2016 Suite

OCR
Oxford Cambridge and RSA

Cambridge **TECHNICALS LEVEL 3**

Cambridge TECHNICALS 2016

ENGINEERING

Unit 11

Materials science

A/506/7277

Guided learning hours: 60

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LEVEL 3

UNIT 11: MATERIALS SCIENCE

A/506/7277

Guided learning hours: 60

Essential resources required for this unit: access to materials testing equipment (see assessment guidance)

This unit is internally assessed and externally moderated by OCR.

UNIT AIM

Awareness of materials science is needed by design engineers and all other types of engineers in order that they can make informed decisions about the engineering materials that they choose to use in design and manufacture.

The aim of this unit is for learners to understand material structure and classification, and common properties, standard forms and failure modes of engineering materials.

They will develop an understanding of industrial material processing techniques, and how this is affected by materials' properties.

They will gain knowledge on the application and uses of modern and smart materials, and develop the ability to be able to test the suitability of different engineering materials for their intended application.

TEACHING CONTENT

The teaching content in every unit states what has to be taught to ensure that learners are able to access the highest grades.

Anything which follows an i.e. details what must be taught as part of that area of content. Anything which follows an e.g. is illustrative, it should be noted that where e.g. is used, learners must know and be able to apply relevant examples in their work, although these do not need to be the same ones specified in the unit content.

For internally assessed units you need to ensure that any assignments you create, or any modifications you make to an assignment, do not expect the learner to do more than they have been taught, but must enable them to access the full range of grades as described in the grading criteria.

Please note – if learners are completing this unit as part of the Extended Diploma qualification they will be required to complete the synoptic unit 25: Promoting continuous improvement. Before your learners complete the assessment of this unit, you must refer to the specification and model assignment requirements for unit 25, so if applicable you can ensure learners gather the appropriate feedback on their own performance and performance of the system, process or artefact that they may have produced in this unit.

Learning outcomes	Teaching content
The Learner will:	**Learners must be taught:**
1. Understand material structure and classification	1.1 material classifications and their microstructures, and how the microstructures affect the properties of the materials i.e. • atomic structures • amount of bonding • periodicity • classification of engineering materials • the crystalline structure of ferrous and non-ferrous metals and alloys, space lattice structures, grain sizes, crystal growth and solidification • the composition and structure of: o plastics o thermo-plastics o long chain molecules o thermo-setting plastics o cross linking o co-polymerisation • the crystalline structure of ceramics and glass and the properties of engineering ceramics e.g. tungsten carbide • the composition and structure of elastomers i.e. o natural rubber o styrene-butadiene o polychloroprene o butyl o ethylene-propylene

Learning outcomes	Teaching content
The Learner will:	**Learners must be taught:**
2. Understand properties, standard forms and failure modes of materials	2.1 definitions of material properties i.e. • hardness • toughness • elasticity/plasticity • ductility • malleability • stiffness • conductivity/resistivity • machinability • fusibility • corrosion resistance • compressive strength • tensile strength • sheer strength • torsional strength 2.2 standard forms in which materials are supplied i.e. • sheet • bar • flat stock • ingot/billet • granules • liquid 2.3 safety factors and modes of failure i.e. • Failure Mode and Effects Analysis (FMEA) • work hardening • overstressing • fatigue • creep • sudden loads • expansion • thermal cycling • degradation

Learning outcomes	Teaching content
The Learner will:	**Learners must be taught:**
3. Understand material processing techniques	3.1 the effects of different forming methods on the crystal forms/grain structures and properties of materials i.e. • different casting methods • press forming of sheet metal • hot forged components and comparison with cold formed or wasted component manufacture • extrusion 3.2 the relationship between the machinability of a material and its composition / structure / properties / performance 3.3 heat treatment and its use in modifying material and component characteristics and stress relief i.e. • the interpretation of thermal equilibrium diagrams and their application • annealing • normalising • hardening • tempering • case hardening e.g. carburising, nitriding 3.4 the effects of alloying on melting points and strength 3.5 the heating and forming of thermo plastic and thermo setting materials and the effects on the properties of the materials.
4. Know the applications and benefits of modern and smart materials	4.1 key features of modern materials i.e. • Glass Reinforced Plastic • carbon fibre • MDF • composites 4.2 key characteristics and properties of smart materials. i.e. • shape-memory alloys • shape-memory plastics • Quantum Tunnelling Composite (QTC) • nano materials • conductive polymers • self-healing polymers 4.3 applications of modern and smart materials with reference to their features and characteristics (e.g. heat and pressure sensors, contact sensors, reflective signs and clothing, security markers, mechanical power transmission, active dampers)

Learning outcomes	Teaching content
The Learner will:	**Learners must be taught:**
5. Be able to test the suitability of materials for different applications	5.1 how to carry out practical investigations to prove the suitability of materials for various applications i.e. • abrasion resistance • resistance to corrosion • electrical conductivity/resistivity • thermal conductivity • toughness • thermal expansion

GRADING CRITERIA

LO	Pass	Merit	Distinction
	The assessment criteria are the Pass requirements for this unit.	To achieve a Merit the evidence must show that, in addition to the Pass criteria, the candidate is able to:	To achieve a Distinction the evidence must show that, in addition to the pass and merit criteria, the candidate is able to:
1. Understand material structure and classification	P1: Explain the relationship between material structure and classification. **Synoptic link – Unit 2 Science for engineering*	M1: Analyse the effect of periodicity on the properties of materials.	
2. Understand properties, standard forms and failure modes of materials	P2: Define the properties of materials. **Synoptic link – Unit 2 Science for engineering*	M2: Explain how standard forms in which materials are available are influenced by their material properties.	
	P3: Describe the standard forms in which materials are available.		
	P4: Outline safety factors and modes of failure of materials.	M3: Explain the causes and effects of different modes of failure of materials.	
3. Understand material processing techniques	P5: Describe the effects of different forming methods in relation to material properties, composition and machinability.	M4: Justify how engineering components benefit from being subject to a specific production process.	D1: Interpret a thermal equilibrium diagram for ferrous and non-ferrous alloys.

LO	Pass	Merit	Distinction
	P6: Analyse the effects of different heat treatment methods on material and component characteristics.		
	P7: Describe the effects of common processing methods for forming thermo setting and thermo plastic materials.		
4. Know the applications and benefits of modern and smart materials	P8: Describe typical applications of modern materials with reference to their features and characteristics.	M5: For a given product or component analyse how a modern material has replaced a traditional material.	D2: For a given product or component analyse how a smart material has replaced a traditional material.
	P9: Describe typical applications of smart materials with reference to their features and characteristics.		
5. Be able to test the suitability of materials for different applications	P10: Carry out tests to prove the suitability of a range of materials for their intended applications.	M6: Evaluate the suitability of a selection of materials for their intended applications.	D3 Justify the use of alternative materials for their intended applications.

*SYNOPTIC ASSESSMENT AND LINKS BETWEEN UNITS

When learners are taking an assessment task, or series of tasks, for this unit they will have opportunities to draw on relevant, appropriate knowledge, understanding and skills that they will have developed through other units. We've identified those opportunities in the grading criteria. Learners should be encouraged to consider for themselves which skills/knowledge/understanding are most relevant to apply where we have placed an asterisk.

ASSESSMENT GUIDANCE

LO1: Understand material structure and classification
Learners should be able to explain material structure and classification, and analyse the effects of periodicity on materials. P1 provides an opportunity to use knowledge of material structure learnt in Unit 2.

LO2: Understand properties, standard forms and failure modes of materials
Learners should consider properties, standard forms of supply and failure modes of materials. P2 provides an opportunity use knowledge of material properties learnt in Unit 2.

LO3: Understand material processing techniques
Learners should be able to describe and analyse material processing processes. For M4 teachers may wish to provide learners with examples of components for which production processes can be justified. For D1 teachers may wish to supply learners with suitable thermal equilibrium diagrams to interpret.

LO4: Know the applications and benefits of modern and smart materials
Learners should describe typical applications of smart and modern materials. For M5 and D2 teachers might provide a component or product employing smart and modern materials for learners to analyse.

LO5: Be able to test the suitability of materials for different applications
For LO5 learners are required to perform practical tests to determine the suitability of materials for their intended application. The unit specification identifies a number of tests that might be performed. Learners will require access to suitable equipment in order to be able to carry out testing of a range of materials. Most of these tests can be performed using relatively low cost apparatus. Teachers might alternatively be able to access suitable test equipment external to the centre (e.g. with an employer, local college or university).

Feedback to learners: you can discuss work-in-progress towards summative assessment with learners to make sure it's being done in a planned and timely manner. It also provides an opportunity for you to check the authenticity of the work. You must intervene if you feel there's a health and safety risk.

Learners should use their own words when producing evidence of their knowledge and understanding. When learners use their own words it reduces the possibility of learners' work being identified as plagiarised. If a learner does use someone else's words and ideas in their work, they must acknowledge it, and this is done through referencing. Just quoting and referencing someone else's work will not show that the learner knows or understands it. It has to be clear in the work how the learner is using the material they have referenced to inform their thoughts, ideas or conclusions.

For more information about internal assessment, including feedback, authentication and plagiarism, see the centre handbook. Information about how to reference is in the OCR Guide to Referencing available on our website: http://www.ocr.org.uk/i-want-to/skills-guides/.

MEANINGFUL EMPLOYER INVOLVEMENT - a requirement for the Foundation Diploma, Diploma and Extended Diploma (tech level) qualifications

The 'Diploma' qualifications have been designed to be recognised as Tech Levels in performance tables in England. It is a requirement of these qualifications for centres to secure for every learner employer involvement through delivery and/or assessment of these qualifications.

The minimum amount of employer involvement must relate to at least one or more of the elements of the mandatory content.

Eligible activities and suggestions/ideas that may help you in securing meaningful employer involvement for this unit are given in the table below.

Please refer to the *Qualification Handbook* for further information including a list of activities that are not considered to meet this requirement.

Meaningful employer engagement	Suggestion/ideas for centres when delivering this unit
1. Learners undertake structured work-experience or work-placements that develop skills and knowledge relevant to the qualification.	Placements with engineering firms working with the engineering design and/or Research and Development department (where relevant) researching component structure/product material standards.
2. Learners undertake project(s), exercises(s) and/or assessments/examination(s) set with input from industry practitioner(s).	• A task involving the testing of product components to determine if the materials and treatment processes selected for the product are capable of manufacture and meet customer specifications/requirements. • A local company may set a problem linked to a material, process or failure case study, or through a scheme such as the EES.
3. Learners take one or more units delivered or co-delivered by an industry practitioner(s). This could take the form of master classes or guest lectures.	• Lecture from practicing material scientists/mechanical engineers involved in the early stages of product design, development and testing. Content to include examples of material testing principles, related calculations, and standards (such as FMEA) and working documentation used within professional commercial engineering practice. • Engineering Ambassadors, key company personnel or guest speakers from the institutions, i.e. IOM^3, IOM, BINDT, TWI

Meaningful employer engagement	Suggestion/ideas for centres when delivering this unit
4. Industry practitioners operating as ‘expert witnesses’ that contribute to the assessment of a learner’s work or practice, operating within a specified assessment framework. This may be a specific project(s), exercise(s) or examination(s), or all assessments for a qualification.	• Review by practicing material scientists/mechanical engineers relating to learners’ appropriate identification of engineering materials for a given project, and correct identification of appropriate testing methodologies within that project.

To find out more
ocr.org.uk/engineering
or call our Customer Contact Centre on **02476 851509**

Alternatively, you can email us on **vocational.qualifications@ocr.org.uk**

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