Cambridge NATIONALS

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CAMBRIDGE NATIONALS IN ENGINEERING

R109 - ENGINEERING MATERIALS, PROCESSES AND PRODUCTION

DELIVERY GUIDE

VERSION 1

OCR
Oxford Cambridge and RSA

CONTENTS

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INTRODUCTION

This Delivery Guide has been developed to provide practitioners with a variety of creative and practical ideas to support the delivery of this qualification. The Guide is a collection of lesson ideas with associated activities, which you may find helpful as you plan your lessons.

OCR has collaborated with current practitioners to ensure that the ideas put forward in this Delivery Guide are practical, realistic and dynamic. The Guide is structured by learning objective so you can see how each activity helps you cover the specification.

We appreciate that practitioners are knowledgeable in relation to what works for them and their learners. Therefore, the resources we have produced should not restrict or impact on practitioners' creativity to deliver excellent learning opportunities.

Whether you are an experienced practitioner or new to the sector, we hope you find something in this guide which will help you to deliver excellent learning opportunities.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk.

PLEASE NOTE

The activities suggested in this Delivery Guide MUST NOT be used for assessment purposes. (This includes the Consolidation suggested activities).

The timings for the suggested activities in this Delivery Guide DO NOT relate to the Guided Learning Hours (GLHs) for each unit.

Assessment guidance can be found within the Unit document available from www.ocr.org.uk.

The latest version of this Delivery Guide can be downloaded from the OCR website

OPPORTUNITIES FOR ENGLISH AND MATHS SKILLS DEVELOPMENT

We believe that being able to make good progress in English and maths is essential to learners in both of these contexts and on a range of learning programmes. To help you enable your learners to progress in these subjects, we have signposted opportunities for English and maths skills practice within this resource. These suggestions are for guidance only. They are not designed to replace your own subject knowledge and expertise in deciding what is most appropriate for your learners.

KEY

English

Maths

UNIT R109 - ENGINEERING MATERIALS, PROCESSES AND PRODUCTION

Guided learning hours : 30

PURPOSE OF THE UNIT

This unit will develop learners' knowledge and understanding of engineering materials and processes, and their application in the manufacture of engineered products. The content of this unit includes basic engineering processes, allowing for a practical approach to be taken in the delivery of the unit.

This unit also covers types of engineering materials such as ferrous - non-ferrous metals, alloys, polymers, thermosetting plastics, ceramics, composites, smart materials and new and emerging materials. Learners will understand properties of engineering materials and learn the theory of hand and machine skills to engineer a product.

On completion of this unit, learners will understand how the properties and characteristics of materials impact on the design specification for the development of a new product and appreciate the different production methods available to produce engineered products.

Learners studying for the Certificate will be able to apply knowledge and understanding gained in this unit to help develop their skills further during the completion of units R111 and R112.

Learning Outcome — The learner will:
LO1: Know about properties and uses of engineering materials
LO2: Understand engineering processes and their application
LO3: Know about developments in engineering processes
LO4: Understand the impact of modern technologies on engineering production

LO1 - KNOW ABOUT PROPERTIES AND USES OF ENGINEERING MATERIALS

Learning Outcome — The learner will:
LO1: Know about properties and uses of engineering materials

Suggested content	Suggested activities	Suggested timings	Possible relevance to
1 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 & 4)
2 Engineering materials: polymers 	A similar approach might be adopted throughout this Learning Outcome for other engineering materials including plastics. Learners could be given real materials (polymers) to handle and tasked to research and investigate their properties and applications including: Thermoplastics: Acrylonitrile-Butadiene-Styrene (ABS), polyethylene, High Impact Polystyrene (HIPS), Polyvinyl Chloride (PVC), nylon, polycarbonate, polypropylene Thermosetting plastics: polyester resin, urea-formaldehyde, epoxy resin, phenol-formaldehyde Again, internet sources might prove useful such as the following that explains polymers: http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/materialsrev4.shtml.	2 hours	R103 (LO1) R106 (LO3 & 4)
3 Engineering materials: other materials 	Ceramics, composites and Smart materials will form a natural follow-on from learners' investigations of metals and polymers including: Ceramics: tungsten carbide, glass, ceramic bearing material. Composites: Glass Reinforced Plastic (GRP), carbon fibre, concrete. Smart materials: shape-memory alloys, thermochromatic materials, shape-memory alloys, Quantum Tunnelling Composite (QTC). Learners might research smart materials, how they function and their applications. The teacher might demonstrate real smart materials (kits are available relatively cheaply) or use videos if access to practical resources is not available (eg Shape Memory Alloy (SMA): http://www.youtube.com/watch?v=424-3G0jNqU).	2 hours	R103 (LO1) R106 (LO3 & 4)

Suggested content	Suggested activities	Suggested timings	Possible relevance to
4 New and emerging materials 	Learners could undertake a research activity to explore the applications of nanotechnology and advanced metal alloys in engineering. Internet sources (such as http://nanozone.org/) could prove a useful starting point. A poster presentation could be used for learners to present their findings.	1 hour	
5 Properties of engineering materials 	The teacher could take a practical approach to demonstrating the properties of a range of materials including their malleability, ductility, conductivity/ resistance, hardness, machinability, corrosion resistance and elasticity/plasticity. Internet sources could prove useful in explaining materials properties and learners could compare a range of properties across a range of different materials (eg http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/materialsrev6.shtml). With suitable teacher explanation, more advanced comparison of density, strength and maximum temperature of different materials could be made using materials data (eg http://www.engineeringtoolbox.com/engineering-materials-properties-d_1225.html).	2 hours	
6 Materials testing 	Again, internet sources will most likely prove useful in explaining destructive and non-destructive testing of engineering materials. The teacher may have access to practical test equipment where these techniques could be demonstrated: Destructive testing: tensile testing, hardness testing. Non-destructive testing: conductivity testing, crack detection. The following website explains the importance of materials testing and shows non-destructive testing in action: http://www.bindt.org/videos/.	1 hour	R112 (LO3)
7 Characteristics of engineering materials 	Characteristics of engineering materials include relative cost, availability, ease of use, safety in use, forms of supply and sustainability. Learners could undertake a tabular comparison of a range of engineering materials in terms of their characteristics. The following website could be a useful starting point: http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/materialsrev6.shtml.	1 hour	
8 Uses of materials 	Teachers could provide learners with a range of products and ask them to select and justify suitable engineering materials for their manufacture. This could include: Ferrous and non-ferrous metals and alloys: cast iron for machining bases, bronze for boat propellers. Thermoplastics: ABS for appliance casings. Thermosetting plastics: phenol-formaldehyde for heat resistant pan handles. Ceramics: tungsten carbide for cutting tool tips. Composites: carbon fibre for bicycle frames. Smart materials: shape memory alloy in alarm systems. Learners could present their findings as a PowerPoint presentation or as a poster. See Lesson Element: Use of materials.	2 hours	R103 (LO1) R106 (LO3 & 4)

LO2 - UNDERSTAND ENGINEERING PROCESSES AND THEIR APPLICATION

Learning Outcome — The learner will:
LO2: Understand engineering processes and their application

Suggested content	Suggested activities	Suggested timings	Possible relevance to
1 Safe use of tools and equipment 	Throughout this Learning Outcome safe use of tools and equipment will be a key consideration for any practical activity undertaken. The teacher may wish to deliver health and safety instruction as an introduction and also prior to any practical activities being undertaken. Learners might consider features and controls of machines, risk assessment, the use of Personal Protective Equipment (PPE) and appropriate safety precautions.	1 hour	
2 Basic engineering processes: materials removal and hand forming 	Throughout this Learning Outcome teachers might use a blend of theoretical delivery reinforced with practice to give learners the opportunity to develop an understanding of hand and machine-based engineering manufacturing processes. Processes for materials removal by hand might include sawing, filing and threading while hand-forming processes could include forging, casting and bending. Where practical activities are not possible then suitable internet videos could be used to show hand and machine-based processes taking place. The following video shows thread cutting: https://www.youtube.com/watch?v=x-Q34j0NceE and hand forging is shown at: https://www.youtube.com/watch?v=y0meRCdhZoI .	1 hour	
3 Basic engineering processes: joining methods 	Similarly jointing methods could be explained theoretically and undertaken practically including soldering, brazing, welding, riveting, using adhesives, using threaded fasteners and self-tapping screws. Videos could again be used to show joining practices in action eg https://www.youtube.com/watch?v=BLfXXRfRIzY which shows soldering and https://www.youtube.com/watch?v=TQP8EBQRvr0 which shows brazing.	1 hour	

Suggested content	Suggested activities	Suggested timings	Possible relevance to
4 Basic engineering processes: heat treatment and surface finishing 	Heat treatment includes hardening and tempering, case hardening, annealing, normalising and nitriding Surface finishing includes linishing, polishing, plastic/powder coating, painting, electroplating and galvanising. Again a mix of theoretical delivery reinforced with practical activities might be used by teachers and learners to develop an understanding of heat treatment and surface finishing. The following video shows annealing taking place: https://www.youtube.com/watch?v=3jSz11lz8MA with the following linishing: https://www.youtube.com/watch?v=U_u1TSGhUGo	2 hours	
5 Machine processes: materials removal and forming 	Having developed an understanding of hand processes used in engineering manufacture, teachers and learners might then move onto machine-based processes. Processes for machine-based materials removal include drilling, turning, milling and grinding while forming processes include die and investment casting, shell moulding, forging, extrusion and press forming. Internet sources might be used by the teacher to explain these processes in detail (eg http://en.wikipedia.org/wiki/Machining) and learners may be able to undertake some of these practically to reinforce their understanding.	2 hours	
6 Machine processes: moulding 	Moulding processes including vacuum forming, injection moulding, blow moulding, rotational moulding and compression moulding may prove more challenging to support with practical activities for learners. If possible, an industrial visit might be arranged to see some of these processes in action. Alternatively internet videos could be used to explain moulding processes prior to the teacher explaining related theory of how the process operated. The following video shows injection moulding: https://www.youtube.com/watch?v=uQgc8ZZAFEs See Lesson Element: Machine processes: moulding.	2 hours	

LO3 - KNOW ABOUT DEVELOPMENTS IN ENGINEERING PROCESSES

Learning Outcome — The learner will:
LO3: Know about developments in engineering processes

Suggested content	Suggested activities	Suggested timings	Possible relevance to
1 Application of CNC processes 	Teachers could arrange an industrial visit for learners to see the industrial applications of CNC machining processes. Alternatively internet videos might be used to show these in operation. Learners could undertake an individual research activity to explore a range of CNC machining processes including CNC lathes and milling/ router machines, multi-axis machining centres, water jet cutting, punching machines and press brake machines Laser applications could also be investigated including laser welding and cutting. The following videos show multi-axis CNC machining and wave jet cutting taking place: https://www.youtube.com/watch?v=CqePrbeAQoM https://www.youtube.com/watch?v=4aM93yuLU28.	2 hours	R111
2 Additive manufacture and rapid prototyping 	Teachers might have access to rapid prototyping facilities which could be demonstrated to learners as an introduction. Where access to equipment is not available then internet videos or industrial visits could be used to show these processes in operation including Selective Laser Sintering (SLS), Stereo Lithography (SLA), Direct Metal Laser Sintering (DMLS), Fused Deposition Modelling (FDM), 3D printing and electron beam melting. Learners could be tasked with a research activity to investigate and explore a range of rapid prototyping techniques. The following videos show stereo lithography and fused deposition modelling: https://www.youtube.com/watch?v=BUfh5wxj3qA https://www.youtube.com/watch?v=P0JRxHJrUuk See Lesson Element: Adaptive manufacture and rapid prototyping.	2 hours	R109 (LO3)

LO4 - UNDERSTAND THE IMPACT OF MODERN TECHNOLOGIES ON ENGINEERING PRODUCTION

Learning Outcome — The learner will:
LO4: Understand the impact of modern technologies on engineering production

Suggested content	Suggested activities	Suggested timings	Possible relevance to
1 Automating modern engineering production: output and quality 	An industrial visit could be used to show the impact of modern technologies on engineering production. Alternatively, learners could undertake an investigation throughout this Learning Outcome of modern technologies and their impact on engineering production as an individual or group research activity. Presentation of findings could be in the form of a PowerPoint presentation, website or poster. Teachers might provide an introduction and provide guidance at certain points starting with the effects of automation on output (ie increased output, faster to market, reduced production times) and quality (ie consistency – zero defects, Right First Time). Web-based resources might prove useful such as the following which explains zero defects at Lockheed Martin: http://www.lockheedmartin.com/us/100years/stories/zero-defects.html.	1 hour	
2 Automating modern engineering production: workforce and costs 	Teachers might provide additional instruction and guidance during a learner-based research activity. Further factors that learners might consider when exploring the impact of modern technologies on engineering manufacture include its effects on workforce (ie smaller workforce, employee re-training, changes in job profiles, improved working conditions) and costs (ie initial outlay costs, savings in workforce costs, reduced overall cost of production).	1 hour	
3 Digital communications in modern engineering production: uses in research and development 	Digital communications could also form part of a research study on the impact of modern technology on engineering manufacturing. Uses of digital communications in research and development include internet research, Computer Aided Design (CAD), electronic communication of drawings and electronic communication (eg email and video conferencing) Learners may already be familiar with some of these techniques, and may have already undertaken some CAD work. Investigation could be in the context of industrial processes.	2 hours	

Suggested content	Suggested activities	Suggested timings	Possible relevance to
4 Digital communications in modern engineering production: materials supply and control 	Further applications of digital communications include materials supply and control techniques such as Just-In-Time (JIT), inventory control, automatic ordering systems, stock management and electronic transfer of data. Teachers and learners might use suitable internet sources to investigate these in more detail. The following explains Just In Time: http://www.ifm.eng.cam.ac.uk/research/dstools/jit-just-in-time-manufacturing/.	1 hour	

POSSIBLE INTERNET SOURCES

Source	Website
Institute for Manufacturing	www.ifm.eng.cam.ac.uk
British Institute of Non-destructive Testing	www.bindt.org.uk
Lockheed Martin	www.lockheedmartin.com
The Engineering Toolbox	www.engineeringtoolbox.com
Wikipedia	en.wikipedia.org
YouTube	www.youtube.com

Contact us

Staff at the OCR Customer Contact Centre are available to take your call between 8am and 5.30pm, Monday to Friday.

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