OCR
Oxford Cambridge and RSA

Cambridge **NATIONALS LEVEL 1/2**

ENGINEERING MANUFACTURE

Cambridge
NATIONALS

R111 Computer aided manufacturing

J832/J842

Schemes of work

Version 1

CONTENTS

INTRODUCTION

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

• A **longer term** plan which covers the whole academic year over three terms and suggests the order in which each Learning Outcome (LO) could be taught. Links to other units and LOs within Nationals Engineering are also shown.

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

Link to qualification

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

See our range of planning and teaching resources on the link below (including delivery guides, project approaches, teaching activities, teacher guides and resources lists).
https://www.ocr.org.uk/qualifications/cambridge-nationals/engineering-manufacture-level-1-2-award-certificate-j832-j842/planning-and-teaching/

See our range of assessment resources on the link below (including past paper, mark schemes, examiners' reports, candidate exemplars and set assignments).
https://www.ocr.org.uk/qualifications/cambridge-nationals/engineering-manufacture-level-1-2-award-certificate-j832-j842/assessment/

Scheme of work (longer term plan – academic year)

	Learning Outcome	Topic area/theme (from R111 specification)	Links to other Cambridge Nationals Engineering units and LOs
Autumn Term	**LO1**	Planning of operations – sequence of operation and tool changes.	**R108 LO1** – Know how to plan the making of a prototype. **R110 LO1** – Be able to plan for the making of a pre-production product.
	LO1	Production planning – scale of manufacture.	**R106 LO1** – Know how commercial production methods, quality and legislation impact on the design of products and components. **R110 LO3** – Be able to modify a production plan for different scales of production.
	LO1	Types of CNC Machine.	**R109 LO3** – Know about developments in engineering processes.
	LO1	Production planning – setting tools, machining tools and cutting tools.	**R110 LO1** – Be able to plan for the making of a pre-production product.
	LO1	Production planning – tooling requirements.	**R110 LO1** – Be able to plan for the making of a pre-production product.
	LO1	Production planning for CNC – materials.	**R109 LO1** – Know about properties and used of engineering materials. **R110 LO1** – Be able to plan for the making of a pre-production product.
	LO1	Production planning for CNC – speeds and feeds.	
	LO1	Production planning for CNC – planning methods.	**R108 LO1** – Know how to plan the making of a prototype. **R110 LO1** – Be able to plan for the making of a pre-production product.
	LO2	Use of compatible CAD/CAM packages – part 1 – on screen modelling and programming.	**R107 LO2** – Know how to develop designs using engineering drawing techniques and annotation. **R110 LO1** – Be able to plan for the making of a pre-production product.
	LO2	Use of compatible CAD/CAM packages – part 2 – on screen simulation / export drawing to CNC machines.	**R107 LO2** – Know how to develop designs using engineering drawing techniques and annotation. **R110 LO1** – Be able to plan for the making of a pre-production product.

Learning Outcome	Topic area/theme (from R111 specification)	Links to other Cambridge Nationals Engineering units and LOs
LO2	CNC machining programming – part 1 – CNC Language and G-Codes.	
LO2	CNC machining programming – part 2 – setting datum points, co-ordinates, tool change over and tool offsets.	
LO3	Procedures for setting up of CNC equipment – part 1 – tooling and work holding.	
LO3	Procedures for setting up of CNC equipment – part 2 – computer interface and safety procedures.	
LO3	Procedures to produce products to required specification – initial setting up of CNC equipment and safe use.	**R109 LO2** – Understand engineering processes and their application.
LO3	Set up and use CNC equipment to manufacture components – part 1.	
LO3	Set up and use CNC equipment to manufacture components – part 2.	
LO3	Comparison of manual machine and CNC produced items – visual and dimensional.	**R110 LO2** – Be able to use processes, tools and equipment safely to make a pre-production product. **R112 LO3** – Know how modern technologies can be used in quality control.
LO3	Comparison of manual machine and CNC produced items – cycle time and consistency.	**R110 LO2** – Be able to use processes, tools and equipment safely to make a pre-production product. **R112 LO3** – Know how modern technologies can be used in quality control.
LO3	Synoptic links from LO3 to other units.	**R109 LO1** – Know about properties and uses of engineering materials. **R109 LO3** – Know about developments in engineering processes.

Spring Term (row label spanning the table)

	Learning Outcome	Topic area/theme (from R111 specification)	Links to other Cambridge Nationals Engineering units and LOs
Summer Term	**LO4**	Applications of computer control – part 1 – rapid prototyping: laminating and 3D printing.	**R109 LO3** – Know about developments in engineering processes.
	LO4	Applications of computer control – part 2 – rapid prototyping: stereolithography and laser sintering.	**R109 LO3** – Know about developments in engineering processes.
	LO4	Applications of computer control – manufacturing processes – CNC machining.	**R109 LO3** – Know about developments in engineering processes.
	LO4	Applications of computer control – manufacturing processes – additive manufacturing.	**R109 LO3** – Know about developments in engineering processes.
	LO4	Applications of computer control robotics – welding.	**R109 LO3** – Know about developments in engineering processes.
	LO4	Applications of computer control robotics – riveting.	**R109 LO3** – Know about developments in engineering processes.
	LO4	Applications of computer control robotics – pick and place assembly.	**R109 LO3** – Know about developments in engineering processes.
	LO4	Computer control used for different scales of manufacture – prototype manufacture.	**R106 LO1** – Know how commercial production methods, quality and legislation impact on the design of products and components. **R109 LO4** – Understand the impact of modern technologies on engineering production. **R110 LO3** – Be able to modify a production plan for scales of manufacture.
	LO4	Computer control used for different scales of manufacture – batch production.	**R106 LO1** – Know how commercial production methods, quality and legislation impact on the design of products and components. **R109 LO4** – Understand the impact of modern technologies on engineering production. **R110 LO3** – Be able to modify a production plan for scales of manufacture.
	LO4	Computer control used for different scales of manufacture – high volume manufacturing.	**R106 LO1** – Know how commercial production methods, quality and legislation impact on the design of products and components. **R109 LO4** – Understand the impact of modern technologies on engineering production. **R110 LO3** – Be able to modify a production plan for scales of manufacture.

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

	Event	Learning Outcome	Topic area/subtopic Area (from R111 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Autumn Term	1	LO1	Planning of operations – sequence of operation and tool changes.	Learners will be provided with an introduction to Computer Numerical Control (CNC) machining including tool changes and sequence of operations. A practical demonstration using a CNC machine could be carried out with learners observing the sequence of set up and operation, identifying tool changes required during manufacture.	**R111 LO1** – Learners can identify the correct sequence of operation for the CNC machine with a full understanding of tool changes needed for different operations and different materials.	https://www.youtube.com/watch?v=FNYEXjRmDtl gives a basic overview of CNC machining.
	2	LO1	Production planning – scale of manufacture.	Learners will be introduced to scales of manufacture. One off, batch and mass production could be considered. A range of different products or components could be presented to learners who could then determine the most appropriate scale of manufacture. Reduction in wastage of materials during manufacture could also be considered.	**R111 LO1** – Learners can identify relevant manufacturing processes to use for production considering scale of manufacture and waste reduction of materials.	Search for *'BBC Bitesize production methods'* for a range or resources and videos covering scales of production.
	3	LO1	Types of CNC Machine.	Learners could be introduced to different types of CNC machinery. Learners could research CNC milling machines, turning machines and fabrication machines. For each machine they could identify what specific application they are used for together with any advantages and limitations.	**R111 LO1** – Learners will be able to identify specific components that could be manufactured using different types of CNC machine.	For further videos on www.youtube.com search for either: *CNC turning, CNC milling, CNC multi axis machine etc.*
	4	LO1	Production planning – setting tools, machining tools and cutting tools.	Learners will be introduced to different tooling required when using CNC machinery. Learners could be given a range of tools used for CNC machines, and then identify which type of machine they should be used with and what operation they perform.	**R111 LO1** – Learners will be able to identify specific tools for setting up, machining operations and cutting activities.	https://www.axyz.co.uk/2018/06/11/guide-to-cnc-tooling/ gives a basic introduction to different types of CNC tooling including the materials tools are made from.
	5	LO1	Production planning – tooling requirements.	Learners will build on their knowledge of tools used for CNC machinery. A range of short practical activities could be set up enabling learners to select and use correct tooling for a specific materials removal procedure.	**R111 LO1** – Learners will be able to identify specific components that could be manufactured using different types of CNC machine.	

	Event	Learning Outcome	Topic area/subtopic Area (from R111 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Autumn Term	6	LO1	Production planning for CNC – materials.	Learners will be introduced to a range of materials that can be used on CNC machinery. Student could research into materials and their properties giving examples of suitable applications.	**R111 LO1** – Learners can identify materials and their properties and their suitability for different CNC machining operations.	www.technologystudent.com search for *'resistant materials'* or *'types of materials'*
	7	LO1	Production planning for CNC – speeds and feeds.	Learners will be introduced to speeds and feeds relative to CNC programming and machining. Learners could be tasked with researching into specific CNC machinery and for each explaining why the speed and feed of material are important and how they can affect manufacturing and planning times and quality of finish. Alternative demonstrations could take place in the workshop area using a range of materials.	**R111 LO1** – Learners understand how materials properties, speed of cutting, and feed of the tool will affect manufacturing timings and quality of finished component.	https://www.youtube.com/watch?v=gTnkNHB7dss provides a clear introduction to speeds and feeds, and how they are calculated.
	8	LO1	Production planning for CNC – planning methods.	Learners could be introduced to planning methods for a CNC machine. Learners could research into flowcharts and planning tables. A tabular form plan could be produced detailing how to safely manufacture a CNC part minimising any waste time or material.	**R111 LO1** – Learners will be able to produce a detailed production plan for the manufacture of a CNC-produced component.	
	9	LO2	Use of compatible CAD/CAM packages – part 1 – on screen modelling and programming.	Learners will be introduced to the use of Computer Aided Design (CAD) software for designing and modelling a component suitable for CNC machining. A suitable CAD package will be chosen that will enable learners to model and reproduce a given component ready for simulation.	**R111 LO2** – Learners will be able to model a given component using suitable CAD software.	https://www.youtube.com/watch?v=5XihF05K4yM provides a short video introduction to programming a CNC machine, including G and M codes https://www.youtube.com/watch?v=Do_C_NLH5sw shows a short introduction to CAD/CAM using Fusion 360
	10	LO2	Use of compatible CAD/CAM packages – part 2 – on screen simulation / export drawing to CNC machines.	For this session, learners could be shown and practice how to use Computer Aided Manufacture (CAM) software to perform a CNC 'tool path' simulation for a given design and export to a chosen CNC machine ready for manufacture.	**R111 LO2** – Learners can model a component using CAM software and carry out detailed simulation.	www.technologystudent.com search for *'CNC – stages of manufacture'*.

	Event	Learning Outcome	Topic area/subtopic Area (from R111 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Spring Term	1	**LO2**	CNC machining programming – part 1 – CNC Language and G-Codes.	Learners will be introduced to direct (non-simulation) CNC programming languages such as G-codes. Learners could be asked to research into G codes, and how they are used for programming CNC machinery. Learners could be presented with a simple G-code program and be asked to explain what a selection of the main codes represent.	**R111 LO2** – Learners will demonstrate they understand G codes and how they are used for CNC programming and CNC machine control.	Go to www.autodesk.com and search for *'getting started with G-codes'*
	2	**LO2**	CNC machining programming – part 2 – setting datum points, co-ordinates, tool change over and tool offsets.	Learners will be introduced to machine programming operations. Learners could be asked to program their chosen CNC machine to manufacture a component part. Datum points, co-ordinates, tool changeover and offsets will be included within their programming.	R111 LO2 – Learners can program and set-up CNC software to successfully simulate the manufacture of a component.	
	3	**LO3**	Procedures for setting up of CNC equipment – part 1 – tooling and work holding.	Learners will be shown a CNC machine that will be used for manufacture. A demonstration could be given on the correct set up of tooling and material holding. Learners could be a given the task to safely set up a CNC machine to manufacture a sample component to exact specification.	**R111 LO3** – Learners can set up a CNC machine to enable manufacture to commence safely and accurately.	https://www.youtube.com/watch?v=M5otomckPYU shows a range of different methods for work holding when CNC machining.
	4	**LO3**	Procedures for setting up of CNC equipment – part 2 – computer interface and safety procedures.	Learners will continue from their previous session. They will be shown how to set-up the computer to program and operate the CNC machine. Learners could identify the safety procedures needed when operating the CNC machine and produce a checklist that should be carried out prior to manufacturing the component.	**R111 LO3** – Learners can set up a CNC machine to enable manufacture to commence safely and accurately.	
	5	**LO3**	Procedures to produce products to required specification – initial setting up of CNC equipment and safe use.	Learners will be introduced to safe working practices when setting up and operating CNC machinery. Learners could be shown a demonstration of safe use. A sample machine could then be set up incorrectly with learners having to identify any potential hazards and associated risks. Learners could further produce a simple risk assessment to identify hazards associated with the task, including the appropriate use of Personal Protective Equipment (PPE).	**R111 LO3** – Learners can plan to set up and use CNC machinery safely and correctly, being able to identify potential hazards and risks.	Health and safety in engineering: https://www.hse.gov.uk/engineering/
	6	**LO3**	Set up and use CNC equipment to manufacture components – part 1.	Learners will fully set up and operate a CNC machine to safely manufacture their chosen component. This will include the use of appropriate CAD/CAM software to program the machine.	**R111 LO3** – Learners will be able to independently and safely set up and use CNC machinery to manufacture a component.	

	Event	Learning Outcome	Topic area/subtopic Area (from R111 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Spring Term	7	**LO3**	Set up and use CNC equipment to manufacture components – part 2.	In this session learners will continue the practical CNC machining activity.	**R111 LO3** – Learners will be able to independently and safely set up and use CNC machinery to manufacture a component.	
	8	**LO3**	Comparison of manual machine and CNC produced items – visual and dimensional.	Learners will be introduced to manually and CNC produced components. These could be components previously manufactured in R110 and those in R111 if similar or identical. Learners could then inspect and compare these manually and CNC manufactured components. Using a given criteria, learners could identify differences in terms of standard of finish and accuracy of manufacture of similar components.	**R111 LO3** – Learners can confidently compare components made using hand machining techniques, and using CNC machines, identifying benefits and limitations of each.	https://www.youtube.com/watch?v=Gd-UqQksN3I shows a short video comparing manual milling with CNC milling.
	9	**LO3**	Comparison of manual machine and CNC produced items – cycle time and consistency.	As for the previous session, learners could then inspect and compare manually, and CNC manufactured components. Using a given criteria, learners could identify differences in terms of cycle time to manufacture each component and consistency across a batch of components. Findings could be reviewed and tabulated to produce an overall conclusion of the benefits of CNC manufactured compared with manually manufactured components.	**R111 LO3** – Learners can confidently compare components made using hand machining techniques, and using CNC machines, identifying benefits and limitations of each.	
	10	**LO3**	Synoptic links from LO3 to other units.	In this session, learners could review work completed in LO3 of this unit and make links to other units in the specification (especially unit R109). They could produce a simple table documenting links from content covered in LO3 to R109, and other units.	**R109 LO1** – Learners could relate selection of materials and manufacturing process for practical work to types, properties, characteristics and applications of materials. **R109 LO3** – Learners could demonstrate how they have practically built upon theoretical knowledge of applications of computer-controlled production processes.	

	Event	Learning Outcome	Topic area/subtopic Area (from R111 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Summer Term	1	**LO4**	Applications of computer control – part 1 – rapid prototyping: laminating and 3D printing.	Learners will be introduced to the applications of computer control in manufacturing. Learners could be given a choice of design scenarios for different products and asked to research into suitable applications for rapid prototyping and 3D printing.	**R111 LO4** – Learners can identify and explain different computer-controlled manufacturing processes, how they operate, and relate them to the products or components for which they are suitable.	For videos on www.youtube.com search for either: *rapid prototyping, 3D printing, fused deposition modelling* or *laminated object modelling.*
	2	**LO4**	Applications of computer control – part 2 – rapid prototyping: stereolithography and laser sintering.	For this follow-on session, learners will continue looking at the applications of computer control in manufacturing. Learners could be given a further choice of products to be produced, and be asked to research into suitable applications for their manufacture using stereolithography and laser sintering techniques. Findings about each process for both sessions could be summarised in a table, along with advantages and drawbacks of each process.	**R111 LO4** – Learners can identify and explain different computer-controlled manufacturing processes, how they operate, and relate them to the products or components for which they are suitable.	For videos on www.youtube.com search for either: *rapid prototyping, stereolithography* or *laser sintering.*
	3	**LO4**	Applications of computer control – manufacturing processes – CNC machining.	Learners will be introduced to a selection of CNC machining processes. CNC machining techniques could be investigated with learners summarising and producing a comparison of the advantages and limitations of each.	**R111 LO4** – Learners will be able to explain a range of CNC machining methods identifying components that could be manufactured using each method.	For videos on www.youtube.com search for: *CNC machining.*
	4	**LO4**	Applications of computer control – manufacturing processes – additive manufacturing.	Learners will be introduced to computer controlled additive manufacturing. Additive manufacturing techniques could be investigated with learners summarising and comparing the advantages and limitations of each.	**R111 LO4** – Learners will be able to explain a range of additive manufacturing methods identifying components that could be manufactured using each method.	https://www.ge.com/additive/additive-manufacturing provides an introduction, with videos, to additive manufacturing.
	5	**LO4**	Applications of computer control robotics – welding.	Learners could watch a video on computer-controlled welding. Learners could then explain the operation of the robot with advantages and disadvantages of using the method.	**R111 LO4** – Learners will be able to explain robotic welding identifying strengths and weaknesses when used in commercial production.	www.robotwelding.co.uk provides an introductory guide to robotic welding. https://www.youtube.com/watch?v=HUU3HdxOqZs shows a robot welding,

	Event	Learning Outcome	Topic area/subtopic Area (from R111 specification)	Suggestions for delivery/activities (including scope and depth)	'Have they got it?' – internal unit links with commentary	Useful external resources
Summer Term	6	LO4	Applications of computer control robotics – riveting.	Learners will be introduced to the process of riveting. Learners could carry out a practical activity of riveting pieces of metal together. Learners could then review how riveting is carried out using computer-controlled robotics within car manufacturing on a production line.	R111 LO4 – Learners can explain computer-controlled riveting and its application, for example in mass production.	https://www.youtube.com/watch?v=0eTIlqut5-E shows robotic riveting taking place.
	7	LO4	Applications of computer control robotics – pick and place assembly.	Learners will be introduced to pick and place robotics. Learners could investigate a range of robotics used in pick and place assembly explaining their benefit when used for different scales of manufacture. Videos could be used to show pick and place robotics in action.	R111 LO4 – Learners can identify the reasons for using pick and place robots during the manufacture process.	https://www.youtube.com/watch?v=6RKXVefE98w shows a pick and place robot in action.
	8	LO4	Computer control used for different scales of manufacture – prototype manufacture.	Learners will investigate how computers are used for prototype manufacture. Learners could look at a range of computer-controlled machinery that could be used to make a one-off prototype such as a key fob identifying the benefits of using this type of process for one-off manufacture.	R111 LO4 – Learners can identify how and why computer-controlled manufacturing is used across different scales of production. Specific examples could be given.	http://www.technologystudent.com/rmprp07/intman1.html provides an overview of computers in different areas of manufacturing called Computer Integrated Manufacturing (CIM).
	9	LO4	Computer control used for different scales of manufacture – batch production.	Learners will investigate how computers and computer-controlled processes are used for batch manufacture. Learners could research into different methods of computer control and explain the benefits to using when manufacturing a batch of items. Videos could be a good source of information to show batch production of products.	R111 LO4 – Learners can identify how and why computer-controlled manufacturing is used across different scales of production. Specific examples could be given.	https://www.ruthtrumpold.id.au/destech/?page_id=150 includes a video and relates CIM to different scales of production – looking at the advantages and disadvantages.
	10	LO4	Computer control used for different scales of manufacture – high volume manufacturing.	Finally, learners will investigate how computers are used for high volume manufacturing. Learners could explain the benefits to a company for using computer control across its high-volume manufacturing operations. Videos and case studies could be used to illustrate high-volume manufacturing taking place.	R111 LO4 – Learners can identify how and why computer-controlled manufacturing is used across different scales of production. Specific examples could be given.	

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