Cambridge NATIONALS

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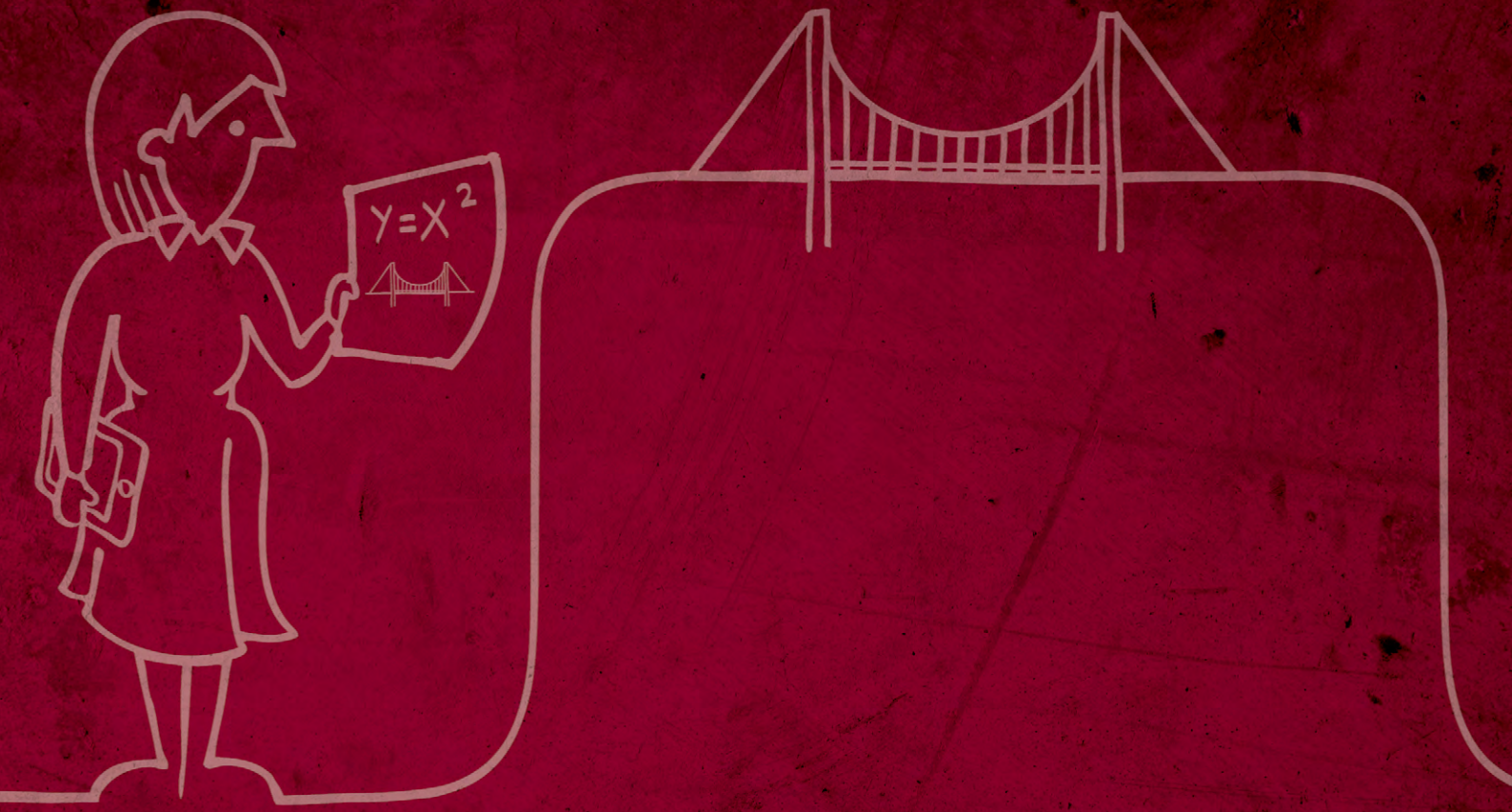


CAMBRIDGE NATIONALS IN ENGINEERING

ENGINEERING MANUFACTURE

A PROJECT APPROACH TO DELIVERY – ENERGY TRANSFORMATION

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 R109: Engineering materials, processes and production

Unit R110: Preparing and planning for manufacture

Unit R111: Computer aided manufacturing

Unit R112: Quality control of engineered products

In this example, the objective is for learners to develop their knowledge of engineering 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.

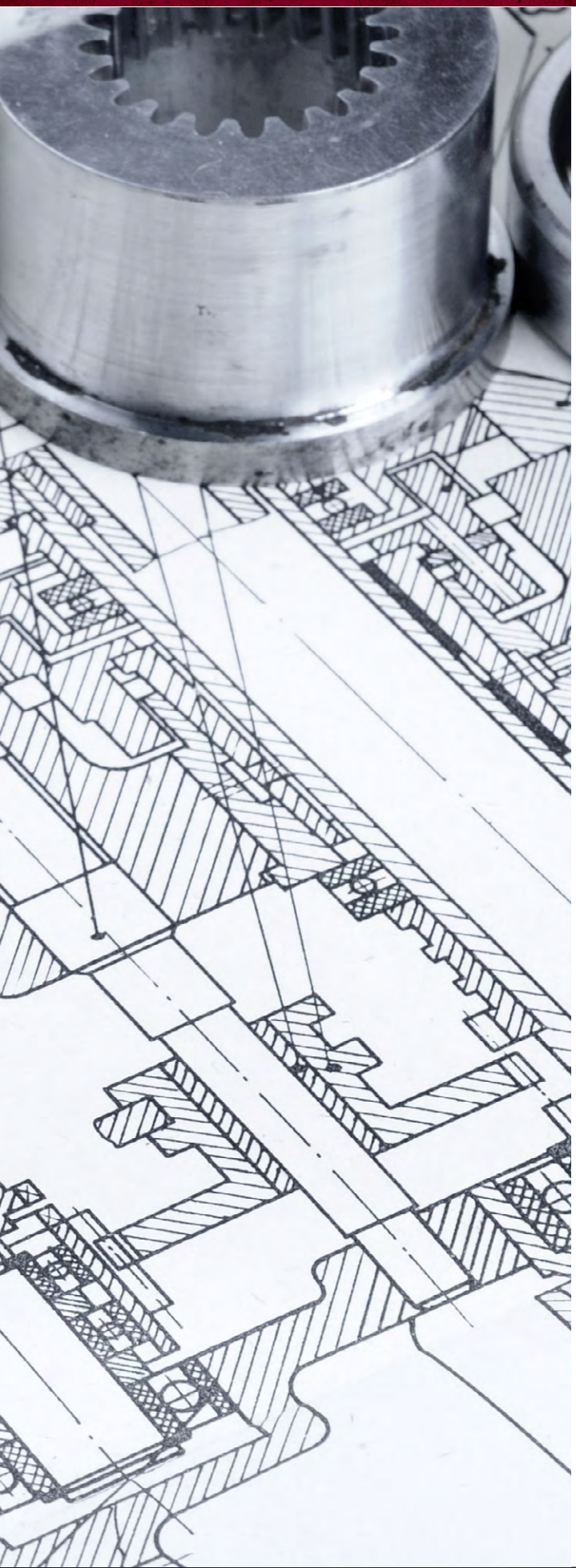
Please note that should final assessment be presented in a similar holistic way, learners must be able to present evidence for each of the controlled assessment units R110, R111 and R112 independently.

By Unit/Learning Outcome (LO)

	LO1	LO2	LO3	LO4
Unit R109	Module 1	Module 1	Module 1	Module 1
Unit R110	Module 2	Module 2	Module 2	
Unit R111	Module 3	Module 3	Module 3	Module 3
Unit R112	Module 4	Module 4	Module 4	Module 4 Module 2

By Module

	Unit	LO
Module 1	R109	LO1 LO2 LO3 LO4
Module 2	R110 R112	LO1 LO2 LO3 LO4
Module 3	R111	LO1 LO2 LO3 LO4
Module 4	R112	LO1 LO2 LO3 LO4



Energy Transformation Project

The Project Brief

(Learner version of the Project Brief is available from http://www.ocr.org.uk/qualifications/cambridge-nationals-engineering-manufacture-level-1-2-award-certificate-j832-j842/)

Learners have been asked to take the CAD drawing of a component, a fly wheel or fly wheel holder would be suitable, and:

- consider alternative materials and suggest the most appropriate material for use in the manufacture of the component
- produce a pre-production version of the component using manual methods
- produce a batch of identical components using CNC manufacturing methods.

Learners will carry out quality inspection in which they:

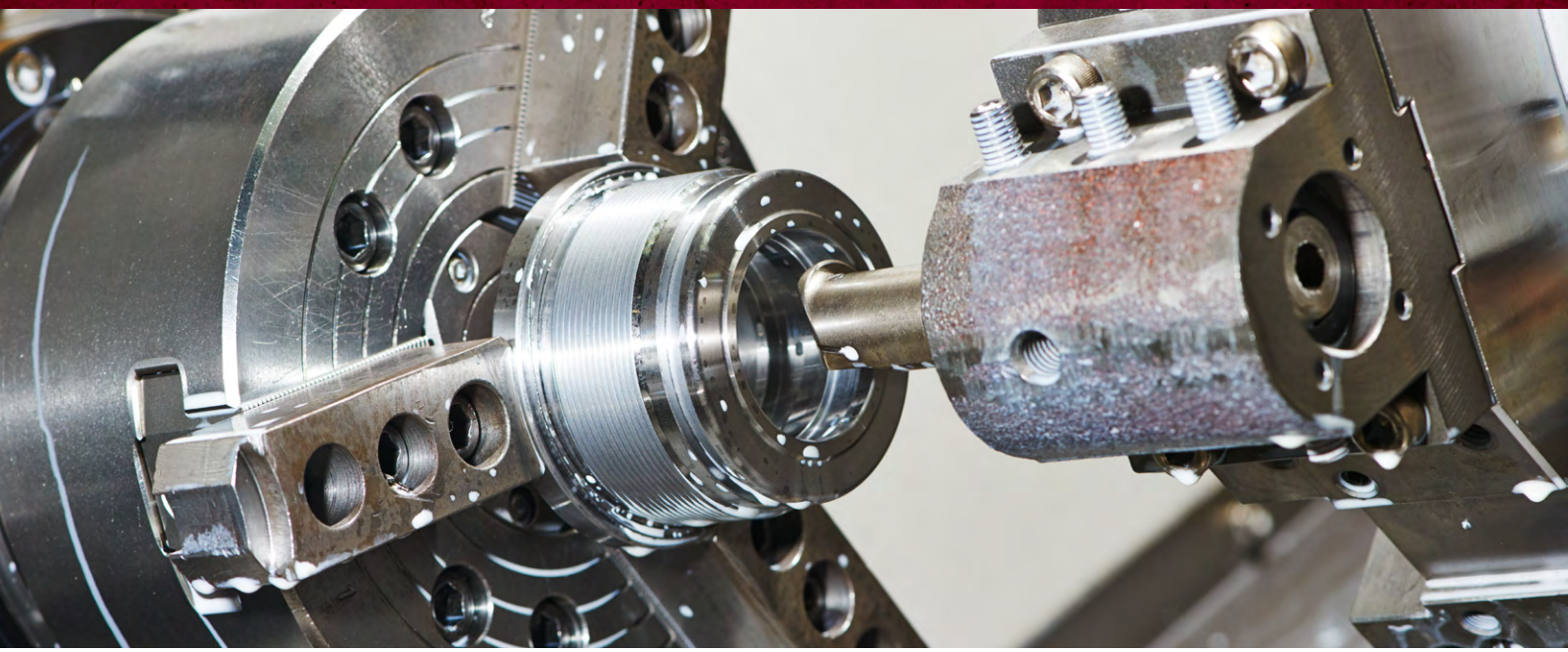
- compare the pre-production version on the component to the those produced using CNC methods
- evaluate the consistency of the batch of components.

This work could be undertaken as individuals or within a team. If working within a team all learners are expected to contribute in each of the areas in order to gain the experience and knowledge required to successfully complete the Cambridge National in Engineering Manufacture.

The Energy Transformation Project explores the challenges of modern manufacturing in the innovative area of energy transformation.

By linking the manufacturing process to the cutting edge area of energy recovery, learners will see the relevance and challenges of the modern engineering manufacture.

Learners will engage with a range of manufacturing methods and approaches before manufacturing a key energy transformation component themselves using CAD and CNC.



Module 1 - Engineering Materials, Processes and Production

The delivery begins with unit R109 (LO1, LO2 and LO3).

Before learners can start to design and test a manufacturing system they need to have a good understanding of:

- engineering materials
- engineering processes
- developments in engineering
- the impact of modern technology on engineering.

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

Know about properties and uses of engineering materials	LO1	R109
Understand engineering processes and their application	LO2	R109
Know about developments in engineering processes	LO3	R109
Understand the impact of modern technologies on engineering production	LO4	R109

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 help learners relate to the range of engineering materials they have been studying, they could annotate engineering drawings or diagrams showing the different materials, classification and the properties of the materials. The drawings should cover a range of materials and learners could include descriptions of the properties and uses of the materials in the annotation. The given drawings or diagrams could be for a single product or a range of products depending on group size for the task. The 'Project Approach Resource Bank' (http://www.siemens.co.uk/education) contains a number of suitable drawings for this purpose.

Activity 2

Learners could embed their understanding of engineering processes and the safe use of tools and equipment by producing a short video showing how to conduct a risk assessment and the correct ways to use engineering equipment. Different groups of learners could be given different workshop processes to focus on. Ideally the processes would link to the process to be used in this project.

Activity 3

Learners could develop their understanding of the application of processes by creating a card or board game where they have to match potential processes with a range of products, highlighting which processes could be used in making the products (a range of Siemens products should be chosen that could be made using multiple processes) Siemens''Products and technology videos' (http://www.energy.siemens.com/br/en/energy-topics/videos/).

Learners could take the full list of processes from the learning outcomes listed on pages 8 and 9 of the specification (http://www.ocr.org.uk/Images/150704-specification.pdf) and create a card for each, with a description of the process and its uses. They could then create a series of 'Product' cards with a description of the materials and major components. Learners could then compete to find the product that could be made using the most different processes.

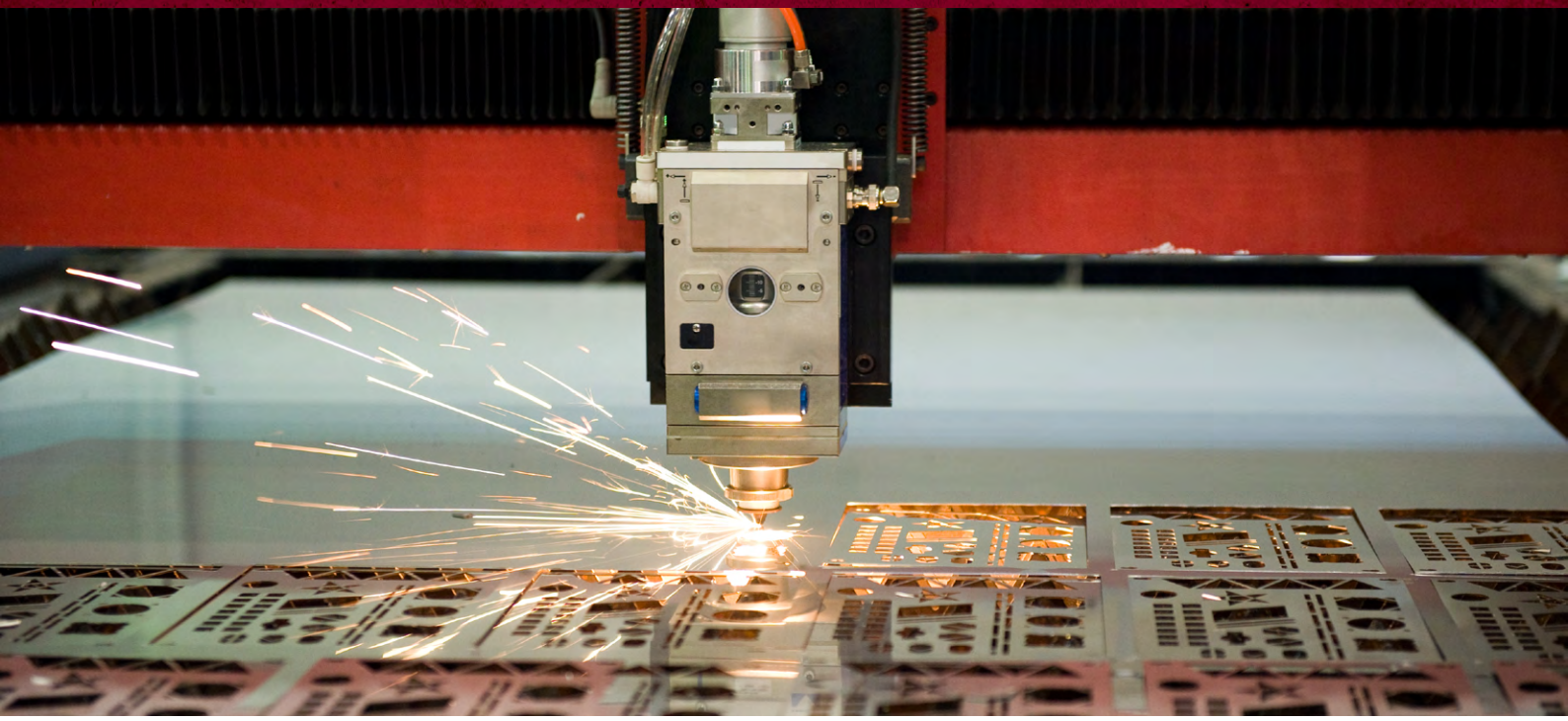
The objective of the game is to get learners to discuss different ways the same component can be made.

Activity 4

Learners could explore the different uses of materials by engaging with the Siemens''Green Racers' (http://www.siemens.co.uk/education/en/teachers/teaching-resources/schemes-of-work-ks4.htm) materials. Based on 'The Green Power Challenge' (https://www.plm.automation.siemens.com/en_us/academic/resources/solid-edge/student-download.cfm?), the different materials used in the construction of the racers is discussed and learners can apply knowledge of materials and production processes to design products and produce practical solutions that are relevant and fit for purpose. Learners could use the information gained to outline their own materials list.

Activity 5

Learners could develop their practical understanding of how modern technology is impacting on manufacturing by visiting a modern manufacturing facility. A visit to the Siemens' Crystal Sustainable Cities Initiative (http://www.siemens.co.uk/education/en/teachers/the-crystal.htm) in London could also be considered. Learners could be given a range of tasks related to identifying and explaining the examples of new technology in engineering.



Module 2 - Preparing and Planning for Manufacture

The delivery then follows through units R110 (LO1, LO2 and LO3).

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

Be able to plan for the making of a pre-production product	LO1	R110
Be able to use processes, tools and equipment safely to make a pre-production model	LO2	R110
Be able to modify a production plan for different scales of production	LO3	R110

This will allow learners to develop their skills in using a range of engineering processes to produce a model of the component to be manufactured.

Using knowledge gained researching real life manufacturing processes learners may develop their planning and organisational skills.

During the delivery of the units 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

Learnerscould develop their understanding of engineering drawings by producing a production plan based on a series of given 2D and 3D engineering drawings of a product.

See 'Project Approach Resource Bank' (http://www.siemens.co.uk/education).

The plan should include details of tools, equipment, sequence of operation, health and safety and quality checks for the production.

Activity 2

Learners could develop their practical understanding of production plans by creating a flow chart summarising the stages in the production of a product.

Activity 3

Learners may practice their use of tools, equipment and processes by following the flow chart they have created to manufacture a pre-production model of the product. Learners should be encouraged to consider how they could record and present the work they are undertaking through the use of; photographs, logs, video, audio and diagrams.

Activity 4

Learners could develop their understanding of production planning by taking part in the Siemens''Lean Machines' (http://www.siemens.co.uk/education/en/students/interactives.htm) game. Learners could undertake the activity in class time or a competition could be set up for the learners to compete in their own time. A follow on presentation could be included where learners explain how they optimised the production of the MINIs.

Activity 5

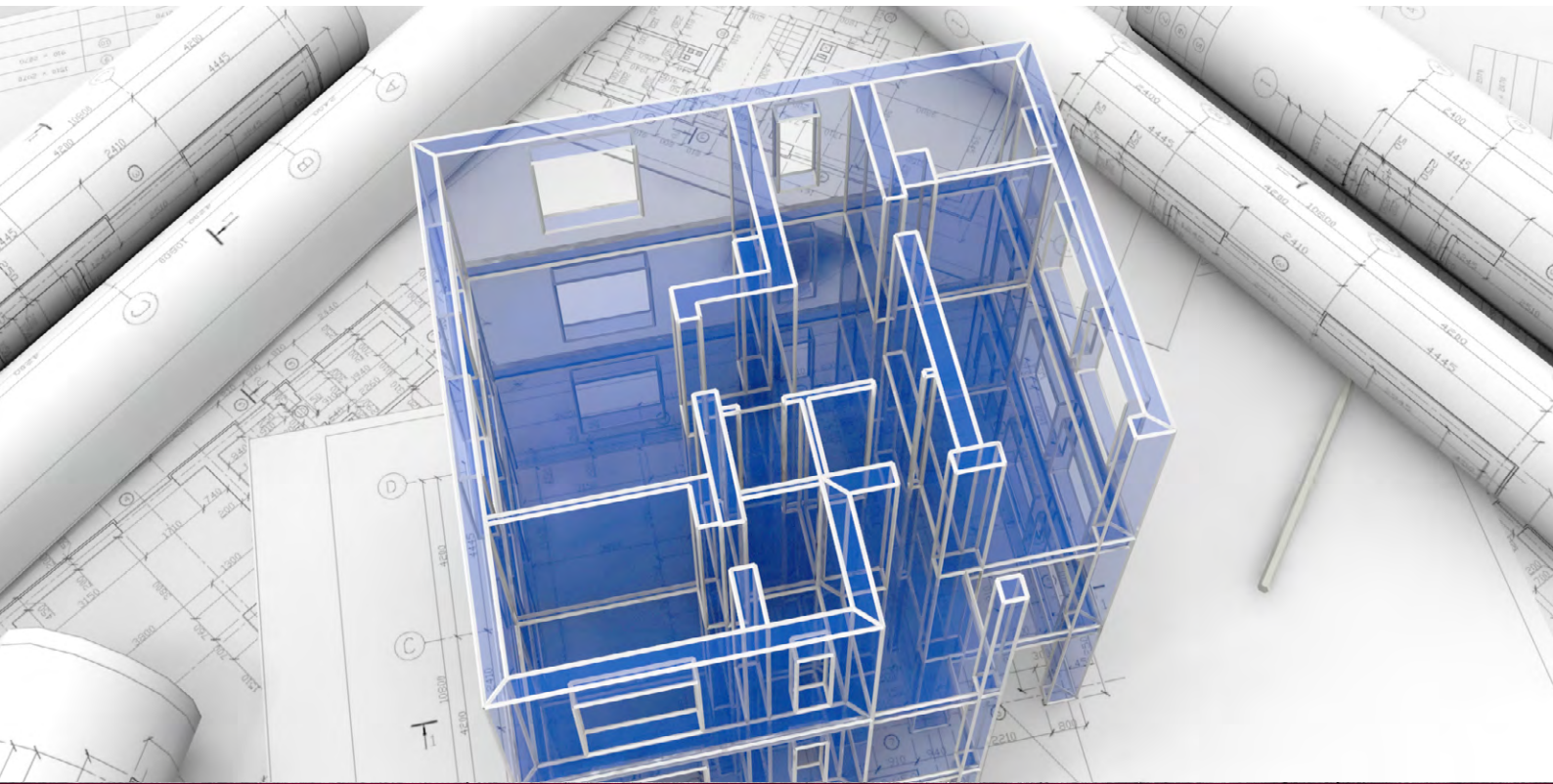
Learners could improve their understanding of scales of production by reviewing the production plan they created for a pre-production model. Production plans should be modified to encompass:

- batch production techniques
- mass production techniques.

The revisions should include detail on the challenges and advantages of each of these types of production.

Energy Transformation Project – related task

Learners could analyse the product information and create a production plan for the manufacture of the model of a fly wheel.



Module 3 - Computer Aided Manufacture

The delivery then follows through units R111 (LO1, LO2, 103 and LO4).

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

Be able to plan the production of components on Computer Numerical Control (CNC) machines	LO1	R111
Be able to interpret information from CAD to manufacture components on CNC equipment	LO2	R111
Be able to set-up and use Computer Numerical Control (CNC) equipment to manufacture components	LO3	R111
Know about applications of computer control processes used to manufacture products	LO4	R111

This will allow learners to develop the ability to interpret CAD information and use it to manufacture a range of components on a CNC machine.

Learners will gain a practical understanding of how computers are used in manufacturing.

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

In order to give maximum exposure to this topic, learners should be given access to a CNC simulation (several are available with educational licences). Learners are then given a range of simple tasks and then programme the simulator accordingly. This may be delivered as a classroom or homework task, depending on access to the simulation software.

Activity 2

Learners develop their CNC programming skills by making virtual products from given information using a CAD package eg Siemens''Solid Edge Student Edition' (https://www.plm.automation.siemens.com/en_us/academic/resources/solid-edge/student-download.cfm?), which they import into the CNC simulation. Learners should evaluate the performance of the simulation activity.

Activity 3

Learners could develop the understanding gained in producing virtual products by selecting one product and creating a production plan to manufacture it using a CNC machine.

Learners could use the plan to manufacture the product on a CNC machine. They should reflect on how useful the plan was in supporting the activity.

Learners should be encouraged to record their progress and techniques throughout the activity, using suitable formats.

Activity 4

Learners could develop their understanding of 'methods of comparison' by creating a balanced scorecard for the product they made via manual methods and CNC production. The aspects of the scorecard should be: visual, dimensional, cycle time, consistency.

Videos demonstrating the Siemens use of the Balanced Scorecard are included in the 'Project Approach Resource Bank' (http://www.siemens.co.uk/education).

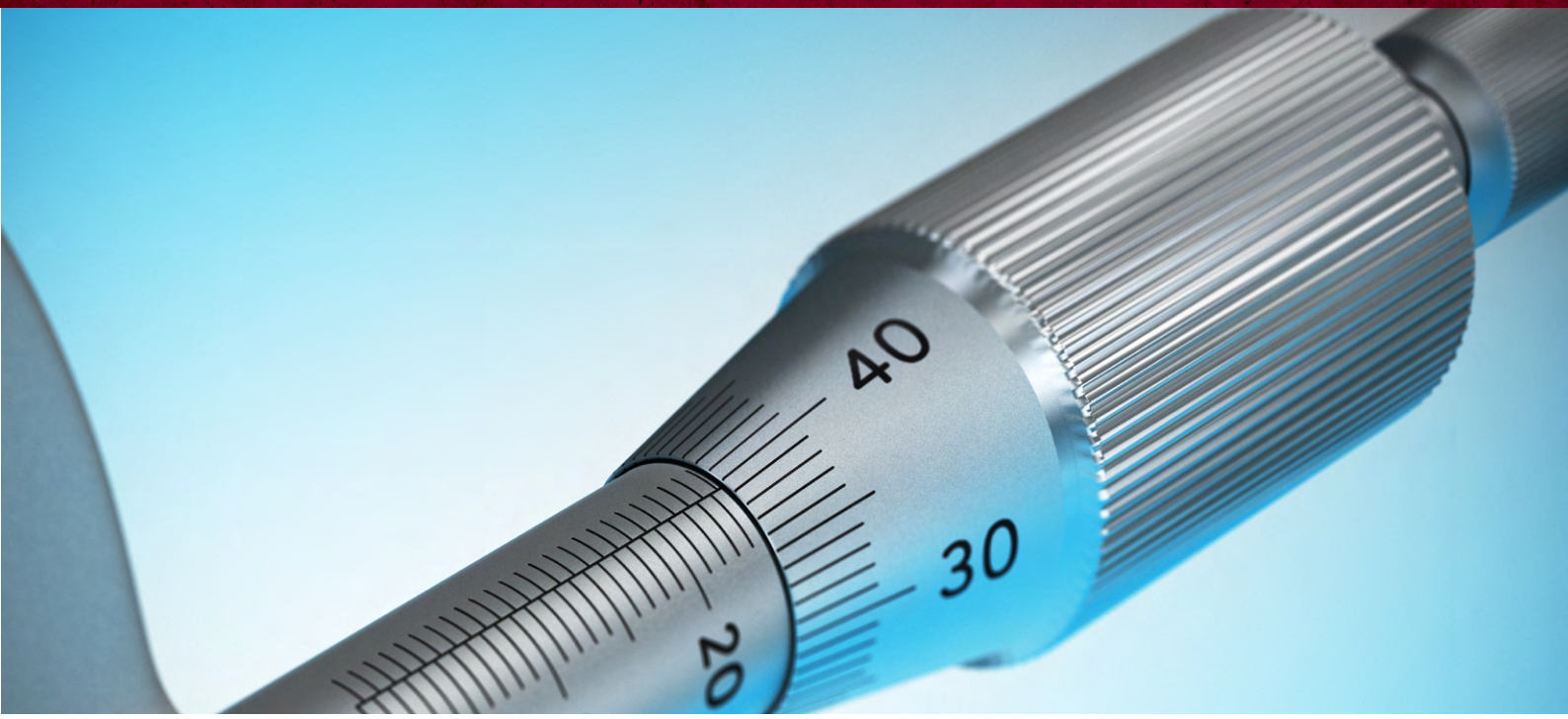
Activity 5

Learners could develop their understanding of the relationship between computer controlled processes and manufacturing by researching how Siemens use:

- rapid prototyping
- manufacturing processes
- robotics
- different scales of production.

A treasure hunt style activity could be used where the learners work in teams to carry out the research and must complete the full range of identified elements.

Videos demonstrating the Siemens' scales of production at an electronics plant are included in the 'Project Approach Resource Bank' (http://www.siemens.co.uk/education).



Module 4 - Quality control of engineered products

The delivery then follows through unitsR112 (LO1, LO2, LO3 and LO4).

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

Understand the importance of quality control	LO1	R112
Be able to assess product quality from inspection and quality control techniques	LO2	R112
Know how modern technologies can be used in quality control	LO3	R112
Know the principles of lean manufacturing	LO4	R112

Learners will develop an understanding of quality control philosophy and techniques.

The will develop skills in applying the principles of lean manufacture to manufacturing processes.

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 and appreciation of the different approaches to quality by working in teams to hold a balloon debate based on the different quality procedures:

- quality control
- quality standards
- quality assurance
- total quality management.

This will help the learners to prioritise and rank the different procedures.

Learners could create a comparison table for the four different quality procedures listed. This could be presented as a wall chart.

Videos demonstrating the Siemens' approach to quality control are included in the 'Project Approach Resource Bank' (http://www.siemens.co.uk/education).

Activity 2

Learners could develop an understanding of the importance of quality by taking a Siemens product (a train would be suitable) and writing a newspaper story based on what would happen if Siemens decided to abandon all quality procedures.

The story should cover issues such as production problems, waste, consistency, cost, safety, conformity and customer complaints.

'Rail Solutions' (http://w3.siemens.co.uk/MOBILITY/UK/EN/RAIL_SOLUTIONS/Pages/rail_solutions.aspx) has detail on Siemens' rail interests.

Activity 3

Learners could enhance their understanding of the relationship between quality and manufacturing by producing a diagram of a given production process and annotate it with details of which quality control techniques and equipment would be used at each stage and why. This activity could be effectively linked to a manufacturing visit or a visit to Siemens' Crystal Sustainable Cities Initiative (http://www.siemens.co.uk/education/en/teachers/the-crystal.htm).

Activity 4

Learners could improve their understanding of lean manufacturing by taking part in the Siemens' online manufacturing game, 'Lean Machines' (http://www.siemens.co.uk/education/en/students/interactives.htm) where they have to optimise the production of MINI cars using Lean principles.

http://www.dbda.net/clients/siemens/lean/

Glossary

Balanced Scorecard – a business technique used to focus on four different aspects of an operation. The four aspects can vary according to the operation being assessed, with each of the four aspects being assessed individually and then being combined to give an overall picture. For more information: http://www.businessballs.com/balanced_scorecard.htm

Treasure Hunt – teachers prepare a list of key elements that learners should find during their research. The learners are set up in teams and compete to find as many of the elements as possible within a given time. Collaboration between teams may or may not be encouraged depending on time and the objectives of the group.

Balloon Debate – a small number of teams or individuals (no more than 6) are given different issues or approaches to debate. The scenario is that the teams are all in a hot air balloon losing height and needs to lose weight to stay afloat. The group, as a whole, vote to keep the most important teams in the balloon. The teams prepare an argument based on how important their issue or approach is. The teams present their arguments and then the whole group votes for the teams they wish to stay in the balloon. This works well with two rounds of debate. Depending on the number of teams, the first round of votes sees all but two or three teams thrown out of the balloon. The remaining teams then have a second, shorter debate, after which all but one team is thrown from the balloon.

Crystal - a sustainable cities initiative by Siemens exploring the future of cities. Home to the world's largest exhibition focused on urban sustainability and a world-class centre for dialogue, discovery and learning. http://www.thecrystal.org/

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 R109: Engineering materials, processes and production LO1: Know about properties and uses of engineering materials can be delivered using these resources.

Learners could study relevant Siemens resources bank http://www.siemens.co.uk/education/en/. Learners could annotate engineering drawings or diagrams showing the different materials, classification and the properties of the materials. The drawings should cover a range of materials and learners could include descriptions of the properties and uses of the materials in the annotation.

Learners are required to interpret drawings that will include dimensions, tolerance and scale, which will require them to make comparisons of relevant data. In maths, learners are required to convert measurements from one metric unit to another and interpret scales on a range of measuring instruments. Learners could extract numeric values from any technical drawing to manipulate the dimensions and use simple proportion calculations to consider economies of scale or different production quantities of one off, batch and mass production.

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 (http://www.energy.siemens.com/br/en/energy-topics/videos/). provide useful background information on the different forms of energy production as part of their research.

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 R109: Engineering materials, processes and production

LO1: Know about properties and uses of engineering materials

	Unit	Learning Outcome (LO)
Module 1	R109	LO1 LO2 LO3 LO4

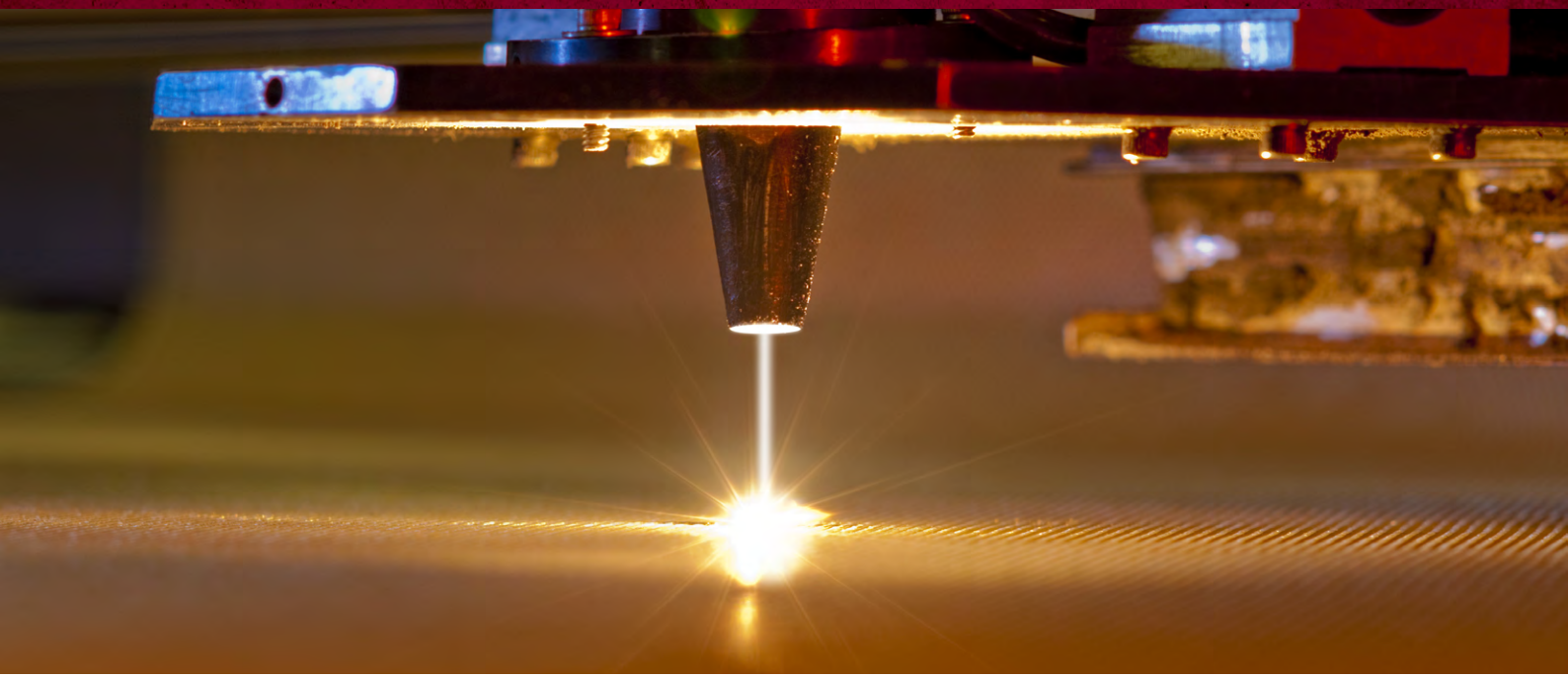
The Project Approach

Activity 1 (R109 – LO1)

To help learners relate to the range of engineering materials they have been studying, they could annotate engineering drawings or diagrams showing the different materials, classification and the properties of the materials. The drawings should cover a range of materials and learners could include descriptions of the properties and uses of the materials in the annotation. The given drawings or diagrams could be for a single product or a range of products depending on group size for the task. The 'Project Approach Resource Bank' (Link to be created) contains a number of suitable drawings for this purpose.

The Delivery Guide (R109 – LO1)

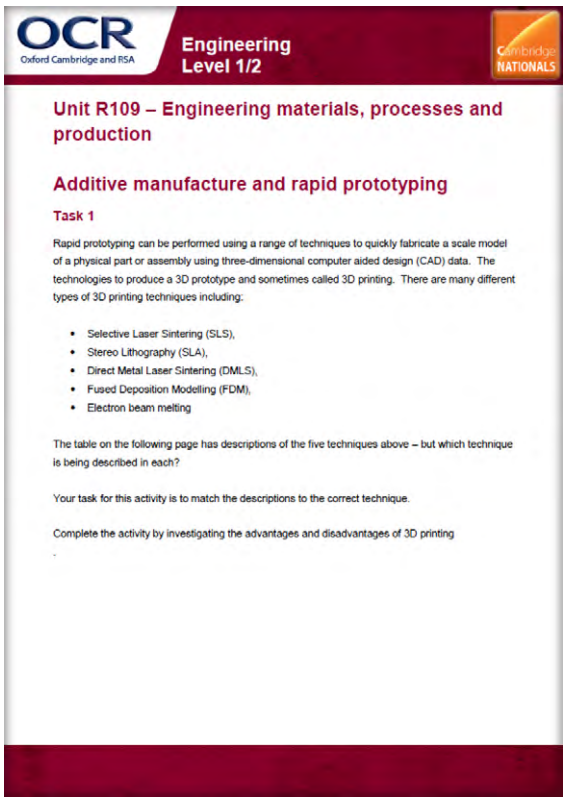
Suggested content	Suggested activities	Suggested timings	Possible relevance to
Engineering materials: metals	Teachers might develop an understanding of the properties of engineering materials through practical demonstrations or develop simple practical experiments for learners to perform. Learners could be given a range of metals to handle and tasked to research their properties including: Ferrous metals and alloys: iron, carbon steels, stainless steel, high speed steel Non-ferrous metals and alloys: copper, brass, bronze, aluminium alloys, zinc, tin, lead, titanium The use of internet sources to explain and explore properties of materials might be useful such as: http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/materialsrev3.shtml which explains ferrous and non-ferrous metals.	2 hours	R103 (LO1) R106 (LO3, LO4)



Lesson Element (R109)
Additive manufacture and rapid prototyping

Learners are required to research 3D printing techniques used in rapid prototyping.

http://www.ocr.org.uk/qualifications/cambridge-nationals-engineering-manufacture-level-1-2-award-certificate-j832-j842/



OCR Oxford Cambridge and RSA

Engineering Level 1/2

Cambridge NATIONALS

Unit R109 – Engineering materials, processes and production

Additive manufacture and rapid prototyping

Task 1

Rapid prototyping can be performed using a range of techniques to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. The technologies to produce a 3D prototype and sometimes called 3D printing. There are many different types of 3D printing techniques including:

- Selective Laser Sintering (SLS),
- Stereo Lithography (SLA),
- Direct Metal Laser Sintering (DMLS),
- Fused Deposition Modelling (FDM),
- Electron beam melting

The table on the following page has descriptions of the five techniques above – but which technique is being described in each?

Your task for this activity is to match the descriptions to the correct technique.

Complete the activity by investigating the advantages and disadvantages of 3D printing

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 R110 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	Drawings and views. Dimensions, tolerance, scale. Materials Production plans: sequence, time, QC	Be able to interpret engineering drawings including dimensions, tolerances and scale.	FIG1 Convert measurements from one metric unit to another Interpret scales on a range of measuring instruments. FIG2 Make sensible estimates of a range of measures in everyday settings.	FBN9 Use simple proportion, particularly in the context of recipes.

Learners are required to interpret drawings that will include dimensions, tolerance and scale, (R110) which will require them to make comparisons of relevant data. In maths, (FIG1) learners are required to convert measurements from one metric unit to another and interpret scales on a range of measuring instruments. Learners could extract numeric values from any technical drawing to manipulate the dimensions and use simple proportion calculations (FBN9) to consider economies of scale or different production quantities of one off, batch and mass production. 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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