Cambridge NATIONALS

Accredited

CAMBRIDGE NATIONALS IN ENGINEERING

ENGINEERING DESIGN

A PROJECT APPROACH TO DELIVERY – ENERGY RECOVERY

OCTOBER 2014

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 R105: Design briefs, design specifications and user requirements

Unit R106: Product analysis and research

Unit R107: Developing and presenting engineering designs

Unit R108: 3D design realisation

In this example, the objective is for learners to develop their knowledge of design and manufacturing 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 Engineering Design.
- 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 R106, R107 and R108 independently.

By Unit/Learning Outcome (LO)

	LO1	LO2	LO3	LO4
Unit R105	Module 1 Module 4	Module 1 Module 4	Module 1	
Unit R106	Module 2	Module 2	Module 2	
Unit R107	Module 3	Module 3	Module 3	
Unit R108	Module 4	Module 4	Module 4	Module 4

By Module

	Unit	LO
Module 1	R105	LO1 LO2 LO3
Module 2	R106	LO1 LO2 LO3
Module 3	R107	LO1 LO2 LO3
Module 4	R108	LO1, LO2, LO3, LO4
	R105	LO1, LO2

Energy Recovery Project

The Project Brief

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

Learners have been asked to design or modify a system that recovers or converts energy from existing energy sources.

Learners will:

Apply the design cycle elements to:

- identify the key requirements for the energy recovery system
- researching commercial energy recovery systems through primary and secondary methods
- develop a justified design specification for the energy recovery system
- produce design ideas for the energy recovery system
- optimise the energy recovery system components through the use of prototyping and modelling
- evaluate the success of the prototype of the energy recovery system components.

This work can be undertaken as an individual or within a team. If working within a team 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 Engineering Design.

The Energy Recovery Project explores the technologies being used to improve the efficiency and lower the running costs of a range systems that use energy

From trains and buses to Formula 1 cars, energy recovery systems are commonly used. With the high cost of fuel and environmental concerns affecting everyone, this project will help learners develop an understanding of how technological advances in engineering contribute to environmental improvements.

Learners will engage with a range of construction techniques and simulation software to design and test environmental solutions with learners applying CAD/CAM software to design and prototype an energy recovery system.

Module 1 – Briefs and Specifications

The delivery begins with unit R105 (LO1, LO2, LO3 and LO4)

Before learners can start the design process for an energy recovery system, or other engineered product, they need to have a good understanding of:

- the four phases of the design cycle
  - identify phase
  - design phase
  - optimise phase
  - validate phase
- how commercial production methods, quality and legislation impact on the design of products and components
- the identification of design needs
  - initial design brief from client
  - information which may inform the design brief
  - the relationship between a design brief and a design specification
- the wider influences on the design of new products.

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

Understand the design cycle and the relationship between design briefs and design specifications	LO1	R105
Understand the requirements of design specifications for the development of a new product	LO2	R105
Know about the wider influences on the design of new products	LO3	R105

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 create and deliver a presentation explaining the four phases of the design cycle. The purpose of the presentation would be to explain how the learners are planning to approach the design of the energy recovery system for the Energy Recovery Project.

Activity 2

Learners could work from a given client design brief, found in the 'Project Approach Resource Bank' (http://www.siemens.co.uk/education) and explore the situation and context that has led to the brief, the needs of the client eg. corporate branding, target audience, the purpose and functions of the product. Learners should consider other information which may inform the design brief, ie market research, strengths and weaknesses of competitors' products, improvements in materials and production processes and budgetary constraints.

Learners should analyse the information gained before the production of a final design brief from which a specification could be developed.

Activity 3

Learners could use the 'Green Racers' (http://www.siemens.co.uk/education/en/teachers/teaching-resources/schemes-of-work-ks4.htm), based on the 'Green Power Challenge' (http://www.siemens.co.uk/education/en/activities-challenges.htm) from Siemens to explore the impact of ideas, design decisions and technological advances and how these provide opportunities for new design solutions. Learners can compare the different ways in which the same design brief has been interpreted by different teams.

Activity 4

Learners could examine the wider influences upon the design of products such as hybrid vehicles. The Siemens' 'Inspired Bus Company' (http://www.siemens.co.uk/education/en/teachers/teaching-resources/schemes-of-work-ks4.htm) has a useful graph showing the relationship between diesel, hybrid and hydrogen powered vehicle outputs.

'Siemens' Product and technology videos' (http://www.energy.siemens.com/br/en/energy-topics/videos/) contain examples of Siemens products.

Activity 5

Learners could use the Siemens' 'I can see clearly now' (http://www.siemens.co.uk/education/en/teachers/teaching-resources/schemes-of-work-ks4.htm) materials, responding creatively to briefs, developing their own proposals and producing specifications for products to solve technical problems.

Activity 6

To understand the wider influences on the design of new products, learners could use the Siemens' resources 'Underwater Energy' (http://www.siemens.co.uk/education/en/teachers/teaching-resources/schemes-of-work-ks4.htm) and then create a presentation that explains how the design of the Seagen turbine has been influenced by:

- market pull / technology push
- fashion trends
- legislation, life cycle analysis
- sustainable design
- new materials
- environmental pressures

The Siemens' Seagen video can be accessed from: http://youtu.be/ZPi9HeDgN58

The Siemens' 'Crystal Sustainable Cities Initiative' (http://www.siemens.co.uk/education/en/teachers/the-crystal.htm) has specific topic related work sheets that can be used during a visit.

Activity 7

To develop an understanding of intellectual property, learners could research the regulations and safeguards in place. These include copyright, patents, registered designs, trademarks, British Standards, European Conformity. Learners could create chart showing how each method is used by Siemens to cover at least one of its products or services. Where applicable, learners could highlight where Standards are different in different countries.

Module 2 Product Analysis and Research

The delivery then follows through units R106 (LO1, LO2, and LO3).

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

Know how commercial production methods, quality and legislation impact on the design of products and components	LO1	R106
Be able to research existing products	LO2	R106
Be able to analyse an existing product through disassembly	LO3	R106

This unit will support learners in developing their understanding of both formulating and interpreting design specifications. They will develop skills of analysis, using primary sources and secondary analysis techniques. Learners will, through examination of products, begin to recognise the wider influences upon product design.

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

To better understand commercial production methods and manufacturing, an industrial visit to a Siemens manufacturing facility could be arranged. Siemens also provide a range of videos illustrating the manufacturing processes they have and support. See 'Project Approach Resource Bank' (http://www.siemens.co.uk/education)

Activity 2

Manufacturing processes and their impact on design decisions might also be seen as part of an industrial visit. Manufacturing processes may include moulding, pressing/forming, shaping (including computer numeric control), machining, finishing and assembly. If a visit is not possible then learners could be shown suitable videos of manufacturing processes and then be asked to research their impact on design decisions.

The following video link shows injection moulding taking place: http://youtu.be/y1Zhpdx-XtA

The production of Siemens' composite rotor blades is covered in this video link: http://youtu.be/UN83zG7jHIk illustrating the impact of manufacturing location on design.

Activity 3

Learners could engage in a class discussion about the end of life implications for products including recycling of materials, reusing components and safe disposal of toxic hazards. The relationship to design could also be made.

The video Car Transplants at http://youtu.be/61FE2ABVOOU looks at end of life engineering for cars.

End of life considerations could be researched for a range of Siemens' products.

Suitable products might be a train, a wind turbine, a washing machine, a computer or mobile telephone. Learners could be asked to identify which components are recycled, reused and disposed of, and how this takes place. For the example of the mobile phone this might be: case (recycled), printed circuit board (reused), battery (disposed). Recycling websites might be useful, including www.recycling-guide.org.uk/.

Learners could prepare a presentation, based on the end of life disposal / recycling / reuse of components from within the product.

Activity 4

Learners could undertake the disassembly of a physical item. Learners could undertake the safe disassembly of an item. They should follow a structured approach, to disassembly, using manufacturer's instructions and manuals where available. Learners will need to consider safe use of appropriate tools including: screwdrivers, pliers, cutters, spanners, and measuring equipment.

Learners should document each stage of disassembly.

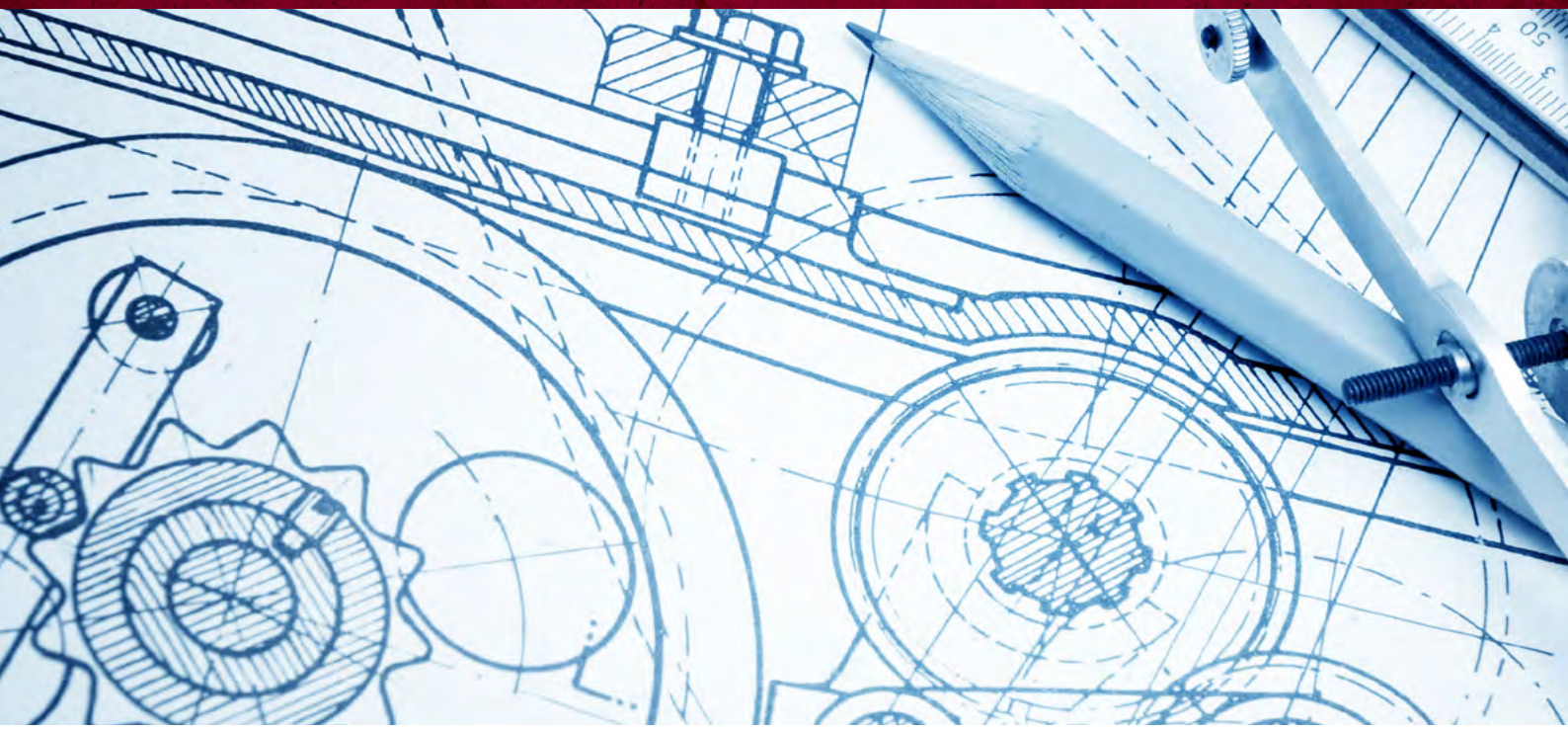
Siemens''Customer Service Videos' (http://www.siemens-home.co.uk/features-and-benefits/customer-service-video-gallery.html) provide some detail on domestic product servicing.

Suitable items in relation to the overall task might be a hair dryer, wind up torch or wind-up radio.

The following two web sites have supporting information for the disassembly of a hairdryer:

http://home.howstuffworks.com/how-to-repair-small-appliances9.htm

http://youtu.be/WITmaE5F9bI



Module 3 Developing and Presenting Engineering Designs

The delivery then follows through units R107 (LO1, LO2 and LO3).

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

Be able to generate design proposals using a range of techniques	LO1	R107
Know how to develop designs using engineering drawing techniques and annotation	LO2	R107
Be able to use Computer Aided Design (CAD) software and techniques to produce and communicate design proposals	LO3	R107

This will allow learners to develop techniques in the generation, concept development and the communication of design ideas using hand rendering and computer-based presentation techniques. They will learn to analyse designs as they develop and will consider the design brief and specification within their design development work.

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 presented with an image of a Siemens' product (see 'Project Approach Resource Bank') (http://www.siemens.co.uk/education). Learners should develop a range of design ideas for the exterior housing of this product using a range drawing and presentation techniques.

The techniques should include freehand sketching in 2D and 3D with shade, tone and texture.

Suitable products could include: invertor drives, portable radios, washing machines or other domestic products.

Activity 2

To develop their skills in presenting engineering designs, learners could draw 2D and 3D representation of an existing energy conversion system from a train, bus or car, using different techniques to render the object and evaluate the rendering techniques used. The existing system could be presented as a model, photograph or drawing.

Activity 3

To develop the range of techniques, learners could use 'exploded drawing' to show an energy recovery product assembly, such as a wind up torch.

Activity 4

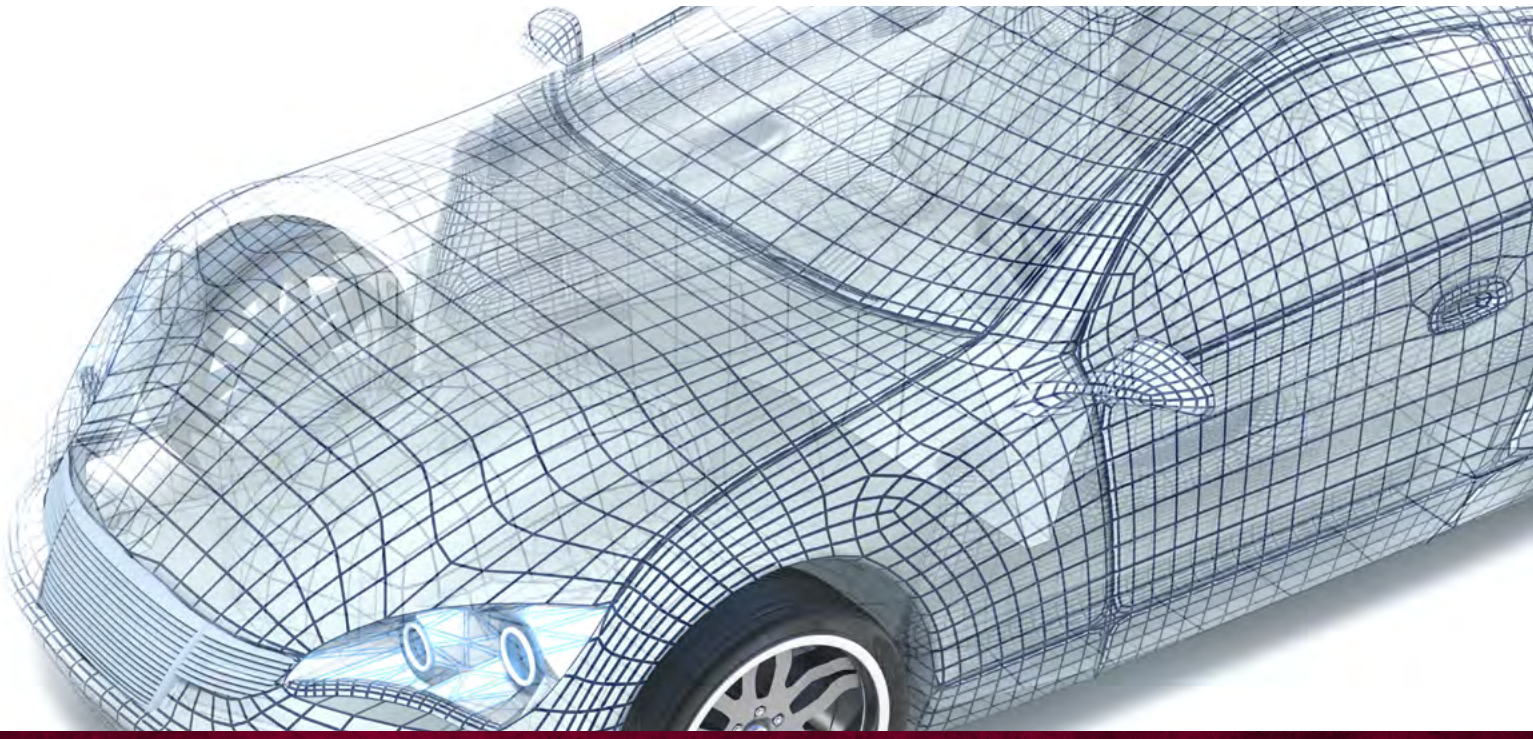
Learners could produce a working drawing for an energy recovery product using the free Siemens' education 3D software Solid Edge or other 3D package. 'Solid Edge Student Edition' (https://www.plm.automation.siemens.com/en_us/academic/resources/solid-edge/student-download.cfm?)

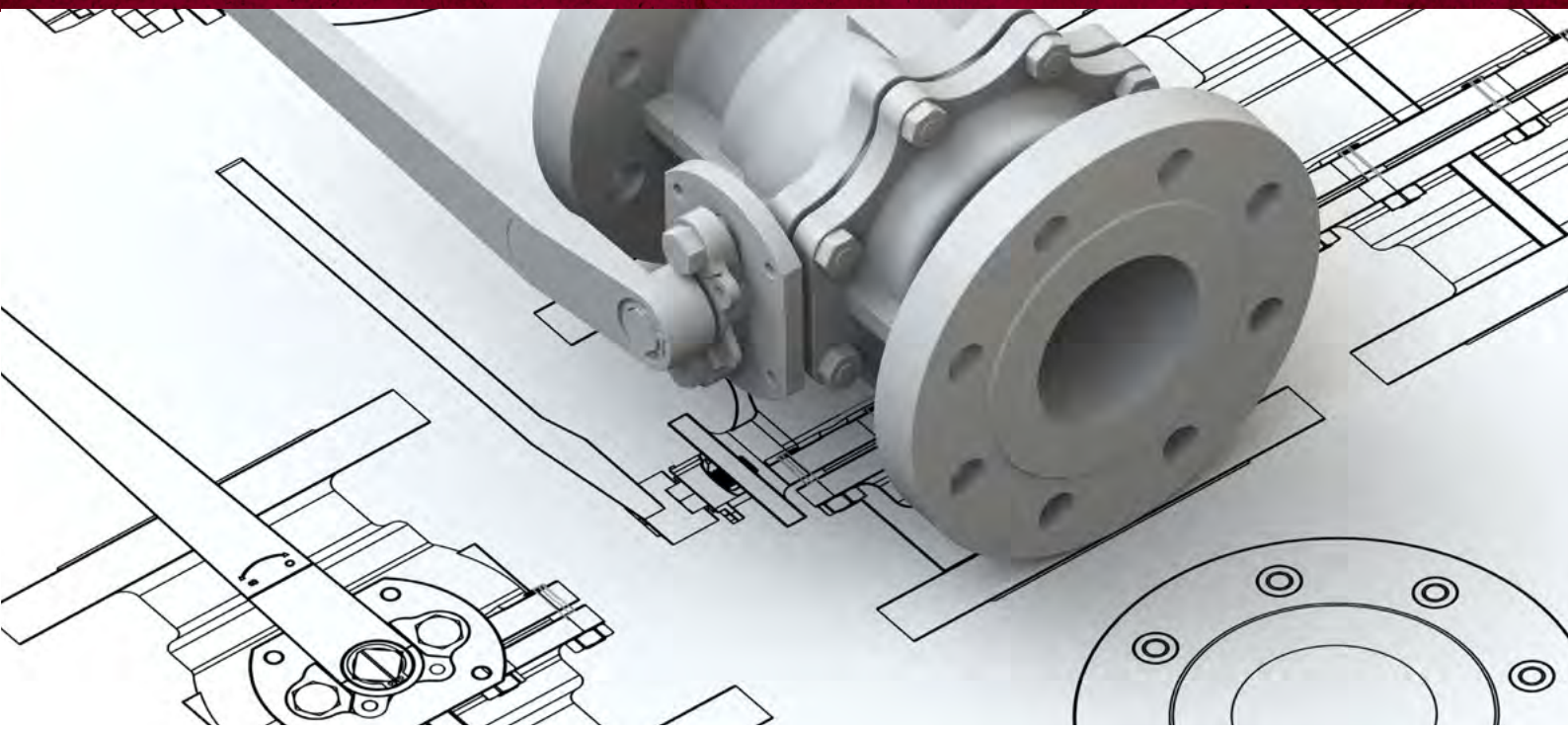
Activity 5

Learners could produce and present design drawings for an engineered product using Siemens education 3D software Solid Edge or other 3D package. 'Solid Edge Student Edition' (https://www.plm.automation.siemens.com/en_us/academic/resources/solid-edge/student-download.cfm?)

Learners should be encouraged to expand the ways in which they communicate their design proposals including display boards, models and PowerPoint. Learners might be given the opportunity to take design drawings produced for a given design proposal and use suitable techniques to develop and present these. This might also include producing physical models. Some example presentations are shown at: http://www.technologystudent.com/despro_flsh/desidea1.html.

Learners could be more innovative with the presentation techniques they use to include videos, simple web pages and animations.





Module 4 3D Design Realisation

The delivery then follows through units R108 (LO1, LO2 and LO3).

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

Know how to plan the making of a prototype	LO1	R108
Understand safe working practices used when making a prototype	LO2	R108
Be able to produce a prototype	LO3	R108
Be able to evaluate the success of a prototype	LO4	R108
Understand the design cycle and the relationship between design briefs and design specifications	LO1	R105
Understand the requirements of design specifications for the development of a new product	LO2	R105

This unit will allow learners to develop techniques for the evaluation of prototype products and the associated production planning against product specifications and briefs. Learners will identify possible improvements to their designs through the analysis of the performance of their prototype products. They will also develop the skills associated with self-evaluation as they assess their own performance.

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 might begin by interpreting the requirements of a design specification, provided by Siemens 'Project Approach Resource Bank' (http://www.siemens.co.uk/education), in preparation for the making of a prototype.

Learners progress from the design specification to the consideration of the materials and processes they might use for making a prototype and for the actual (production) item. Learners might, at this stage, begin to develop a basic plan for the making of a prototype in terms of materials and processes. This could be limited to the resources available to them.

Learners could be encouraged to modify a wind up torch to be used as an energy recovery device.

Activity 2

Learners should develop a production plan for the prototype product. Elements of a typical plan might include resources (eg materials, component parts, cutting lists, tools/ equipment, health and safety requirements, hazards and time requirements) and stages of development (eg making, process testing and evaluation).

The plan might account for some or all of these. Learners might use online tools to help produce a plan. The following is a free Gantt chart tool: http://www.tomsplanner.com/. Similar tools are available for producing flow charts and tables.

Learners could undertake a risk assessment prior to the manufacturing process and add this detail to the production plan.

Activity 3

Learners should be encouraged to keep a diary, documenting their prototype production activities.

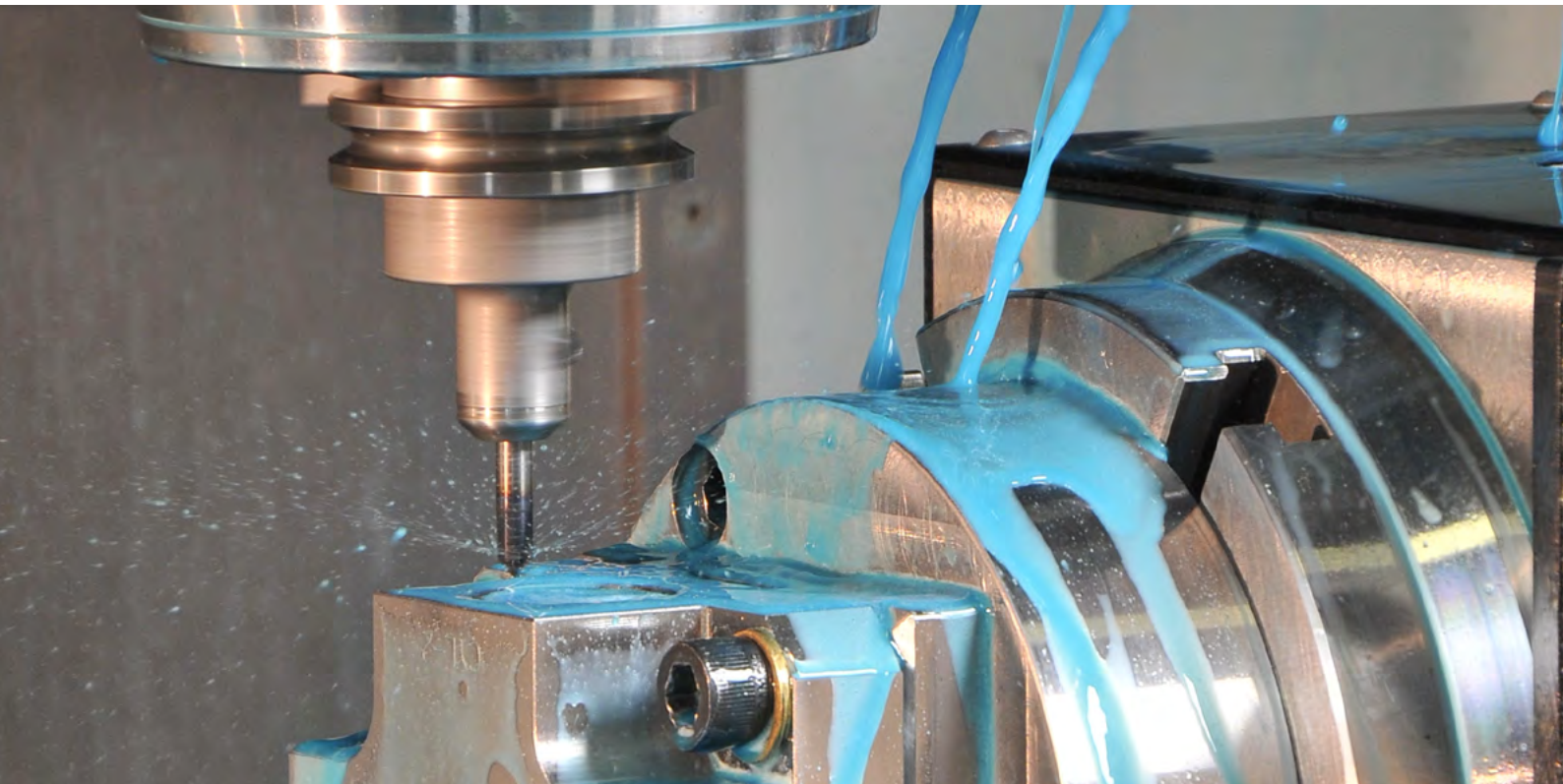
Learners will need to identify an appropriate method for recording the making of the prototype, this could include note taking, photographs, video, audio or a combination of all of these. This activity will allow learners to develop their recording skills before they need to apply this in the actual assessment.

Activity 4

Learners could create a prototype of a component from the energy conversion system using the supplied engineering drawing and the learner developed production plan.

If working in a group then learners could create different components from the system.

Learners could then evaluate the effectiveness of the design and manufacture using the records made of the process.



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 R105: Design briefs, design specifications and user requirements LO1: Understand the design cycle and the relationship between design briefs and design specifications can be delivered through the use of these resources.

Learners could study relevant Siemens resources bank (http://www.siemens.co.uk/education), identifying the key phases of the development cycle. They could for example, be taught in mathematics to use tables and graphs (both linear and non-linear) and apply this knowledge to inform a detailed and comprehensive conclusion.

Building up research skills and applying appropriate mathematics and science, learners could use resource links documents web sites such as www.technologystudent.com/designpro/despro1.htm as part of their research. From this, learners could be better informed to present their ideas through the use of well researched analysis.

Use the OCR guide to research to develop learners' research skills.

http://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 R105: Design briefs, design specifications and user requirements

LO1: Understand the design cycle and the relationship between design briefs and design specifications

	Unit	Learning Outcome (LO)
Module 1	R105 R106	LO1 LO3 LO2

The Project Approach

Activity 1 (R105 – LO1)

Learners could create and deliver a presentation explaining the four phases of the design cycle. The purpose of the presentation would be to improve understanding of the design cycle in learners joining a Key Stage 4 Engineering course.

The Delivery Guide (R105 – LO1)

Suggested content	Suggested activities	Suggested timings	Possible relevance to
The design cycle: identify and design phases	Learners could use a product case study in order to explore the four stages of the design cycle: identify, design, optimise and validation. The first two stages involve devising the design brief, undertaking research, process planning, producing a specification, design, and producing manufacturing plans. Websites might prove useful to teachers for explaining the design cycle such as BBC Bitesize : http://www.bbc.co.uk/schools/gcsebitesize/design/systemscontrol/designevaluationrev1.shtml	2 hours	

Lesson Element (R105)

Life Cycle Analysis

This lesson element gives learners the opportunity to practice life cycle analysis.

http://www.ocr.org.uk/qualifications/cambridge-nationals-engineering-design-level-1-2-award-certificate-j831-j841/

OCR Oxford Cambridge and RSA

Engineering

Level 1/2

Unit R105 – Design briefs, designs specifications and user requirements

Life Cycle Analysis

Task 1:

When designing and manufacturing products, it is important to consider life cycle analysis (LCA). Life cycle covers the time from when a product is manufactured to its recycling or disposal.

Some products have a relatively short life cycle, and some have a life cycle that is much longer.

Look at the photos below. Working in groups; research the life cycle for glass bottles and the mobile phone. Draw diagrams to show the life cycle for each product and make sure to label your diagrams and add notes.

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 R105 LO1 to maths foundation – initial and bronze

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

	Keywords/Themes	Theme	Foundation Initial	Foundation Bronze
LO1	Market research (surveys) Improvements in materials Budgets	Be able to interpret data (market research) used to influence the design process.[Direct]	FIA5 Construct and interpret simple graphs, including conversion graphs. FIS4 Draw and interpret simple frequency tables, charts, pictograms and bar charts for discrete data. FIS5 Extract and use information from common two-way tables including timetables.	FBA5 Interpret information presented in a range of linear and non-linear graphs, including travel (distance/time) graphs. FBS3 Construct and interpret pie charts. FBS4 Interpret graphs representing real data, including recognising misleading diagrams.

Learners are required to interpret data that will influence a design idea (R105) which will require them to make comparisons of relevant data and perhaps present them visually. In maths, (FIS4) learners are required to draw and interpret simple frequency tables, charts, pictograms and bar charts for discrete data, then FIS5) extract and use information from common two-way tables including timetables. 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.

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