Cambridge NATIONALS

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CAMBRIDGE NATIONALS IN ENGINEERING

SYSTEMS CONTROL IN ENGINEERING

A PROJECT APPROACH TO DELIVERY – SMART HOMES

MARCH 2015

In partnership with

SIEMENS

OCR

Oxford Cambridge and RSA

INTRODUCTION

The purpose of this guide is to give you an overview of how you could holistically deliver a range of units from the Cambridge National in Engineering Level 1/2 in conjunction with Siemens. When delivering any qualification it is always useful to be able to look at the variety of units and consider how they are or could be linked together – a holistic approach.

An holistic approach will provide you with a structured plan to teach the learners how a range of topics work together across a number of units, providing them with some understanding of how skills and knowledge could link together in a working environment.

This guide looks at the delivery and facilitation of learning of the following units:

Unit R113: Electronic principles

Unit R114: Simulate, construct and test electronic circuits

Unit R115: Engineering applications of computers

Unit R116: Process control systems

In this example, the objective is for learners to develop their knowledge of the way in which systems control is used in engineering through practical engagement with projects and activities designed and supported by Siemens.

The intention is that the learners will be taught a range of knowledge and skills within each of the units and then carry out relevant review activities at various stages. Each of the review activities (once successfully completed by the learner) will provide foundation knowledge for their final assessment. The practice review activities within the modules must not be used for Cambridge National final assessment purposes. Model assignment tasks for each of the Cambridge National qualifications can be found at www.ocr.org.uk.

It is assumed that the learners will be given the opportunity to carry out activities that will enable them to practice the skills they have learned within each module prior to being given final assessment activities.

When considering a holistic approach to delivery and learning it is important to consider the overall objectives. In this guide the objectives are to:

- Deliver all four units to achieve the Level 2 Cambridge National Certificate in Systems Control in Engineering.
- Structure a programme of learning and reviews which are exciting and engaging for the learners.
- Provide the learners with an overview of how the knowledge and skills gained in one unit, support the knowledge and skills used within other units.
- Provides the learners with an opportunity to consider how they would use their engineering skills holistically within the working environment.

This guide is divided into four modules which may be sub-divided or combined according to the teaching time available.

The tables below show where each module provides delivery approaches and learning opportunities to ensure a thorough review of skills and understanding prior to final assessment and evidencing by the learner.

Please note that should final assessment be presented in a similar holistic way, learners must be able to present evidence for each of the controlled assessment units R114, R115 and R116 independently.

By Unit/Learning Outcome (LO)

	LO1	LO2	LO3	LO4
Unit R113	Module 1	Module 1	Module 1	Module 1
Unit R114	Module 2	Module 2 Module 1	Module 2 Module 1	
Unit R115	Module 3	Module 3	Module 3	
Unit R116	Module 4	Module 4	Module 4	

By Module

	Unit	LO
Module 1	R113 R114	LO1, LO2, LO3, LO4 LO2,LO3
Module 2	R114	LO1, LO2, LO3
Module 3	R115	LO1, LO2, LO3
Module 4	R116	LO1, LO2, LO3

SMART Homes Project
The Project Brief

(Learner version of the Project Brief is available from www.ocr.org.uk/qualifications/cambridge-nationals-engineering-design-level-1-2-award-certificate-j831-j841/.

SMART Homes use a range of micro-generation technologies to provide power generation.

Any surplus power generated can be sold back to the national grid.

Learners have been asked to test and manufacture an electronic circuit that indicates the balance of energy generation and energy usage, suitable for use in a model SMART home for school use.

The circuit provide by Siemens is suitable for this application.

Task 1:

- Use CAD simulation to :
  - simulate and test the circuit operation
  - design the printed circuit board
- Use appropriate tools and techniques to:
  - manufacture the circuit board
  - assemble components to the circuit board
  - test and evaluate the operation of the constructed circuit

Task 2:

To ensure energy efficiency within a SMART house, an automatic control system is required to control lighting and heating.

The task is to:

- design a control system solution that will enable lighting and heating to be automatically adjusted considering elements such as:
  - external temperature
  - external light level
  - room usage (movement)
  - time of day
- Simulate the control system operation
- Transfer the control programme to a programmable device and test.

This work can be undertaken as an individual or as a team. If working as a team all learners are expected to contribute to each of the areas in order to gain the experience and knowledge required to successfully complete the Cambridge National in Systems Control.

The SMART Homes project explores the design challenges of designing an educational simulation that explains net energy production within a SMART Home.

Environmental issues and climate change are high on everyone's agenda, through this project learners will develop a balanced view of the challenges and opportunities for individuals who want to make a difference.

Learners will engage with a range of construction techniques and simulation software to design and test electronic circuits and automated control solutions, with learners using ICT to learn about physics, electronics, mathematics and systems design.

Module 1 – Electronic principles

The delivery begins with unit R113 (LO1, LO2, LO3 and LO4).

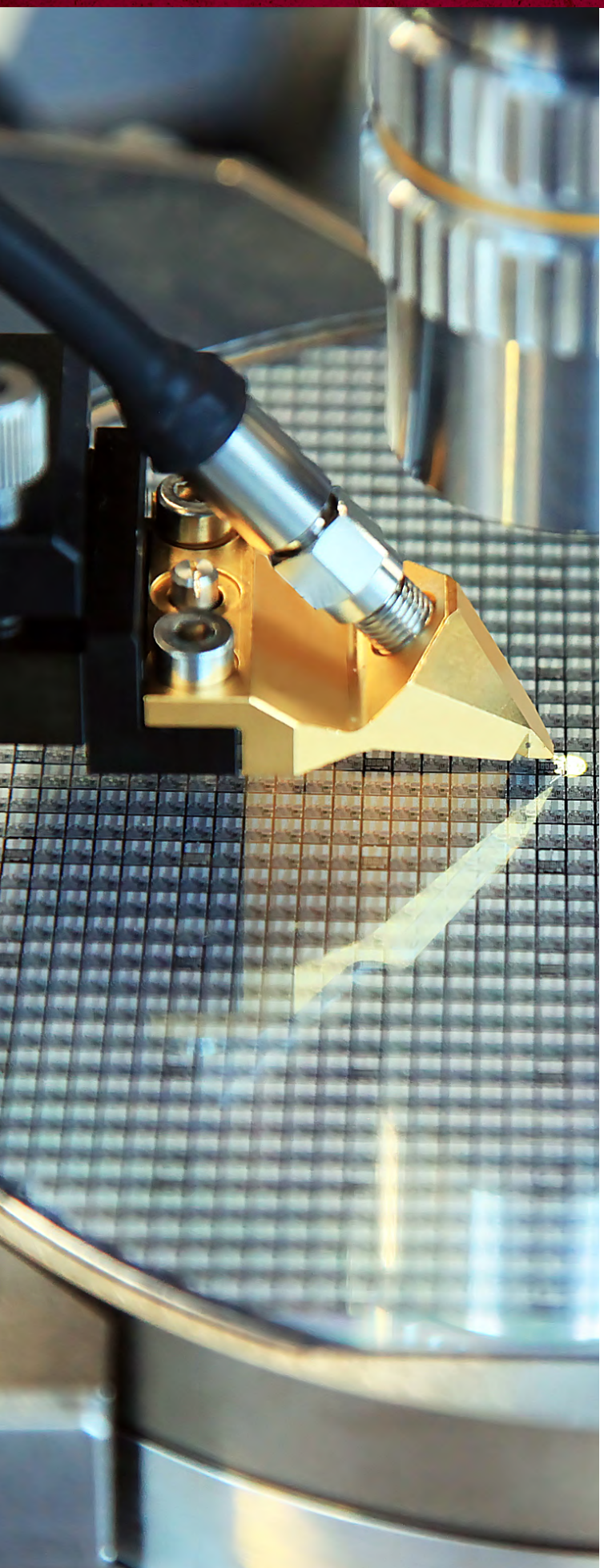
Before learners can start to design a control system for a SMART Home they need to have a good understanding of:

- electronic principles
- circuit simulation
- circuit construction
- circuit testing.

Contained within the following assessment criteria/LO(s)/ units:

Understand basic electronic principles	LO1	R113
Understand the operating principles of electronic components	LO2	R113
Know test methods for electronic circuits	LO3	R113
Understand commercial circuit construction methods	LO4	R113
Be able to construct circuits	LO2	R114
Be able to test electronic circuits	LO3	R114

During the delivery of the units, the learners should carry out a range of activities to demonstrate and check their knowledge and understanding. They should also undertake review activities as they work through the programme of learning.



Practice Review Activities

Activity 1

Learners could develop their understanding of electronic principles by producing a series of teaching aids for the delivery of electronics to lower school pupils.

A number of the Siemens education resources can be used for reference.

Activity 2

Learners could apply their understanding of electronic components by creating an electronic component bingo game. The bingo cards could be different electronic circuits with electronic component symbols instead of numbers and the bingo balls would be the component names. This would help to introduce the concept of electronic components, the circuits they are linked with and linking the component name with the symbol.

The activity will help learners to match component symbols with the names and to recognise typical components in familiar circuits.

Activity 3

Learners' abilities to carry out electronic testing could be developed by presenting them with a circuit with known parameters. They should then obtain values at identified test points using the testing techniques they have been taught. The application of science and maths could be enhanced by asking them to calculate component values as part of the exercise.

The results should be entered onto a prepared table and compared with the correct figures at the end. Learners should revisit any tests where their values did not match the expected values.

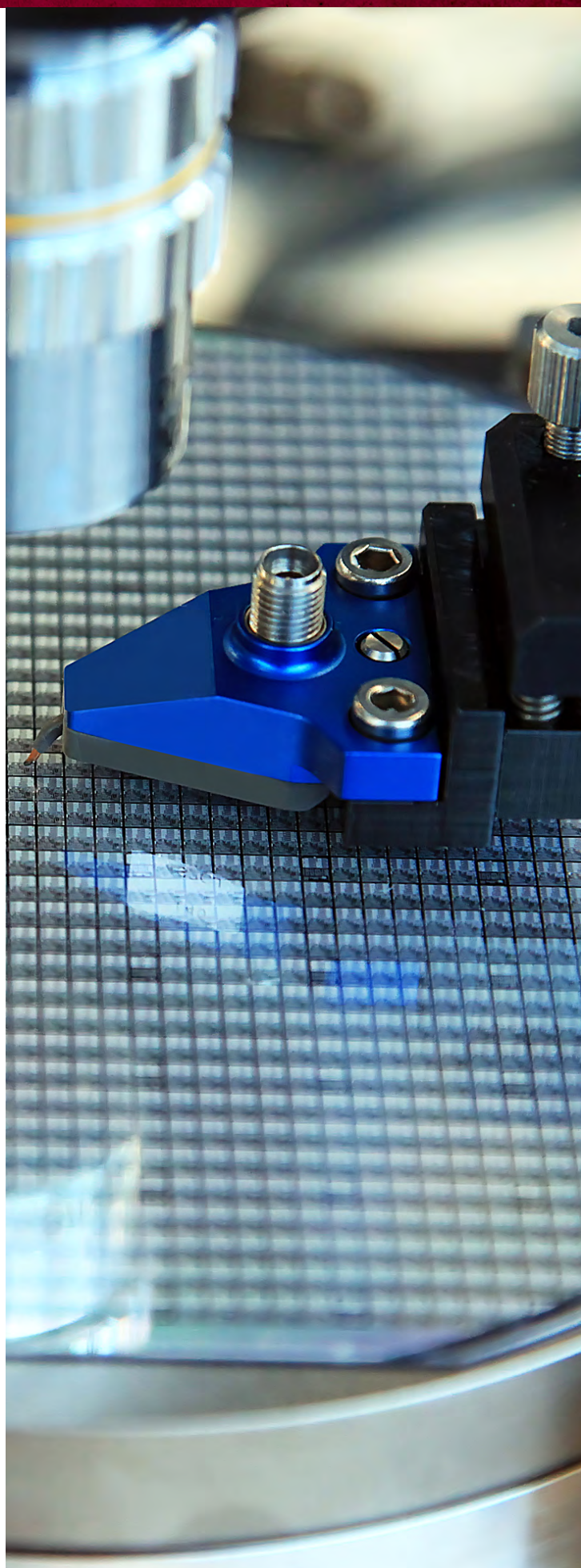
Activity 4

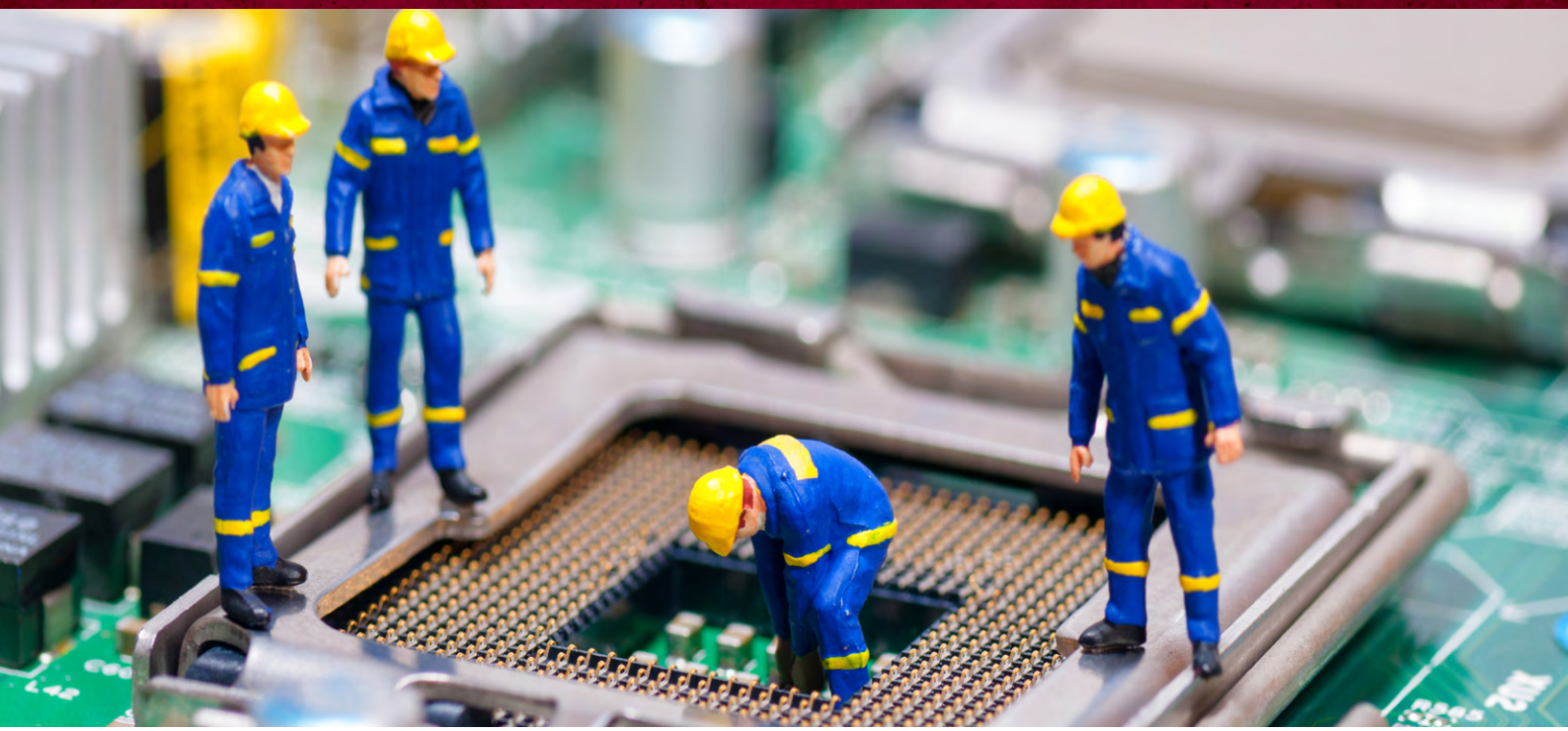
After being taught fault finding techniques, learners could consolidate their learning by working in teams to create a 'faulty circuit' (no more than two faults) for other teams to solve. Learners should construct a relatively simple circuit, or use one given, and introduce faults to the circuit. A circuit diagram and a description of the correct operation should be provided to the opposing team. The opposing team should then use fault finding techniques to identify the faults. Restrict the circuit to: low voltage operation only, 9v battery maximum.

Activity 5

Learners could confirm their understanding of circuit manufacturing methods in an exercise where they are presented with a series of pictures of circuits constructed using different commercial methods. 'Project Approach Resource Bank' (http://www.siemens.co.uk/education).

From the picture of the given circuit they should identify the likely construction method, considering pick and place robotic component placement, manual component placement, flow soldering and explain possible reasons why the method was selected.





Module 2 – Electronic Circuits

The delivery then follows through units R114 (LO1, LO2 and LO3).

Contained within the following assessment criteria/LO(s)/ units:

Be able to use CAD for circuit simulation and design	LO1	R114
Be able to construct circuits	LO2	R114
Be able to test electronic circuits	LO3	R114

During the delivery of the units, the learners should carry out a range of activities to demonstrate and check their knowledge and understanding. They should also undertake review activities as they work through the programme of learning.

This will allow learners to develop their skill in using CAD to design, test and optimise circuits.

Learners will practice the construction and testing of circuits.

During the delivery of the units, the learners should carry out a range of activities to demonstrate and check their knowledge and understanding. They should also undertake review activities as they work through the programme of learning.

Practice Review Activities

Activity 1

Learners could follow on from their introductions to circuits by being given a circuit diagram from a Siemens' product, 'Project Approach Resource Bank' (http://www.siemens.co.uk/education), naming the different components in the circuit and then describing the operation of the circuit.

Activity 2

Learners then develop their understanding by being given access to a circuit simulation CAD package (a number are available for educational use). They are provided with a range of simple circuits, 'Project Approach Resource Bank' (http://www.siemens.co.uk/education), which they then create and test using the simulation software.

Activity 3

To develop their construction skills, learners are given a simple circuit design, maybe an audio amplifier for a portable music device, which they then construct.

The finished circuits are then tested and the learners write a short report evaluating the method they used, procedures followed, equipment used and any fault finding techniques applied.

Activity 4

Learners could practice their fault finding techniques by locating a fault on a given circuit. The learners should devise a plan to test the circuit, noting down what tools, processes and approaches they could take and the results they could expect to see.

Learners then carry out the fault finding exercise according to their plan and then evaluate the effectiveness of the plan.

SMART Home Task links

Learners could use CAD simulation to design the SMART Home demonstrator circuit and construct elements of the circuit. Learners completing just the Award can undertake Task 1 of the SMART Homes Project.

Module 3 – Engineering applications of computers

The delivery then follows through units R115 (LO1, LO2 and LO3).

Contained within the following assessment criteria/LO(s)/ units:

Understand how computers are used in engineering design, manufacture and process control	LO1	R115
Understand how computers are used for maintenance of engineering systems	LO2	R115
Know how computers are used to communicate and use data for production and maintenance	LO3	R115

This will allow learners to develop an understanding of how computers are integral to all areas of the product lifecycle, from design and manufacture to operation and maintenance.

Learners will experience the integration of HMI (Human Machine Interface) control and remote computer communication.

During the delivery of the units, the learners should carry out a range of activities to demonstrate and check their knowledge and understanding. They should also undertake review activities as they work through the programme of learning.

Practice Review Activities

Activity 1

Learners could embed their understanding of the integration of computer control through a visit to the Siemens' Crystal Sustainable Cities Initiative (www.Siemens.co.uk/education/en/teachers/the-crystal.htm) experience in London to see one of the most sustainable buildings in Europe and understand how it was designed.

www.thecrystal.org/

Learners could explore the use of computer control through the Siemens' 'Totally in Control' (www.Siemens.co.uk/education/en/teachers/teaching-resources/schemes-of-work-ks4.htm) activity exploring the use of electronic communication for fairground rides and pedestrian crossings.

Activity 2

Learners could develop their practical understanding of the relationship between computer control and manufacturing by visiting a manufacturing facility. During the visit, learners create a flow diagram showing all the stages where computers are used in the process. They should identify the extent to which the computer is controlling each process. A SWOT (Strengths Weaknesses Opportunities Threats) analysis based on how computer control was used at the facility could be produced.

Activity 3

Learners could explain the functions of a HMI (Human Machine Interface) and an Expert System. Learners could be encouraged to imagine the HMI and the Expert System as people and describe an operational discussion the two people might have.

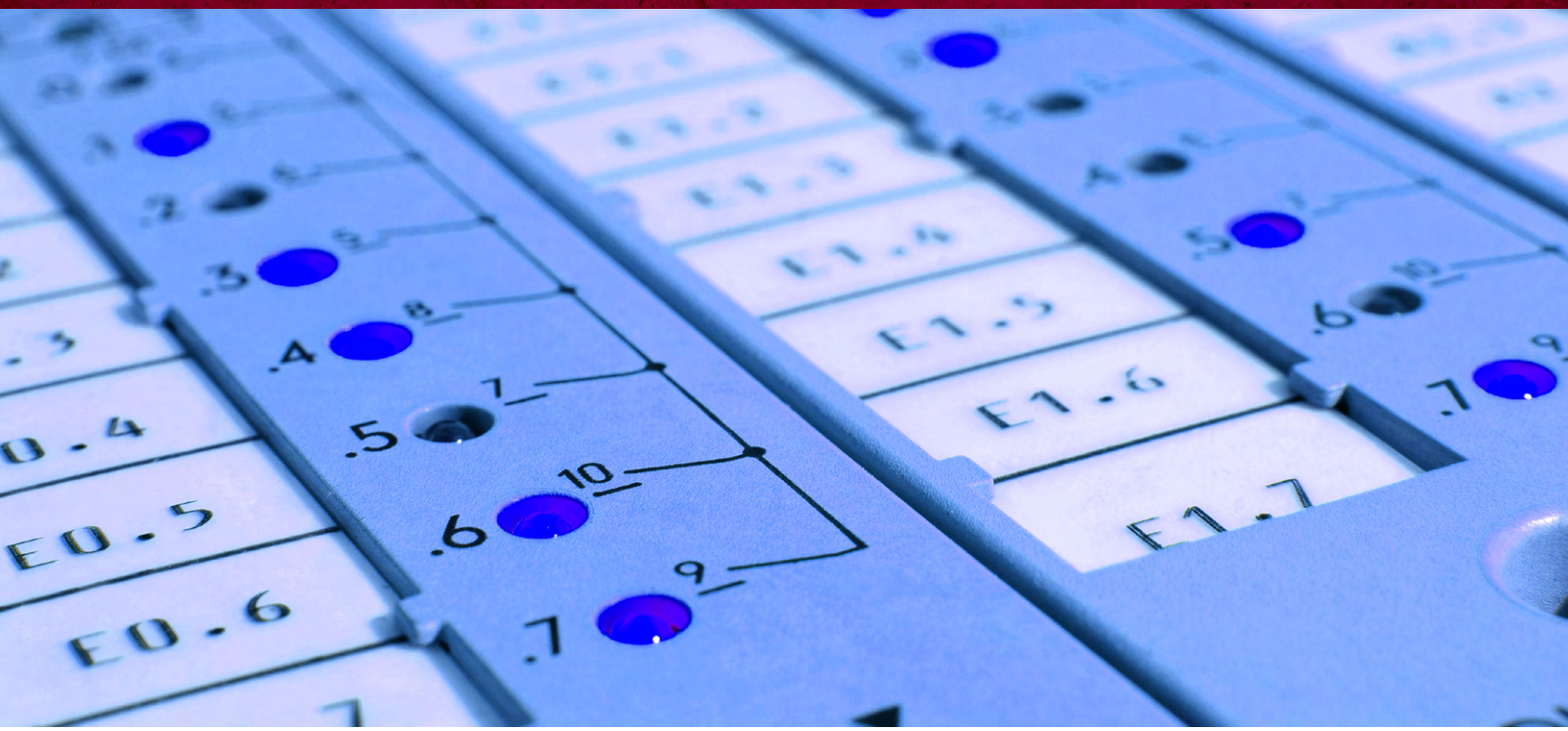
This is an opportunity for role play in the classroom, depending on the group, the teacher may ask some of the learners to act out their discussion for the group.

The objective is for learners to understand the different roles and impacts of HMI and Expert Systems.

Learners could use the Siemens"London Underground' (w3.Siemens.co.uk/smartgrid/uk/en/Services/mcs/smb/Pages/Case-Studies.aspx) case study to better understand Expert Systems.

Activity 4

Learners could develop their understanding of computers in collecting data and communicating by creating a map of communication and data collection for a given process (possibly from a manufacturing visit). Learners should be given a list of approaches and encouraged to use as many as possible as part of the plan. Learners create a diagram of the manufacturing process and then add in lines of communication with annotations to show where data is travelling and the purpose for the data. They could complete the exercise with a short reflection on how the process would continue if all computer communication was banned for some reason and had to revert to non-electronic control.



Module 4 – Process control systems

The delivery then follows through units R116 (LO1, LO2 and LO3).

Contained within the following assessment criteria/LO(s)/ units:

Understand the application and operation of microcontrollers and microprocessors in engineered products	LO1	R116
Be able to design, develop and simulate a control system	LO2	R116
Be able to test control systems	LO3	R116

This will allow learners to develop an understanding of control systems and how they operate, they will develop a skill in programming of PLC and/or PIC controllers and use a range of components in building a simple control system.

They will also develop the skills associated with risk assessment and contingency planning.

During the delivery of the units, the learners should carry out a range of activities to demonstrate and check their knowledge and understanding. They should also undertake review activities as they work through the programme of learning.

Practice Review Activities

Activity 1

Learners could be introduced to the idea of control systems by using the Siemens''Totally in control' (www.Siemens.co.uk/education/en/teachers/teaching-resources/schemes-of-work-ks4.htm) activity focused on the use of circuits in modern life. The activity focuses on how sequential process control operates in the context of fairground rides and pelican crossings.

Activity 2

Learners could develop their skills in testing control systems using a control system with a given fault condition. The learners should devise a plan to test the system, noting down what procedures would be followed, what equipment would be used and the fault finding technique. They should then follow the plan they set out and evaluate how effective the plan was at identifying the fault. They should be given the opportunity to revise the plan to see if it could be made more efficient.

Activity 3

Learners could develop their understanding of microprocessor control through access to PLC or PIC simulation software (there are a number available). Simple operation sequences of domestic products, such as Siemens washing machines, can be simulated by learners using the software. 'Siemens' Product and Technology Videos' (www.energy.Siemens.com/br/en/energy-topics/videos/)

'Living Energy e-magazine' (www.energy.Siemens.com/br/en/energy-topics/publications/living-energy/).

Activity 4

Learners could take part in the Siemens' 'A case to resolve' (www.Siemens.co.uk/education/en/teachers/teaching-resources/schemes-of-work-ks4.htm) activity where they will learn how systems are developed to meet certain requirements and use logical reasoning to analyse the outcomes from a process within the context of the baggage handling system at an airport.

Activity 5

Learners could develop their programming skills by being given access to a PIC programmer or PLC programmer and set the task of writing a suitable programme. The task could be related to the functionality of the SMART home simulator in Task 2 of this project.

Delivering the project holistically

This project should be delivered in conjunction with other resources available on the OCR website. www.ocr.org.uk/cambridgenationals in the teaching and learning resources area.

Teaching and learning resources

Teaching and learning resources for each Cambridge National in Engineering are:

- the Delivery Guide
- Lesson Elements
- Resource Links
- Sample assessment materials
- Cambridge Nationals in Engineering – Mapping to Mathematics and Science
- Skills Guides www.ocr.org.uk/i-want-to/skills-guides/.

Use the delivery guide and lesson elements to enhance teaching and learning through each module in the project approach.

The example below shows how Unit R113: Electronic principles LO1: Understand basic electronic principles can be delivered using these resources.

Learners could study relevant Siemens resources bank http://www.siemens.co.uk/education/en/. Learners will understand the fundamentals of electronic circuits and be able to calculate resistor and capacitor values applying them to a range of electronic circuits. Learners will use techniques to identify potential electrical hazards and apply fault-finding procedures using multi-meter for voltage, current, resistance and continuity.

Learners are required to calculate values of power, voltage, current, resistance, capacitance, inductance, electromagnetism and frequency. In maths, learners are required to add and subtract three-digit numbers, multiply and divide any number by 10, 100 and 1000 without the use of a calculator. They should also be able to round numbers to the nearest integer or to any given number of significant figures or decimal places

Building up research skills and applying appropriate mathematics and science, learners could use resource links documents web sites such as (www.siemens.co.uk/education/en/teachers/the-crystal.htm) experience in London to see one of the most sustainable buildings in Europe and understand how it was designed.

Use the OCR guide to research to develop learners' research skills. www.ocr.org.uk/i-want-to/skills-guides/

Examples showing how the resources available from the OCR website can be used with this project approach

Unit R113: Electronic principles

LO1: Understand basic electronic principles

	Unit	Learning Outcome (LO)
Module 1	R113 R114	LO1 LO3 LO2 LO4 LO2 LO3

The Project Approach

Activity 1 (R113 – LO1)

Learners could develop their understanding of electronic principles by producing a series of teaching aids for the delivery of electronics to lower school pupils.

A number of the SIEMENS education resources can be used for reference.

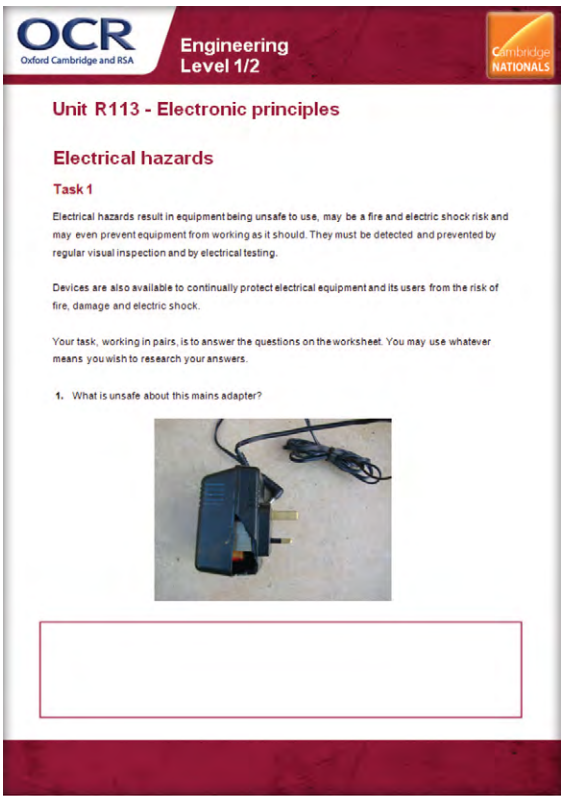
The Delivery Guide (R113 – LO1)

Suggested content	Suggested activities	Suggested timings	Possible relevance to
1 Components and Circuits	Learners could be given real electrical components to handle, and worksheets may be developed with pictures and circuit symbols of components to identify. The learners could be asked in groups or individually to research (using catalogues, data sheets and supplier websites such as http://uk.rs-online.com/web/) various aspects of different electrical components such as size and cost. Teachers might show circuit diagrams to learners for them to identify various components and to encourage them to research components not yet recognised. An outcome of the activity could be an expectation that learners could develop their skills in identifying a range of electrical components alone and as part of circuits.	1 hour	R101 (LO2) 2 Principles, Units and R114

Lesson Element (R113) Electrical Hazards

In this lesson element the students are tasked with identifying unsafe devices and wiring practices in a variety of appliances.

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



OCR Oxford Cambridge and RSA

Engineering Level 1/2

Cambridge NATIONALS

Unit R113 - Electronic principles

Electrical hazards

Task 1

Electrical hazards result in equipment being unsafe to use, may be a fire and electric shock risk and may even prevent equipment from working as it should. They must be detected and prevented by regular visual inspection and by electrical testing.

Devices are also available to continually protect electrical equipment and its users from the risk of fire, damage and electric shock.

Your task, working in pairs, is to answer the questions on the worksheet. You may use whatever means you wish to research your answers.

1. What is unsafe about this mains adapter?

Cambridge Nationals in Engineering – Mapping to mathematics and science

This document will help you plan your curriculum and assist you in delivering related subjects such as mathematics, science and ICT when teaching your Cambridge Nationals in Engineering.

The mapping of R113 LO1 to maths foundation – initial and bronze

The example below is an extract from this mapping document and suggests how GCSE maths could be taught and then applied to develop skills in evaluating market data necessary for LO1.

	Keywords/Themes	Theme	Foundation Initial	Foundation Bronze
LO1	Calculations: ohms law and potential divider. Power law. Voltage, current, resistance, capacitance, inductance, electromagnetism, frequency.	Fundamental electrical calculations e.g. Using ohms law, power law.	FIN2 Add and subtract three-digit numbers, without the use of a calculator. FIN3 Multiply and divide numbers with no more than one decimal digit by an integer between 1 and 10, without the use of a calculator. Multiply and divide any number by 10, 100 and 1000 without the use of a calculator.	FBN2 Round numbers to the nearest integer or to any given number of significant figures or decimal places. Estimate answers to one-stage calculations, particularly calculations involving measurement or money. FBN3 Use the terms square and square root (positive square roots only) and the correct notation.

Learners are required to calculate values of power, voltage, current, resistance, capacitance, inductance, electromagnetism and frequency. In maths, (FIN2) learners are required to add and subtract three-digit numbers, multiply and divide any number by 10, 100 and 1000 without the use of a calculator. They should also be able to round numbers to the nearest integer or to any given number of significant figures or decimal places (FBN2). Learners could apply the knowledge they acquire from their maths studies to use when calculating electrical units. Joining these two requirements together makes the learning experience much more relevant to learners and should ultimately increase their interest.

The Skills Guides

Learners could use the OCR guide to research skills and the OCR guide to presentation skills to help them develop these skills.
www.ocr.org.uk/i-want-to/skills-guides/

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