OCR bank of set assignments.
Unit R116: *Process control systems*	
30 GLH Centre-assessed tasks 60 marks (60 UMS) Centre-assessed and OCR-moderated	The centre-assessed tasks: • will be practical tasks in the context of an assignment, selected from the OCR bank of set assignments.

A bank of set assignments is available free of charge from the OCR website for the centre-assessed units R114–R116.
To claim the OCR Level 1/2 Cambridge National Award in Systems Control in Engineering (60 GLH) qualification, learners must complete Units R113 and R114.

To claim the OCR Level 1/2 Cambridge National Certificate in Systems Control in Engineering (120 GLH) qualification, learners must complete Unit R113, Unit R114, Unit R115 and Unit R116.

3.2 Synoptic assessment

Synoptic assessment is an important aspect of the OCR Level 1/2 Cambridge National Certificate in Systems Control in Engineering. Assessment in this qualification is designed to require learners to draw on the skills, knowledge and understanding they have acquired through their studies and utilise them in an appropriate and relevant way to complete the key tasks, leading to a more progressive and holistic understanding of the subject content. We have taken this approach to support learners in developing their ability to go on to apply what they learn from this qualification to new and different situations and contexts.

Learners will take four mandatory units. We do not prescribe the order in which the units are assessed but because of the interdependence between the units, learners will need to synthesize the knowledge, skills and understanding they develop in the first two units, in order to apply them to relevant contexts when they complete the assessment for the other units. For that reason, we strongly recommend that learners complete the learning for the following units R113 Electronic principles, and R114 Simulate, construct and test electronic circuits, before undertaking assessment in other units.

Synoptic assessment is included between units R113 and R114 and all other units. This specification will support synoptic assessment by:

- showing teaching and learning connections between the units across the specification
- giving guidance, with the marking criteria for the units, about where learners could apply the knowledge and understanding from the core units to improve their performance.

At the end of the marking criteria for each unit, we have provided information on connections between areas of learning to help with the planning of teaching and learning, and to support assessment decisions for the internally assessed units. Learners should sequentially build up their knowledge, skills and understanding between the first two units R113 and R114 and the other units through their programme of learning. You will find that no matter what units are taken, they will always draw on fundamental knowledge, skills and understanding from the first two units. For example, in Unit R113 learners will develop the following knowledge, skills and understanding which can be applied to other units within the qualification, such as:

- In unit R114, learners may build on their learning from R113, about the basic electronic principles covering circuits and their uses when they construct circuits
- In unit R116, learners may build on their learning from R113 about switches and sensors, in developing and designing their control systems and also use the testing processes knowledge from unit R114.

This qualification also supports synoptic learning and assessment by employing the following principles:

- to enable learners to demonstrate an ability to use and apply a range of different methods and/or techniques
- to provide assessment that encourages learners to put forward different ideas and/or explanations to support decisions they have made
- to develop learners' ability to suggest or apply different approaches to contexts and situations
- to develop and assess learners' use of transferable skills
- to enable learners to demonstrate analytical and interpretation skills (of situations and/or results) and the ability to formulate valid well-argued responses
- to enable learners to evaluate and justify their decisions, choices and recommendations.

3.3 Grading and awarding grades

All results are awarded on the following scale:

- Distinction* at Level 2 (*2)
- Distinction at Level 2 (D2)
- Merit at Level 2 (M2)
- Pass at Level 2 (P2)
- Distinction at Level 1 (D1)
- Merit at Level 1 (M1)
- Pass at Level 1 (P1).

The shortened format of the grade will be displayed on Interchange and some administrative documents provided by OCR. However, the full format of the grade will appear on the certificates issued to learners.

The boundaries for Distinction at Level 2, Pass at Level 2, and Pass at Level 1 are set judgementally. Other grade boundaries are set arithmetically.

The Merit (Level 2) is set at half the distance between the Pass (Level 2) grade and the Distinction (Level 2) grade. Where the gap does not divide equally, the Merit (Level 2) boundary is set at the lower mark (e.g. 45.5 would be rounded down to 45).

The Distinction* (Level 2) grade is normally located as far above Distinction (Level 2) as Merit (Level 2) is below Distinction (Level 2).

To set the Distinction (Level 1) and Merit (Level 1) boundaries, the gap between the Pass (Level 1) grade and the Pass (Level 2) grade is divided by 3, and the boundaries set equidistantly. Where this division leaves a remainder of 1, this extra mark will be added to the Distinction (Level 1)-Pass (Level 2) interval (i.e. the Distinction (Level 1) boundary will be lowered by 1 mark). Where this division leaves a remainder of 2, the extra marks will be added to the Distinction (Level 1)-Pass (Level 2) interval, and the Merit (Level 1)-Distinction (Level 1) interval, i.e. the Distinction (Level 1) boundary will be lowered by 1 mark, and the Merit (Level 1) boundary will be lowered by 1 mark.

For example, if Pass (Level 2) is set judgementally at 59, and Pass (Level 1) is set judgementally at 30, then Distinction (Level 1) is set at 49, and Merit (Level 1) is set at 39.

Grades are indicated on qualification certificates. However, results for learners who fail to achieve the minimum grade (Pass at Level 1) will be recorded as *unclassified* (U or u) and this is **not** certificated.

These qualifications are unitised schemes. Learners can take units across several different series and they can also resit units. Please refer to section 7.4 *Unit and qualification resits*. Grade boundaries are set per unit, per series. As such, grade boundaries may be set in different places for a unit in different series. When working out learners' overall grades, OCR needs to be able to compare performance on the same unit in different series when different grade boundaries may have been set, and between different units. OCR uses a Uniform Mark Scale to enable this to be done.

A learner's uniform mark for each unit is calculated from the learner's raw mark on that unit. The raw mark boundary marks are converted to the equivalent uniform mark boundary. Marks between grade boundaries are converted on a pro rata basis.

When unit results are issued, the learner's unit grade and uniform mark are given. The uniform mark is shown out of the maximum uniform mark for the unit, e.g. 40/60.

The uniform mark boundaries for each of the assessments are shown below:

Unit GLH	Max Unit Uniform Mark	Unit Grade							
		Distinction* at L2	Distinction at L2	Merit at L2	Pass at L2	Distinction at L1	Merit at L1	Pass at L1	U
30	60	54	48	42	36	30	24	18	0

The learner's uniform mark for Unit R113 will be combined with the uniform mark for the centre-assessed units to give a total uniform mark for the qualification. The learner's overall grade will be determined by the total uniform mark. The following table shows the minimum total mark for each overall grade:

Qualification	Max Uniform Mark	Qualification Grade							
		Distinction* at L2	Distinction at L2	Merit at L2	Pass at L2	Distinction at L1	Merit at L1	Pass at L1	U
Award	120	108	96	84	72	60	48	36	0
Certificate	240	216	192	168	144	120	96	72	0

3.4 Performance descriptors

The performance descriptors indicate the level of attainment associated with Distinction at Level 2, Pass at Level 2 and Pass at Level 1. They are for use at awarding meetings. They give a general indication of the levels of attainment likely to be shown by a representative learner performing at these boundaries.

Performance descriptor – Distinction at Level 2

Learners will be able to:

- recall, select and apply **detailed** knowledge and **thorough** understanding of engineering
- present information **clearly** and **accurately**, using a **wide range** of technical language and engineering terminology
- apply **relevant** knowledge, understanding and skills in a **range** of situations to plan and carry out investigations and tasks **effectively**, testing their solutions, and working safely and with a **high degree** of **precision**
- analyse and evaluate the evidence available, reviewing and adapting their methods **where appropriate**
- make **reasoned** judgements and **substantiated** conclusions
- work **confidently and independently** to create material which reflects **thoughtful** planning, **skilled** development and **perceptive** evaluation as well as **actively demonstrating** practical skills at a **high level**.

Performance descriptor – Pass at Level 2

Learners will be able to:

- recall, select and apply **sound** knowledge and understanding of engineering
- present information **clearly** and with **some accuracy**, using a **range of** technical language and engineering terminology
- apply knowledge, understanding and skills in a **range** of situations to plan and carry out investigations and tasks, testing their solutions, and working safely and with **precision**
- review evidence available, analysing and evaluating **some** information **clearly** and making **some basic** adaptations to their methods
- make **judgements** and draw **appropriate** conclusions
- work with **independence** to create material which reflects **effective** planning, development and evaluation and an ability to demonstrate **sound** practical skills.

Performance descriptor – Pass at Level 1

Learners will be able to:

- recall, select and apply knowledge and understanding of **basic** aspects of engineering
- present **basic** information, using **limited** engineering terminology
- apply **limited** knowledge, understanding and skills to plan and carry out **simple** investigations and tasks, with an awareness of the need for safety and precision
- review evidence and draw **basic** conclusions
- show **some evidence of independent work** to create material which demonstrates a degree of planning, development and evaluation and **limited** practical skills.

3.5 Quality of written communication

Quality of written communication (QWC) is assessed in the mandatory externally assessed unit.

Learners are expected to:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- present information in a form that suits its purpose
- use a suitable structure and style of writing
- use specialist terminology, where applicable.

QWC is integrated into mark schemes and therefore assessed qualitatively, as an integral part of extended response questions.

4 The centre-assessed units (R114–R116)

This section provides guidance on the completion of the centre-assessed units.

4.1 The centre-assessed units

Each of the centre-assessed units (R114–R116) is designed to provide learners with the opportunity to build a portfolio of evidence to meet the learning outcomes for that unit.

We recommend that teaching and development of subject content and associated skills be referenced to real vocational situations, through the utilisation of appropriate industrial contact, vocationally experienced delivery personnel, and real-life case studies.

Units R114–R116 are centre-assessed and externally moderated by OCR. Centres can choose whether they would like moderation via the OCR Repository or postal moderation.

Appendix B of this specification contains assessment guidance for the centre-assessed units, which should be referred to in conjunction with the unit content and marking criteria grids to inform delivery of the units. The assessment guidance aims to provide clarification regarding the scope of the learning required in specific areas of the units where this is felt to be beneficial.

4.2 Tasks for the centre-assessed units

4.2.1 Units R114–R116

A bank of set assignments is provided by OCR for Units R114–R116. Centres must select from the set assignments provided to use when assessing their learners. The assignments will be available free of charge from the OCR website. Learners are able to work on the tasks anytime until the date the centre collects the work for internal assessment. OCR will review the set assignments annually which may result in an assignment being withdrawn and replaced. It is up to the centre to check the OCR website to see which set assignments are available to be used. We will give approximately 12 months' notice if a set assignment is to be withdrawn and replaced so that we do not disadvantage any learners who have already started working on an assignment that is to be replaced.

Centres can make modifications to the set assignments that OCR provides so that the assignment can be put within a local context that learners might relate to more easily, or to allow for differences in the materials, equipment and facilities at different centres. Guidance on what can be modified is given in each assignment in the section 'Information for Teachers' under *Scope of permitted set assignment modification*. If modifications are made to the set assignment, whether to just the scenario or to both the scenario and tasks, it is up to the centre to ensure that all learning outcomes can be met and that learners can access the full range of marks.

The duration of the assessment for centre-assessed units is included in the guided learning hours for the unit. Guidance will be given within the section 'Information for Teachers' in each set assignment as to approximately how long learners should expect to spend on each task.

The OCR set assignments are provided for summative assessment and not as practice materials.

Teachers must ensure learners are clear about the tasks they are to undertake and the criteria which they are expected to meet.

4.2.2 Methods of assessment

It is the assessor's responsibility to choose the best method of assessing a learner in relation to their individual circumstances. The methods chosen must be:

- valid
- reliable
- safe and manageable
- suitable to the needs of the learner.

Valid

Validity can be compromised if a learner does not understand what is required of them. For example, one valid method of assessing a learner's knowledge and understanding is to question them. If the questions posed are difficult for the learner to understand (not in terms of the content but the way they are phrased, for example) the validity of the assessment method is questionable.

As well as assessment methods being valid, the evidence presented must also be valid. For example, it would not be appropriate to present an organisation's equal opportunities policy as evidence towards a learner's understanding of how the equal opportunities policy operates within the organisation. It would be more appropriate for the learner to incorporate the policy within a report describing different approaches to equal opportunities.

Reliable

A reliable method of assessment will produce consistent results for different assessors on each assessment occasion. Internal moderators must make sure that all assessors' decisions are consistent.

Safe and manageable

Assessors and internal moderators must make sure that the assessment methods are safe and manageable and do not put unnecessary demands on the learner.

Suitable to the needs of the learner

OCR is committed to ensuring that achievement of these awards is free from unnecessary barriers. Centres must follow this commitment through when designing tasks and/or considering assessment.

4.3 Completing the tasks (for units R114–R116)

Teachers/assessors are expected to supervise and guide learners when undertaking work that is centre-assessed. It should be remembered, however, that the final pieces of work must be produced solely by the individual learner.

When supervising tasks, teachers/assessors are expected to:

- exercise continuing supervision of work in order to monitor progress and to prevent plagiarism
- exercise continuing supervision of practical work to ensure essential compliance with Health and Safety requirements
- ensure that the work is completed in accordance with the specification requirements and can be assessed in accordance with the specified marking criteria and procedures.

Centre-assessed work should be completed in the course of normal curriculum time, and supervised and marked by the teacher/assessor. Some of the work, by its very nature, may be undertaken outside the centre, for example, research work, testing, etc. As with all centre-assessed work, the teacher must be satisfied that the work submitted for assessment is the learner's own.

Learners are free to revise and redraft work without teacher/assessor involvement before submitting the work for assessment. The advice provided prior to final submission should only enable the learner to take the initiative in making amendments, rather than detailing what amendments should be made. This means that teachers/assessors must not provide templates, model answers or detail specifically what amendments should be made.

Adding, amending or removing any work after it has been submitted for final assessment will constitute malpractice.

4.3.1 Presentation of the final piece of work

Learners must observe the following procedures when producing their final piece of work for the centre-assessed tasks:

- work can be word processed or handwritten
- tables and graphs (if relevant) may be produced using appropriate ICT
- any copied material must be suitably acknowledged
- quotations must be clearly marked and a reference provided wherever possible
- a completed cover sheet must be attached to work submitted for moderation. The cover sheet must include the following information as well as the marks given for each of the assessment criteria:
  - centre number
  - centre name
  - candidate number
  - candidate name
  - unit code and title
  - assignment title.

4.4 Marking and moderating centre-assessed units

All centre-assessed units are internally marked by centre staff using OCR marking criteria and guidance and externally moderated by the OCR-appointed moderator.

The centre is responsible for appointing someone to act as the assessor. This could be the teacher who has delivered the programme or another person from the centre.

The marking criteria must be used to mark the learner's work. These specify the levels of skills, knowledge and understanding that the learner is required to demonstrate.

The primary evidence for assessment is the work submitted by the learner, however the following assessment methods are considered suitable for teachers/assessors to adopt for these qualifications:

- **observation** of a learner performing a task
- **questioning** of the learner or witness.

Observation

The teacher/assessor and learner should plan observations together but it is the teacher's/assessor's responsibility to record the observation properly (for example observing a learner undertaking a practical task). Further guidance on recording observations can be found in *Appendix A – guidance on witness statements*.

Questioning

Questioning the learner is normally an ongoing part of the formative assessment process and may, in some circumstances, provide evidence to support achievement of learning outcomes.

Questioning is often used to:

- test a learner's understanding of work which has been completed outside of the classroom
- check if a learner understands the work they have undertaken
- collect information on the type and purpose of the processes a learner has gone through.

If questioning is to be used as evidence towards achievement of specific learning outcomes, it is important that teachers/assessors record enough information about what they asked and how the learner replied, to allow the assessment decision to be moderated.

Questioning witnesses is normally an ongoing part of validating written witness statements. However, questioning witnesses can be used for other purposes. Teachers/assessors should be able to speak to witnesses and record, in whatever way is suitable, the verbal statements of these witnesses. A record of a verbal statement is a form of witness statement and could provide valuable evidence. Further guidance on the use of witness statements can be found in *Appendix A*.

4.4.1 Use of a 'best fit' approach to marking criteria

The assessment tasks should be marked by teachers/assessors according to the OCR marking criteria using a 'best fit' approach. For each of the marking criteria, teachers/assessors select the band descriptor provided in the marking grid that most closely describes the quality of the work being marked.

A range of marks is allocated to each learning outcome. Where marks are allocated to a number of statements within a learning outcome, marks should be awarded using a 'best fit' approach. For each of the learning outcomes, one of the descriptors provided in the mark scheme that most closely describes the quality of the work being marked should be selected.

Marking should be positive, rewarding achievement rather than penalising failure or omissions.

The award of marks **must be** directly related to the marking criteria.

- Each band descriptor covers all the relevant content for the learning outcomes.
- The descriptors should be read and applied as a whole.
- Make a best fit match between the answer and the band descriptors.
- An answer does not have to meet all of the requirements of a band descriptor before being placed in that band. It will be placed in a particular band when it meets more of the requirements of that band than it meets the requirements of other bands.
- Where there is more than one strand within the band descriptors for a learning outcome and a strand has not been addressed at all, it is still possible for the answer to be credited within that mark band depending upon the evidence provided for the remaining strands. The answer should be placed in the mark band most closely reflecting the standard achieved across all strands within the band descriptors for a learning outcome; however, in this scenario, the mark awarded for that band should reflect that a strand has not been addressed.

When deciding the mark within a band, the following criteria should be applied:

- the extent to which the statements within the band have been achieved.

For example:

- an answer that convincingly meets nearly all of the requirements of a band descriptor should be placed at or near the top of that band. Where the learner's work *convincingly* meets the statements, the highest mark should be awarded
- an answer that meets many of the requirements of the band descriptor should be placed in the middle of the band. Where the learner's work *adequately* meets the statements, the most appropriate mark in the middle range should be awarded
- if an answer is on the border-line between two bands but it is decided that it fits better the descriptors for the lower of these two bands, then it should be placed near the top of that band. Where the learner's work *just* meets the statements for the higher band, the lowest mark for that band should be awarded.

Teachers/assessors should use the full range of marks available to them and award full marks in any band for work that fully meets that descriptor. This is work that is 'the best one could expect from learners working at that level'.

4.4.2 Annotation of learners' work

Each piece of internally assessed work should show how the marks have been awarded in relation to the marking criteria.

The writing of comments on learners' work, and cover sheet, provides a means of communication between teachers during the internal standardisation and with the moderator if the work forms part of the moderation sample.

4.5 Authentication

Teachers/assessors must be confident that the work they mark is the learner's own. This does not mean that a learner must be supervised throughout the completion of all work, but the teacher must exercise sufficient supervision, or introduce sufficient checks, to be in a position to judge the authenticity of the learner's work.

Wherever possible, the teacher should discuss work-in-progress with learners. This will not only ensure that work is underway in a planned and timely manner, but will also provide opportunities for teachers/assessors to check authenticity of the work.

Learners must not plagiarise. Plagiarism is the submission of another's work as one's own and/or failure to acknowledge the source correctly. Plagiarism is considered to be malpractice and could lead to the learner being disqualified. Plagiarism sometimes occurs innocently when learners are unaware of the need to reference or acknowledge their sources. It is therefore important that centres ensure that learners understand that the work they submit must be their own and that they understand the meaning of plagiarism and what penalties may be applied. Learners may refer to research, quotations or evidence but they must list their sources. The rewards from acknowledging sources, and the credibility they will gain from doing so, should be emphasised to learners as well as the potential risks of failing to acknowledge such material.

Both learners and teachers must declare that the work is the learner's own.

- **Each learner** must sign a declaration before submitting their work to their teacher. A candidate authentication statement that can be used is available to download from the OCR website. These statements should be retained within the centre until all enquiries about

results, malpractice and appeals issues have been resolved**. A mark of zero must be recorded if a learner cannot confirm the authenticity of their work**.

- **Teachers** are required to declare the work submitted for internal assessment is the candidate's own work by completing a centre authentication form (CCS160) for each unit. Centre authentication forms should be retained within the centre until all post-results issues have been resolved.

4.5.1 Internal standardisation

It is important that all teachers/assessors work to common standards. Centres must ensure that, within each unit, the internal standardisation of marks across teachers/assessors and teaching groups takes place using an appropriate procedure.

This can be done in a number of ways. In the first year, reference material and OCR training meetings will provide a basis for centres' own standardisation. In subsequent years, this, or centres' own archive material, may be used. Centres are advised to hold preliminary meetings of staff involved to compare standards through cross-marking a small sample of work. After most marking has been completed, a further meeting at which work is exchanged and discussed will enable final adjustments to be made.

4.5.2 Submitting marks

All work for centre assessment is marked by the teacher and internally standardised by the centre. Marks are then submitted to OCR; see Section 4.6 for submission dates of the marks to OCR.

There should be clear evidence that work has been attempted and some work produced. If a learner submits no work for a centre-assessed unit, then the learner should be indicated as being absent from that unit. If a learner completes any work at all for a centre-assessed unit, then the work should be assessed according to the marking criteria and the appropriate mark awarded, which may be zero.

4.6 Moderation

The purpose of external moderation is to ensure that the standard of marking is the same for each centre and to ensure that internal standardisation has taken place.

Centres can select from:

- **Moderated via OCR Repository (see section 4.6.1)**
- **Moderated via postal moderation (see section 4.6.2)**

The deadline dates for entries and submission of marks for each moderation method are detailed below. Centres must ensure when selecting a moderation method that the appropriate entry and marks submission deadlines can be adhered to.

Moderation method	January Series		June Series		November Series	
	Entries	Marks	Entries	Marks	Entries	Marks
Moderated via OCR Repository	21st Oct	10th Jan	21st Feb	15th May	4th Oct	5th Nov
Moderated via postal moderation	21st Oct	10th Jan	21st Feb	15th May	4th Oct	5th Nov

When making your entries, the entry option specifies how the work is going to be moderated.

For each unit, you must choose the same moderation method for **all** learners (i.e. all learners for that unit in that series must be entered using the same entry option). However, you can choose different moderation methods for different units and in different series.

Sample requests

Once you have submitted your marks, your exams officer will receive an email telling you which work will be sampled as part of the moderation. Samples will include work from across the range of attainment of the learners' work.

Each learner's work must have a cover sheet attached to it with a summary of the marks awarded for the task. If the work is to be submitted via OCR Repository this cover sheet must also be submitted electronically within each learner's files.

OCR will require centres to release work for awarding and archive purposes and the co-operation of the centre is most appreciated in these instances, as it is imperative to have work available at awarding meetings. If this is required, then centres will be notified as early as possible.

Centres will receive the final outcome of moderation when the provisional results are issued. The following reports will be issued via Interchange:

- Moderation adjustments report – this lists any scaling that has been applied to internally assessed units
- Moderator report to centres – this is a brief report by the moderator on the internal assessment of learners' work.

4.6.1 Moderated via OCR Repository

The OCR Repository is a secure website for centres to upload candidate work and for assessors to access this work digitally. Centres can use the OCR Repository for uploading marked candidate work for moderation.

Centres can access the OCR Repository via OCR Interchange, find their candidate entries in their area of the Repository, and use the Repository to upload files (singly or in bulk) for access by their moderator.

The OCR Repository allows candidates to produce evidence and files that would normally be difficult for postal submissions, for example multimedia and other interactive unit submissions.

The OCR Repository is seen as a faster, greener and more convenient means of providing work for assessment. It is part of a wider programme bringing digital technology to the assessment process, the aim of which is to provide simpler and easier administration for centres.

All moderated units can be submitted electronically to the OCR Repository via Interchange. Please check section 7.2.2 for unit entry codes for the OCR Repository.

There are three ways to load files to the OCR Repository:

1. Centres can load multiple files against multiple candidates by clicking on 'Upload candidate files' in the 'Candidates' tab of the Candidate Overview screen.

2. Centres can load multiple files against a specific candidate by clicking on 'Upload files' in the 'Candidate Details' screen.

3. Centres can load multiple administration files by clicking on 'Upload admin files' in the 'Administration' tab of the Candidate Overview screen.

Instructions for how to upload files to OCR using the OCR Repository can be found on OCR Interchange.

4.6.2 Moderated via postal moderation

Your sample of work must be posted to the moderator within three days of receiving the request. You should use one of the labels provided by OCR to send the learners' work.

We would advise you to keep evidence of work submitted to the moderator, e.g. copies of written work or photographs of practical work. You should also obtain a certificate of posting for all work that is posted to the moderator.

Work may be submitted in digital format (on CD) for moderation but must be in a suitable file format and structure as detailed in Appendix C at the end of this specification.

5 Support for Cambridge Nationals in Systems Control in Engineering

5.1 Free resources available from the OCR website

The following materials are available on the OCR website:

- specification
- specimen assessment materials for unit R113
- a bank of set assignments for the centre-assessed units R114–R116.

5.2 Free teaching and Learning resources

Our resources are designed to provide you with a range of teaching activities and suggestions that enable you to select the best activity, approach or context to support your teaching style and your particular students. Some resources also include sample candidate work and assessment, for exemplification of particular aspects of the specification. The resources are a body of knowledge that will grow throughout the lifetime of the specification. They include:

- Teaching activities
- Resources Links
- Delivery Guides
- Mapping Guides and Progress Trackers
- Examiners' Reports

5.2.1 Endorsed publications

We also work with a number of leading publishers who publish textbooks and resources for our specifications.

To see endorsed resources for individual subjects, visit the subject page on https://www.ocr.org.uk/

For more information on OCR's endorsement process visit https://www.ocr.org.uk/qualifications/gcse-and-a-level-reform/teaching-and-learning-resources/endorsed-resources/

5.3 Training

We provide face-to-face courses and live online training events (webinars) where you can benefit from information, advice and guidance from subject experts and network with fellow professionals. We'll also produce presentations and films that provide detailed information and feedback about specifications, grading criteria and candidate performance in past sessions.

To find out more about professional development, please visit our website.

5.4 OCR support services

5.4.1 Active results

Active Results is available to all centres offering Cambridge Nationals qualifications.

Active Results is a free results analysis service to help teachers review the performance of individual learners or whole schools.

Devised specifically for the UK market, data can be analysed using filters on several categories such as gender and other demographic information, as well as providing breakdowns of results by question and topic.

Active Results allows you to look in greater detail at your results:

- richer and more granular data will be made available to centres including question level data available from e-marking.
- you can identify the strengths and weaknesses of individual learners and your centre's cohort as a whole.
- our systems have been developed in close consultation with teachers so that the technology delivers what you need.

Further information on Active Results can be found on the OCR website.

5.4.2 OCR Interchange

OCR Interchange has been developed to help you to carry out day-to-day administration functions online, quickly and easily. The site allows you to register and enter learners online. In addition, you can gain immediate and free access to learner information at your convenience. Sign up at https://interchange.ocr.org.uk.

6 Access to Cambridge Nationals in Systems Control in Engineering

6.1 Equality Act information relating to Cambridge Nationals in Systems Control in Engineering

Cambridge Nationals in Systems Control in Engineering require assessment of a broad range of competences and, as such, prepare learners for further study and higher level courses.

The Cambridge Nationals in Systems Control in Engineering qualifications were reviewed to identify whether any of the competences required by the subject presented a potential barrier to any disabled learners. If this was the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject.

6.2 Accessibility

There can be adjustments to standard assessment arrangements on the basis of the individual needs of learners. It's important that you identify as early as possible whether learners have disabilities or particular difficulties that will put them at a disadvantage in the assessment situation and choose a qualification or adjustment that allows them to demonstrate attainment.

If a candidate requires access arrangements in Cambridge Nationals assessments that require awarding body approval, then approval covering Cambridge Nationals must be gained in Access Arrangements Online. Approval from GCSE or GCE applications alone no longer extends to other qualification types. For guidance or support please contact the OCR Special Requirements Team.

The responsibility for providing adjustments to assessment is shared between your centre and us. Please read the JCQ booklet *Access Arrangements and Reasonable Adjustments* at www.jcq.org.uk.

If you have learners who need a post-examination adjustment to reflect temporary illness, indisposition or injury when they took the assessment, please read the JCQ documents *A guide to the special consideration process.*

If you think any aspect of these qualifications unfairly restricts access and progression, please email or call our Customer Support Centre.

The access arrangements permissible for use in this specification are as follows:

Access arrangement	Yes/No	Type of assessment
Readers	Yes	All assessments
Scribes	Yes	All assessments
Practical assistants	Yes	All assessments
Word processors	Yes	All assessments
BSL interpreters	Yes	All assessments
Oral language modifiers	Yes	All assessments
Modified question papers	Yes	Timetabled examinations
Extra time	Yes	All assessments

7 Administration of Cambridge Nationals in Systems Control in Engineering

Full details of the administrative arrangements can be found in the administration area of the OCR website www.ocr.org.uk/administration/ .

7.1 Availability of assessment

There are three assessment series each year in January, June and November. Learners can be entered for different units in different exam series. Assessment availability can be summarised as follows:

	Unit R113	Unit R114–R116
January	✓	✓
June	✓	✓
November	–	✓*

Certification is available each January, June and November.

7.2 Making entries

Centres must be registered with OCR in order to make any entries. It is recommended that centres apply to OCR to become a registered centre well in advance of making their first entries. Details on how to register with OCR can be found on the OCR website.

It is essential that unit entry codes are quoted in all correspondence with OCR.

7.2.1 Making estimated entries

Estimated entries are not required for Cambridge Nationals in Systems Control in Engineering.

7.2.2 Making final unit entries

When making an entry, centres must quote unit entry code and component codes. For the centre-assessed units, centres must decide whether they want to submit learners' work for moderation via the OCR Repository or via postal moderation. Learners' submitting work must be entered for the appropriate unit entry code from the table over the page.

Unit entry code	Component code	Assessment method	Unit title
R113	01	Written paper	*Electronic principles*
R114 A	01	Moderated via OCR Repository	*Simulate, construct and test electronic circuits*
R114 B	02	Moderated via postal moderation	
R115 A	01	Moderated via OCR Repository	*Engineering applications of computers*
R115 B	02	Moderated via postal moderation	
R116 A	01	Moderated via OCR Repository	*Process control systems*
R116 B	02	Moderated via postal moderation	

The short title for these Cambridge National qualifications is CAMNAT and will display as such on Interchange and some administrative documents provided by OCR.

You do not need to register your candidates first; individual unit entries should be made for the series in which you intend to submit an internally assessed unit or sit the externally assessed examination.

Only make a certification entry using the overall qualification code (see below) in the final series.

7.3 Certification rules

Learners must be entered for qualification certification separately from unit assessment(s). If a certification entry is **not** made, no overall grade can be awarded.

Learners may be entered for:

- OCR Level 1/2 Cambridge National Award – certification code J833
- OCR Level 1/2 Cambridge National Certificate – certification code J843

Learners may be entered for certification of any combinations of the Award and Certificate qualifications concurrently.

Unit results used to calculate the result for one qualification can be re-used toward certification of other qualifications of a different size. This means that, as learners' progress through the course, they may certificate for the Award once they have completed the first two units and then 'top up' to the Certificate as they complete further units.

There are no terminal requirements for these qualifications therefore learners can complete units in any order.

7.4 Unit and qualification resits

Learners may resit each centre-assessed unit and the best unit result will be used to calculate the certification result.

Learners may resit the externally assessed Unit R113, **once**.

Centres must ensure that when arranging resit opportunities they are fair to all learners and do not give learners an unfair advantage over other learners.

Centres must ensure that when arranging resit opportunities they do not adversely affect other assessments being taken.

Arranging a resit opportunity is at the centre's discretion; resits should only be planned if it is clear that the learner has taken full advantage of the first assessment opportunity and formative assessment process. The summative assessment series must not be used as a diagnostic tool.

Learners may enter for the qualification an unlimited number of times. Learners must retake at least one unit, or take a different optional unit, for a new result to be issued.

7.5 Post-results services

Under certain circumstances, a centre may wish to query the result issued to one or more learners. Reviews of results requests for all units must be made immediately following the series in which the relevant unit was taken (by the reviews of results deadline).

Please refer to the JCQ Post-Results Services booklet and the OCR Administration page for further guidance about action on the release of results.

For internally assessed units the review of results process cannot be carried out for one individual learner; the outcome of a review of moderation must apply to a centre's entire cohort.

7.6 Shelf-life of units

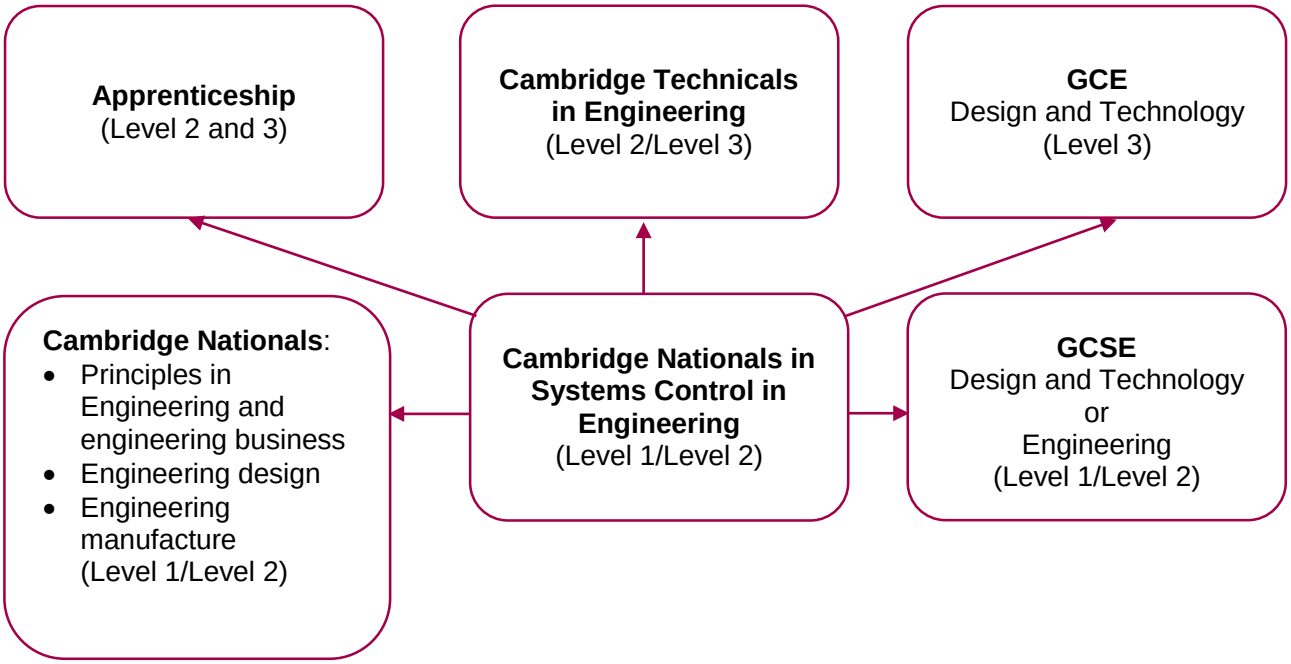
Individual unit results, prior to certification of the qualification, have a shelf-life limited only by that of the qualification.

8 Other information about Cambridge Nationals in Systems Control in Engineering

8.1 Overlap with other qualifications

There is some overlap between the content of these qualifications and that of GCSE in Engineering.

8.2 Progression from these qualifications



OCR offers a flexible and responsive range of general and vocational engineering qualifications that allow suitable progression routes for all types of learners.

Centres are able to use these qualifications to create pathways that provide learners with the underpinning skills and knowledge that will enable them to choose the most appropriate progression routes for their particular needs (further study, Further Education (FE) or employment).

Progression from OCR Level 1/2 Cambridge National Award/Certificate/in Engineering to Cambridge Technicals in Engineering at Level 2 and Level 3.

Learners can progress from OCR Level 1/2 Cambridge National Award/Certificate in Engineering to **GCSE qualifications** in Engineering or various **GCE qualifications** in Design and Technology which will further develop areas of their learning from Level 1/Level 2.

8.3 Avoidance of bias

OCR has taken great care in preparing this specification and assessment materials to avoid bias of any kind. Special focus is given to the nine strands of the Equality Act with the aim of ensuring both direct and indirect discrimination is avoided.

8.4 Criteria requirements

This specification complies in all respects with the Regulators General Conditions of Recognition.

8.5 Language

This specification is available in English only.

8.6 Spiritual, moral, ethical, social, legislative, economic and cultural issues

These qualifications provide potential for centres to develop learners' understanding of spiritual, moral, ethical, social, legislative, economic and cultural issues. This specification offers opportunities to contribute to an understanding of these issues in the following topics.

Issue	Example of opportunities for developing an understanding of the issue during the course
Spiritual issues	o developing knowledge and understanding of: how engineering has changed the way people interact with technology in their daily lives (including communication, shopping, gaming, entertainment, education and training, social networking etc)
Moral issues	o learning about appropriate uses of materials and finite resources and the impact this could have on the environment, and the safe and responsible use of sustainable products
Ethical issues	o learning about the ethical implications of unregulated labour markets and fair-trade suppliers o how engineering can affect the quality of life experienced by people and the responsibility to manufacture responsibly
Social issues	o social issues that can affect users of engineered products, including the use and abuse of communication devices etc
Legislative issues	o the main aspects of legislation relating to engineering: copyright design and patents acts and other legislation as it applies to the design and production of engineered products
Economic issues	o learning about making informed decisions about the choice, implementation, and use of materials in engineered products depending upon cost and the efficient management of money and resources
Cultural issues	o helping learners appreciate that engineering contributes to the development of our culture and to our highly technological future o how learners need to show cultural awareness of their audience when communicating

8.7 Sustainable development, health and safety consideration and European developments, consistent with international agreements

These qualifications provide potential to heighten learners' awareness of sustainable development, health and safety considerations and European developments consistent with international agreements.

The specification incorporates learning about relevant health and safety, European and environmental legislation, and could include learning about how each of these factors has affected the use of engineered products for businesses and individuals.

Environmental issues

Learners have the opportunity to learn about how changes in working practices, due to developments in engineered products, have impacted upon the environment. This may include a reduction in carbon emissions due to improved production methods, the globalisation of manufacturing or the more efficient disposal techniques for engineered products that are used today.

Learners could also explore the effect on the natural resources used in the creation of engineered products, including the environmental impact of digital devices and their use, deployment, and eventual recycling and disposal.

The understanding of environmental issues will only form part of the assessment requirements where they are relevant to the specific content of the specification and have been identified within the taught content. Learners may choose to produce work that has an environmental theme or to enhance their learning by carrying out further personal study.

Appendix A: Guidance on witness statements

It is anticipated that the majority of evidence will be produced directly by the learner. Indirect evidence, such as witness statements, should only be used where it would be impractical for the learner to produce the evidence themselves.

Witness statements will, ideally, support the direct evidence produced by the learner.

- Care should be taken that a witness statement is impartial and free from bias. The use of relatives and close friends as witnesses should be avoided, if possible.
- In all cases the witness will be required to declare their relationship to the learner.
- A witness statement should record what the learner has done and in doing so should not seek to repeat or paraphrase the marking criteria.
- The evidence presented by the witness should record the learner's individual contribution and should focus on the contribution made by the individual learner, as distinct from that of the group or team as a whole.
- Witnesses should describe what the learner did and not assess the learner. It is the responsibility of the teacher/assessor to judge the learner's skill, knowledge and understanding against the marking criteria. In doing so the teacher/assessor will use the witness statement to determine the value of the evidence against the marking criteria.
- The teacher/assessor is responsible for briefing anyone who is to provide a witness statement. It is expected that the teacher/assessor will ensure that the witness is appropriately prepared and that any issues related to child protection have been fully considered.
- The role of the witnesses should be that of impartial observers and they should not become involved in carrying out the activity on behalf of the learner.
- In circumstances where a witness does assist the learner in accomplishing a task or activity their input must be recorded within the statement so that the teacher/assessor can reflect this appropriately in the award of marks.

Where the above guidance has not been followed, the reliability of the witness statement may be called into question. In circumstances where doubt exists about the validity of a witness statement it cannot be used as assessment evidence and no marks may be awarded on the basis of it. If the unreliability of a witness statement becomes apparent during the moderation process moderators will be instructed to adjust centre marks in accordance with this directive.

An exemplar template for recording a witness statement is available from the OCR website and centres are encouraged to use this to assist in recording witness evidence. However, witness evidence may take different forms including digitally recorded spoken commentary or video. In these cases, additional accompanying documentation may be required to corroborate that the guidelines on witness statements detailed above have been followed.

Appendix B: Marking criteria for centre assessment

These qualifications are combined Level 1/ Level 2, therefore the marking criteria for the centre-assessed units span both levels.

Unit R114: *Simulate, construct and test electronic circuits*

Marking criteria guidance

0 marks must be given where there is no evidence or no evidence worthy of credit.

For a description of the key words (printed in **bold**) in the marking criteria, please see the *Marking criteria glossary of terms* in Appendix D, Teachers/assessors must use the complete description in the marking criteria and not rely only on the words in bold.

A range of marks is allocated to each learning outcome. Where marks are allocated to a number of statements within a learning outcome, marks should be awarded using a 'best fit' approach. For each of the learning outcomes, one of the descriptors provided in the mark scheme that most closely describes the quality of the work being marked should be selected. Marking should be positive, rewarding achievement rather than penalising failure or omissions. The award of marks **must be** directly related to the marking criteria.

- Each band descriptor covers all the relevant content for the learning outcomes.
- The descriptors should be read and applied as a whole.
- Make a 'best fit' match between the answer and the band descriptors.
- An answer does not have to meet all of the requirements of a band descriptor before being placed in that band. It will be placed in a particular band when it meets more of the requirements of that band than it meets the requirements of other bands.
- Where there is more than one strand within the band descriptors for a learning outcome and a strand has not been addressed at all, it is still possible for the answer to be credited within that mark band depending upon the evidence provided for the remaining strands. The answer should be placed in the mark band most closely reflecting the standard achieved across all strands within the band descriptors for a learning outcome; however in this scenario, the mark awarded for that band should reflect that a strand has not been addressed.

When deciding the mark within a band, the following criterion should be applied:

- the extent to which the statements within the band have been achieved.

For example:

- an answer that convincingly meets nearly all of the requirements of a band descriptor should be placed at or near the top of that band. Where the learner's work *convincingly* meets the statement, the highest mark should be awarded
- an answer that meets many of the requirements of the band descriptor should be placed in the middle of the band. Where the learner's work *adequately* meets the statement, the most appropriate mark in the middle range should be awarded

- if an answer is on the border-line between two bands but it is decided that it fits better the descriptors for the lower of these two bands, then it should be placed near the top of that band. Where the learner's work *just* meets the statement for the higher band, the lowest mark for that band should be awarded.

Teachers/assessors should use the full range of marks available to them and award full marks in any band for work that fully meets that descriptor. This is work that is 'the best one could expect from learners working at that level'. When learners are taking an assessment task, or series of tasks, for this unit they may be able to use relevant, appropriate knowledge, understanding and skills that they will have developed through the completion of units R115 and/or R116.

Marking criteria grid

LO1:Be able to use CAD for circuit simulation and design		
MB1: 1 – 5 marks	**MB2: 6 – 10 marks**	**MB3: 11 – 15 marks**
Produces circuit schematic diagrams with **limited** accuracy using CAD software, making **some** appropriate use of component libraries. Undertakes **basic** testing of the circuit using circuit simulation and test features of CAD software prior to PCB design. Takes **some appropriate** action to modify circuit design based upon the outcome of testing. Understands **some** of the process of producing PCB layouts using CAD software. **With regular assistance** produces both track and component views of PCB layouts. Undertakes **limited** review of the PCB layout to ensure correct functionality.	Produces circuit schematic diagrams with **some** accuracy using CAD software, making **mostly appropriate** use of component libraries. Undertakes **detailed** testing of the circuit using circuit simulation and test features of CAD software prior to PCB design. Takes action to modify circuit design based upon the outcome of testing that is **mostly** appropriate. Understands **most** of the process of producing PCB layouts using CAD software. With **little** assistance produces both track and component views of PCB layouts. Undertakes **detailed** review of the PCB layout to ensure correct functionality.	**Accurately** produces circuit schematic diagrams using CAD software, making **consistently appropriate** use of component libraries. Undertakes **comprehensive** and **detailed** testing of the circuit using circuit simulation and test features of CAD software prior to PCB design. Takes **appropriate** action to modify circuit design based upon the outcome of testing. **Comprehensively** understands the process of producing PCB layouts using CAD software. **Independently** produces both track and component views of PCB layouts. Undertakes **comprehensive** and **detailed** review of the PCB layout to ensure correct functionality.

LO2:Be able to construct circuits		
MB1: 1 – 3 marks	**MB2: 4 – 6 marks**	**MB3: 7 – 9 marks**
With regular assistance, undertakes **some** of the work to construct the PCB using an appropriate method. On occasions, takes **some** appropriate precautions when using hand operated tools to ensure that the PCB is produced in a safe and appropriate manner. Undertakes **limited** testing of the constructed PCB to ensure its correct functionality.	**With occasional assistance**, undertakes **most** of the work to construct the PCB using an appropriate method. On **most** occasions, takes appropriate precautions when using hand operated tools to ensure that the PCB is produced in a safe and appropriate manner. Undertakes **detailed** and **mostly** appropriate testing of the constructed PCB to ensure its correct functionality.	Works **independently** to **fully** undertake the construction of the PCB using an appropriate method. **Consistently** takes **appropriate** precautions when using hand operated tools to ensure that the PCB is produced in a safe and appropriate manner. Undertakes **comprehensive** and **appropriate** testing of the constructed PCB to ensure its correct functionality.
MB1: 1 – 2 marks	**MB2: 3 – 4 marks**	**MB3: 5 – 6 marks**
Works with **limited accuracy** and requires **regular assistance** to construct the circuit following the circuit diagram. On occasions, takes **some** appropriate precautions to ensure that the circuit is constructed in a safe and appropriate manner.	Works with **some accuracy** and requires **occasional assistance** to construct the circuit following the circuit diagram. On **most** occasions, takes appropriate precautions to ensure that the circuit is constructed in a safe and appropriate manner.	Works **independently** to **accurately** construct the circuit following the circuit diagram. **Consistently** takes **appropriate** precautions to ensure that the circuit is constructed in a safe and appropriate manner.
MB1: 1 – 5 marks	**MB2: 6 – 10 marks**	**MB3: 11 – 15 marks**
Requires **regular assistance to** select appropriate construction techniques. Circuit construction is of a **limited** quality and may not be complete.	Requires **occasional assistance** to select appropriate construction techniques. Circuit construction is of **appropriate** quality with **most** components placed and joined appropriately.	**Independently** selects appropriate construction techniques. Circuit construction is of a **high** quality with **all** components placed and joined appropriately.
LO3:Be able to test electronic circuits		
MB1: 1 – 5 marks	**MB2: 6 – 10 marks**	**MB3: 11 – 15 marks**
Undertakes **basic** testing and evaluation of the operation of the electronic circuit. On **few** occasions, selects test equipment and fault-finding methods with **some** appropriateness.	Undertakes **detailed** testing and evaluation of the operation of the electronic circuit. **Selects** appropriate test equipment and fault-finding methods on **most** occasions.	Undertakes **thorough** and **detailed** testing and evaluation of the operation of the electronic circuit. **Consistently** selects appropriate test equipment and fault-finding methods.

0 marks = no response or no response worthy of credit.

Guidance on synoptic assessment

Synoptic assessment is based upon demonstrating a broad and holistic understanding of the subject content. This is achieved by synthesizing the knowledge, skills and understanding that have been studied across the specification and utilising them in an appropriate and relevant way to complete the assessment for this unit.

The connections to content delivered in unit R113 identified below, are guidance only and learners may find other skills/knowledge/understanding that they are able to apply synoptically either in addition to or in place of this guidance. For example:

Learners will have been taught basic electronic principles and the operating principles of electronic components in unit R113 that can be applied and assessed in context in unit R114 LO2: Be able to construct circuits.

Further, more detailed information regarding synoptic assessment can also be found under section 3.2 *Synoptic Assessment.*

Assessment guidance

Teachers/assessors must only accept evidence for assessment that is **authentic**. If any work is produced outside of direct supervision, the teacher/assessor must be certain that the work is the learners' own. Please see section 4.4 *Marking and moderating centre-assessed units*; 4.5 *Authentication*; for further guidance.

LO1, LO2 and LO3 – Each LO will be assessed through the development of a circuit design and constructed circuit that responds to a given design scenario.

LO2 – Evidence of circuit construction detailing quality of joining methods will be provided in the portfolio by digital photographs, supported by signed witness statements. High quality refers only to fully operational circuits. Although not assessed, it is desirable for learners to experience the use of stripboards, protoboards or breadboards as part of prototype circuit construction and testing.

What do learners need to produce (evidence)	Examples of format of evidence (this list is not exhaustive)
A portfolio of evidence or completed workbook showing the analysis of design problem, circuit design, circuit testing, circuit manufacture and final testing.	• *Design folder or work book.*

Unit R115: *Engineering applications of computers*

Marking criteria guidance

0 marks must be given where there is no evidence or no evidence worthy of credit.

For a description of the key words (printed in **bold**) in the marking criteria, please see the *Marking criteria glossary of terms* in Appendix D, teachers/assessors must use the complete description in the marking criteria and not rely only on the words in bold.

A range of marks is allocated to each learning outcome. Where marks are allocated to a number of statements within a learning outcome, marks should be awarded using a 'best fit' approach. For each of the learning outcomes, one of the descriptors provided in the mark scheme that most closely describes the quality of the work being marked should be selected. Marking should be positive, rewarding achievement rather than penalising failure or omissions. The award of marks **must be** directly related to the marking criteria.

- Each band descriptor covers all the relevant content for the learning outcomes.
- The descriptors should be read and applied as a whole.
- Make a 'best fit' match between the answer and the band descriptors.
- An answer does not have to meet all of the requirements of a band descriptor before being placed in that band. It will be placed in a particular band when it meets more of the requirements of that band than it meets the requirements of other bands.
- Where there is more than one strand within the band descriptors for a learning outcome and a strand has not been addressed at all, it is still possible for the answer to be credited within that mark band depending upon the evidence provided for the remaining strands. The answer should be placed in the mark band most closely reflecting the standard achieved across all strands within the band descriptors for a learning outcome; however, in this scenario, the mark awarded for that band should reflect that a strand has not been addressed.

When deciding the mark within a band, the following criterion should be applied:

- the extent to which the statements within the band have been achieved.

For example:

- an answer that convincingly meets nearly all of the requirements of a band descriptor should be placed at or near the top of that band. Where the learner's work *convincingly* meets the statement, the highest mark should be awarded
- an answer that meets many of the requirements of the band descriptor should be placed in the middle of the band. Where the learner's work *adequately* meets the statement, the most appropriate mark in the middle range should be awarded
- if an answer is on the border-line between two bands but it is decided that it fits better the descriptors for the lower of these two bands, then it should be placed near the top of that band. Where the learner's work *just* meets the statement for the higher band, the lowest mark for that band should be awarded.

Teachers/assessors should use the full range of marks available to them and award full marks in any band for work that fully meets that descriptor. This is work that is 'the best one could expect from learners working at that level'.

When learners are taking an assessment task, or series of tasks for this unit, they may be able to use relevant, appropriate knowledge, understanding and skills that they will have developed through the completion of units R114 and/or R116.

Marking criteria grid

LO1: Understand how computers are used in engineering design, manufacture and process control		
MB1: 1 – 5 marks	**MB2: 6 – 10 marks**	**MB3: 11 – 15 marks**
Demonstrates a **limited** understanding of how computers are used within engineering design, manufacture and process control. Draws upon **limited** skills/knowledge/understanding from other units in the specification.	Demonstrates a **sound** understanding of how computers are used within engineering design, manufacture and process control. Draws upon **some relevant** skills/knowledge/understanding from other units in the specification.	Demonstrates a **thorough** understanding of how computers are used within engineering design, manufacture and process control. **Clearly** draws upon **relevant** skills/knowledge/understanding from other units in the specification.
LO2: Understand how computers are used for maintenance of engineering systems		
MB1: 1 – 6 marks	**MB2: 7 – 12 marks**	**MB3: 13 – 18 marks**
Demonstrates a **limited** understanding of the use of 'Human Machine Interface (HMI)' and 'expert systems' within system operation, diagnostics and maintenance. Interprets **some** results obtained from system operation data with **limited** accuracy. Recommendations for modifications or corrections to a system operation are **basic** with **limited** relevance.	Demonstrates a **sound** understanding of the use of 'Human Machine Interface (HMI)' and 'expert systems' within system operation, diagnostics and maintenance. Interprets results obtained from system operation data with **some** accuracy. Recommendations for modifications or corrections to a system operation are **appropriate** with **some** relevance.	Demonstrates a **thorough** understanding of the use of 'Human Machine Interface (HMI)' and 'expert systems' within system operation, diagnostics and maintenance. **Accurately** interprets results obtained from system operation data. Recommendations for modifications or corrections to a system operation are **thorough** and **relevant**.

LO3: Know how computers are used to communicate and use data for production and maintenance		
MB1: 1 – 4 marks	**MB2: 5 – 8 marks**	**MB3: 9 – 12 marks**
Demonstrates **limited** knowledge of the use of computers to communicate and exchange data during production operations. Provides a **basic** description of how production data is used in maintenance operations.	Demonstrates **some** knowledge of the use of computers to communicate and exchange data during production operations. Provides a **detailed** description of how production data is used in maintenance operations.	Demonstrates **comprehensive** knowledge of the use of computers to communicate and exchange data during production operations. Provides a **comprehensive** and **detailed** description of how production data is used in maintenance operations.
MB1: 1 – 5 marks	**MB2: 6 – 10 marks**	**MB3: 11 – 15 marks**
Provides a **limited** description of how computers are used to communicate and exchange data in maintenance operations. Demonstrates a **basic** knowledge of the use of hand held computer devices in manufacturing and maintenance systems.	Provides a **detailed** description of how computers are used to communicate and exchange data in maintenance operations. Demonstrates a **detailed** knowledge of the use of hand held computer devices in manufacturing and maintenance systems.	Provides a **comprehensive** and **detailed** description of how computers are used to communicate and exchange data in maintenance operations. Demonstrates a **comprehensive** knowledge of the use of hand held computer devices in manufacturing and maintenance systems.

0 marks = no response or no response worthy of credit.

Guidance on synoptic assessment

Synoptic assessment is based upon demonstrating a broad and holistic understanding of the subject content. This is achieved by synthesizing the knowledge, skills and understanding that have been studied across the specification and utilising them in an appropriate and relevant way to complete the assessment for this unit.

The connection to content delivered in unit R114, is guidance only and learners may find other skills/knowledge/understanding that they are able to apply synoptically either in addition to or in place of this guidance. For example in unit R115:

Learners will have been taught to use CAD for circuit simulation and design in unit R114 that can be applied and assessed in context in unit R115 LO1: Understand how computers are used in engineering, design, manufacture and process control.

Further, more detailed information regarding synoptic assessment can also be found under section 3.2 *Synoptic Assessment.*

Assessment guidance

Teachers/assessors must only accept evidence for assessment that is **authentic**. If any work is produced outside of direct supervision, the teacher/assessor must be certain that the work is the learners' own. Please see section 4.4 *Marking and moderating centre-assessed units*; 4.5 *Authentication*; for further guidance.

LO1 – A product study could be used as a method for assessment of this LO. A product could be mapped from design to manufacture identifying each stage which utilises computers in the process of design, manufacture, dispatch and delivery.

LO2 – Learners should have access to computer control systems that utilise HMI and expert systems. Learners should independently interrogate systems and act upon the information gained to enable them to make recommendations of corrections/modifications to be made to a system operation. Learners must show a theoretical understanding of how both HMI and Expert systems work in the first part of the LO, but only need to interpret and make recommendations based on data from one type of system.

LO3 – Learners should consider the use of computers in both production and maintenance situations. They should consider the advantages to both manufacturer and customer of the use of computers. A product case study could be used as a method of assessment of this unit.

What do learners need to produce (evidence)	Examples of format of evidence (this list is not exhaustive)
A product study that follows a product from design to distribution reflecting upon the role of computers at each stage in the process. LO2 could be based around the use of expert systems or HMI in the production processes linked to the product studied.	• *Written report, PowerPoint presentation, video report, article, teaching pack for KS3 learners.*

Marking criteria guidance

0 marks must be given where there is no evidence or no evidence worthy of credit.

For a description of the key words (printed in **bold**) in the marking criteria, please see the *Marking criteria glossary of terms* in Appendix D, teachers/assessors must use the complete description in the marking criteria and not rely only on the words in bold.

A range of marks is allocated to each learning outcome. Where marks are allocated to a number of statements within a learning outcome, marks should be awarded using a 'best fit' approach. For each of the learning outcomes, one of the descriptors provided in the mark scheme that most closely describes the quality of the work being marked should be selected. Marking should be positive, rewarding achievement rather than penalising failure or omissions. The award of marks **must be** directly related to the marking criteria.

- Each band descriptor covers all the relevant content for the learning outcomes.
- The descriptors should be read and applied as a whole.
- Make a 'best fit' match between the answer and the band descriptors.
- An answer does not have to meet all of the requirements of a band descriptor before being placed in that band. It will be placed in a particular band when it meets more of the requirements of that band than it meets the requirements of other bands.
- Where there is more than one strand within the band descriptors for a learning outcome and a strand has not been addressed at all, it is still possible for the answer to be credited within that mark band depending upon the evidence provided for the remaining strands. The answer should be placed in the mark band most closely reflecting the standard achieved across all strands within the band descriptors for a learning outcome; however in this scenario, the mark awarded for that band should reflect that a strand has not been addressed.

When deciding the mark within a band, the following criterion should be applied:

- the extent to which the statements within the band have been achieved.

For example:

- an answer that convincingly meets nearly all of the requirements of a band descriptor should be placed at or near the top of that band. Where the learner's work *convincingly* meets the statement, the highest mark should be awarded
- an answer that meets many of the requirements of the band descriptor should be placed in the middle of the band. Where the learner's work *adequately* meets the statement, the most appropriate mark in the middle range should be awarded
- if an answer is on the border-line between two bands but it is decided that it fits better the descriptors for the lower of these two bands, then it should be placed near the top of that band. Where the learner's work *just* meets the statement for the higher band, the lowest mark for that band should be awarded.

Teachers/assessors should use the full range of marks available to them and award full marks in any band for work that fully meets that descriptor. This is work that is 'the best one could expect from learners working at that level'.

When learners are taking an assessment task, or series of tasks for this unit, they may be able to use relevant, appropriate knowledge, understanding and skills that they will have developed through the completion of units R114 and/or R115.

Marking criteria grid

LO1: Understand the application and operation of microcontrollers and microprocessors in engineered products		
MB1: 1 – 6 marks	**MB2: 7 – 12 marks**	**MB3: 13 – 18 marks**
Demonstrates a **basic** understanding of simple layouts of microprocessor/microcontrollers in products or systems. Uses a **limited range** of examples to explain applications of microcontrollers and microprocessors. **Outlines** the **basic** operation of microprocessor/microcontroller control in a product or system. Describes the basic function of a **limited range** of input, control and output devices used in microprocessor/microcontrollers.	Demonstrates a **detailed** understanding of simple microprocessor/microcontrollers layouts in products or systems. Uses a **range** of examples to explain applications of microcontrollers and microprocessors. Describes the operation of microprocessor/ microcontroller control in a product or system in **some detail**. Describes the basic function of a **range** of input, control and output devices used in microprocessor/ microcontrollers.	Demonstrates a **comprehensive** understanding of simple layouts of microprocessor/microcontrollers in products or systems. Uses a **wide range** of examples to explain applications of microcontrollers and microprocessors. **Comprehensively** describes the operation of microprocessor/microcontroller control in a product or system. Describes the basic function of a **wide range** of input, control and output devices used in microprocessor/ microcontrollers.

LO2: Be able to design, develop and simulate a control system solution		
MB1: 1 – 4 marks	**MB2: 5 – 8 marks**	**MB3: 9 – 12 marks**
Produces a **limited** solution for a control system problem. Requires **regular assistance to** design a solution to a control system problem. Uses **some** resources to select input and output sensors and devices, not all of which may be appropriate. Draws upon **limited** skills/knowledge/understanding from other units in the specification.	Produces a **detailed** solution for a control system problem. Requires **occasional assistance** to design a solution to a control system problem. Uses a **range** of resources to select **some** appropriate input and output sensors and devices. Draws upon **some** relevant skills/knowledge/ understanding from other units in the specification.	Produces a **detailed** and **comprehensive** solution for a control system problem. Works **independently** to design a solution to a control system problem. Uses a **range** of resources to select **appropriate** input and output sensors and devices. **Clearly** draws upon relevant skills/knowledge/ understanding from other units in the specification.
MB1: 1 – 6 marks	**MB2: 7 – 12 marks**	**MB3: 13 – 18 marks**
Requires **regular assistance** to use a programming tool to create a control system programme to solve **some basic** aspects of a control system problem. Undertakes **limited** simulation of the control system programme. Requires **regular assistance** to carry out modifications to the design of the programme. Requires **regular assistance** to download the control programme to a programmable device.	Requires **occasional assistance** to use a programming tool to create a control system programme to solve **most aspects** of a control system problem. Undertakes **detailed** simulation of the control system programme. Requires **occasional assistance** to carry out modifications to the design of the programme. Requires **occasional assistance** to download the control programme to a programmable device.	Works **independently** using a programming tool to create a control system programme to **successfully solve** a control system problem. Undertakes **comprehensive** simulation of the control system programme. **Independently** carries out modifications to the design of the programme. Works **independently** to download the control programme to a programmable device.
LO3: Be able to test control systems		
MB1: 1 – 4 marks	**MB2: 5 – 8 marks**	**MB3: 9 – 12 marks**
Devises a **basic** test plan to ensure functionality of the control system. Undertakes **limited** testing of the control systems using the test plan to evaluate **some** aspects of the performance of the system. Refines **some** of the control systems based upon the outcome of testing. Refines have **limited** effectiveness.	Devises a **detailed** test plan to ensure functionality of the control system. Undertakes **detailed** testing of the control systems using the test plan to evaluate **most** aspects of the performance of the system. Refines **most** of the control systems based upon the outcome of testing. Refines are **mostly** effective.	Devises a **comprehensive** test plan to ensure functionality of the control system. Undertakes **comprehensive** testing of the control systems using the test plan to evaluate **all** aspects of the performance of the system. **Effectively** refines the control systems based upon the outcome of testing.

0 marks = no response or no response worthy of credit.

Guidance on synoptic assessment

Synoptic assessment is based upon demonstrating a broad and holistic understanding of the subject. This is achieved by synthesizing the knowledge, skills and understanding that have been studied across the specification and utilising them in an appropriate and relevant way to complete the assessment for this unit.

The connections to content delivered in units identified below, are guidance only and learners may find other skills/knowledge/understanding that they are able to apply synoptically either in addition to or in place of this guidance. For example:

Learners will build upon their knowledge of switches and sensors from unit R113 in unit R116 LO2 Be able to design, develop and simulate a control system solution, and use this knowledge to identify corrector sensors for control applications. They will use both analogue and digital inputs to control output devices.

Learners will build upon the testing of the control system used within unit R114 in unit R116 LO3 to test the control systems and will encourage learners to reflect and improve upon their system design.

Learners will have been taught how computers are used in engineering design, manufacture and process control in unit R115 and that can be applied and assessed in context in unit R116 LO2 Be able to design, develop and simulate a control system solution.

Further, more detailed information regarding synoptic assessment can also be found under section 3.2 *Synoptic Assessment.*

Assessment guidance

Teachers/assessors must only accept evidence for assessment that is **authentic**. If any work is produced outside of direct supervision, the teacher/assessor must be certain that the work is the learners' own. Please see section 4.4 *Marking and moderating centre-assessed units*; 4.5 *Authentication*; for further guidance.

LO1 – Learners should have access to a range of control systems that have been designed to be used within different scenarios. It would aid learners' understanding if theoretical concepts were used in an applied context (e.g. motor control for a conveyor system). The system design task in LO2 will require learners to select suitable system components and develop control programs.

LO2 – Learners should develop their knowledge of system design from basic control systems such as traffic light sequencing to those used within a production environment. Learners will consider a control problem, develop test and evaluate solutions, making refinements as necessary using systems diagrams for problems in systems. Systems could be in the form of air conditioning control in buildings, environmental control in horticulture, level crossing control, security systems and burglar alarms, manufacturing processes.

LO3 – Learners will reflect upon the initial design problem from unit R114 and test their solutions, suggesting improvements where required.

What do learners need to produce (evidence)	Examples of format of evidence (this list is not exhaustive)
Learners will produce a portfolio of evidence in response to a given control system design problem. This will contain their analysis of the problem and evidence of the development and test of a solution. Screen shots, photographs or video evidence may be used to demonstrate the operation of the system.	• *Portfolio of evidence either electronic or paper based.*

Appendix C: Guidance for the production of electronic internal assessment

Structure for evidence

The centre-assessed units are comprised of units R114–R116. For each learner, all the tasks together will form a portfolio of evidence, stored electronically. Evidence for each unit must be stored separately.

An internal assessment portfolio is a collection of folders and files containing the learner's evidence. Folders should be organised in a structured way so that the evidence can be accessed easily by a teacher or moderator. This structure is commonly known as a folder tree. It would be helpful if the location of particular evidence is made clear by naming each file and folder appropriately and by use of an index called 'Home Page'.

There should be a top level folder detailing the learner's centre number, OCR candidate number, surname and forename, together with the unit code (R114, R115 and R116) so that the portfolio is clearly identified as the work of one learner.

Each learner's internal assessment portfolio should be stored in a secure area on the centre's network. Prior to submitting the portfolio to OCR, the centre should add a folder to the folder tree containing the internal assessment and summary forms.

Data formats for evidence

In order to minimise software and hardware compatibility issues it will be necessary to save learners' work using an appropriate file format.

Learners must use formats appropriate to the evidence that they are providing and appropriate to viewing for assessment and moderation. Open file formats or proprietary formats for which a downloadable reader or player is available are acceptable. Where this is not available, the file format is not acceptable.

Centre-assessed tasks are designed to give learners an opportunity to demonstrate what they know, understand and can do using current technology. Learners do not gain marks for using more sophisticated formats or for using a range of formats. A learner who chooses to use only digital photographs (as required by the specification) and word documents will not be disadvantaged by that choice.

Evidence submitted is likely to be in the form of word-processed documents, presentation documents, digital photos and digital video.

To ensure compatibility, all files submitted electronically must be in the formats listed below. Where new formats become available that might be acceptable, OCR will provide further guidance. OCR advises against changing the file format that the document was originally created in. Files should be exported in a generic format that can be opened on a PC computer system without any specialist software applications. It is the centre's responsibility to ensure that the electronic portfolios submitted for moderation are accessible to the moderator and fully represent the evidence available for each learner.

Standard file formats acceptable as evidence for these Cambridge Nationals in Engineering qualifications are listed below (please note not all these formats can be submitted via the OCR Repository):

- avi
- bmp
- csv
- doc
- fla
- flv
- gif
- jpg
- mov
- mp3
- mp4
- mpeg
- mpg
- odg
- odp
- ods
- odt
- pdf
- png
- pps
- ppt
- psd
- rar
- rtf
- swf
- sxc
- sxd
- sxi
- sxw
- tga
- tif
- txt
- wav
- wks
- wma
- wmf
- wmv
- xls
- zip

It is suggested that pdf files are supplied for native file types where possible.

N.B. Files created on a Mac must include the file extensions (e.g. webpage.html) to allow non Mac users to open the files. When saving files created on a Mac you must make sure the final file is saved as a PC version to allow your work to be moderated.

Accepted File Formats for the OCR Repository
Movie formats for digital video evidence
MPEG (*.mpg)
QuickTime movie (*.mov)
Macromedia Shockwave (*.aam)
Macromedia Shockwave (*.dcr)
Flash (*.swf)
Windows Media File (*.wmf)
MPEG Video Layer 4 (*.mp4)
Audio or sound formats
MPEG Audio Layer 3 (*.mp3)
Graphics formats including photographic evidence
JPEG (*.jpg)
Graphics file (*.pcx)
MS bitmap (*.bmp)
GIF images (*.gif)
Animation formats
Macromedia Flash (*.fla)
Structured markup formats
XML (*xml)
Text formats
Comma Separated Values (.csv)
PDF (.pdf)
Rich text format (.rtf)
Text document (.txt)
Microsoft Office suite
PowerPoint (.ppt)
Word (.doc)
Excel (.xls)
Visio (.vsd)
Project (.mpp)

Appendix D: Marking criteria glossary of terms

Accurately	Acting or performing within care and precision; within acceptable limits from a standard
Advanced	Being at a high level; progressive
All	All relevant as described in the unit content for a specified area
Appropriate	Relevant to the purpose/task
Basic	The work comprises the minimum required and provides the base or starting point from which to develop. Responses are simple and not complicated; the simplest and most important facts are included
Brief	Accurate and to the point but lacking detail/contextualisation/examples
Clear	Focussed and accurately expressed, without ambiguity
Comment	Present an informed opinion
Communicate	Make known, transfer information
Complex	Consists of several interwoven parts, all of which relate together
Comprehensive	The work is complete and includes everything that is necessary to evidence understanding in terms of both breadth and depth
Confident	Exhibiting certainty; having command over one's information/argument etc.
Consider	Review and respond to given information
Considered	Reached after or carried out with careful thought
Consistently	A level of performance which does not vary greatly in quality over time
Create	To originate (e.g. to produce a solution to a problem)
Critical	Incisive – exposing/recognising flaws
Describe	Set out characteristics
Design	Work out creatively/systematically
Detail	To describe something item by item, giving all the facts
Detailed	Point-by-point consideration of (e.g. analysis, argument)
Discuss	Present, explain and evaluate salient points (e.g. for/against an argument)
Effective	Applies skills appropriately to a task and achieves the desired outcome; successful in producing a desired or intended result
Efficient	Performing or functioning in the best possible manner with the least waste of time and effort; having and using requisite knowledge, skill and effort
Note on effective versus efficient: both express approval of the way in which someone or something works but their meanings are different. **Effective** describes something which successfully produces an intended result, without reference to morality, economy or effort, or efficient use of resources. **Efficient** applies to someone or something able to produce results with the minimum expense or effort, as a result of good organisation or good design and making the best use of available resources	

Evaluate	Make a qualitative judgement taking into account different factors and using available knowledge/experience
Explain	Set out the purposes or reasons
Extensive	Large in range or scope
Few	A small number or amount, not many but more than one
Fully	Completely or entirely; to the fullest extent
High	Advanced in complexity or development
Independent	Without reliance on others
Limited	The work produced is small in range or scope and includes only a part of the information required; it evidences partial, rather than full, understanding
List	Document a series of outcomes or events or information
Little	A very small amount of evidence, or low number of examples, compared to what was expected, is included in the work
Many	A large number of (*less than 'most' see below*)
Most	Greatest in amount; the majority of; nearly all of; at least 75% of the content which is expected has been included
Occasionally	Occurring, appearing or done infrequently and irregularly
Outline	Set out main characteristics
Partly	To some extent, but not completely
Plan	Consider, set out and communicate what is to be done
Present	1. Produce an exposition/résumé for an audience (e.g. at the conclusion of the project to demonstrate what has been done and the outcome) 2. Set out (project) aims, content, outcomes and conclusions clearly/logically for the use/ benefit of others
Range	The evidence presented is sufficiently varied to give confidence that the knowledge and principles are understood in application as well as in fact
Reasoned	Justified, to understand and to make judgements based on practical facts
Relevant	Correctly focused on the activity
Simple	The work is composed of one part only, either in terms of its demands or in relation to how a more complex task has been interpreted by the learner
Some	About 50% of the content which would have been expected is included
Sound	Valid, logical, shows the learner has secured relevant knowledge/understanding
Support	Teacher gives training, instruction, guidance and advice as appropriate and monitors activities to assist learners in tackling/completing their projects, ensuring authenticity and a fair and accurate assessment
Thorough	Extremely attentive to accuracy and detail
Wholly	Entirely; fully
Wide	The learner has included many relevant details, examples or contexts thus avoiding a narrow or superficial approach, broad approach taken to scope/scale; comprehensive list of examples given

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01223 553998

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vocationalqualifications@ocr.org.uk

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