Unit 208 Properties of materials for engineering applications

Unit summary

This unit is about the structure-mechanical property interrelationship of engineering materials and their predictive performance at the design, manufacture and in-service stages.

Aims

The unit aims to develop the candidate's knowledge of metals, polymers and ceramics materials and their properties.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination.

Learning outcomes

There are **five** outcomes to this unit. The candidate will be able to:

- Demonstrate understanding of the relationship between atomic bonding mechanisms and the physical properties of materials.
- Distinguish between microstructure and properties in three classes of materials.
- Discuss the interaction between the physical properties of materials and their behaviour during manufacture and in-service
- Describe how the microstructure of a material can be controlled and modified to optimise performance during manufacture.
- Demonstrate the use of simple analytical techniques and models to predict the characteristics of materials

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

C4.1

Develop a strategy for using communication skills over an extended period of time.

C4.2

Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- **one** group discussion about a complex subject;
- **one** extended written communication about a complex subject.

C4.3

Evaluate your overall strategy and present the outcomes from your work, using at least **one** formal oral presentation, including the use of two images to illustrate complex points.

Occupational Standards

This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
6.1.1 Analyse the risks arising from engineering products and processes
6.2.1 Assure the quality of engineering products or processes
7.1.1 Develop objectives for projects
7.1.2 Plan the delivery of projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

Unit 208 Properties of materials for engineering applications

Outcome 1 Demonstrate understanding of the relationship between atomic bonding mechanisms and the physical properties of materials.

Knowledge requirements
The candidate knows how to:

1 describe a materials solidification under equilibrium conditions

2 describe the concepts of metallographic structures

3 interpret phases, phase diagrams and phase changes

4 recognise cast structures

5 explain departures from equilibrium conditions

6 describe the effects of thermomechanical treatments on microstructure

7 explain the formation of polymer molecules by

- a addition reactions
- b condensation reactions

8 demonstrate the structure of

- a thermoplastics
- b thermosetting resins
- c elastomers

9 explain the compounding of plastics and rubbers for manufacture and service

10 conceptualise timber as a natural polymer

11 categorise ceramics and cements

- a naturally occurring
- b manufactured

12 relate atomic bonding mechanisms to physical and mechanical properties

Unit 208 Properties of materials for engineering applications

Outcome 2 Distinguish between microstructure and properties in three classes of materials.

Knowledge requirements
The candidate knows how to:

Structural steels and cast iron

1 use the iron-carbon diagram to explain the effect on plain carbon steel of
   a hardening
   b tempering
   c normalising
   d stress relieving
   e surface treatments
2 explain the relationship between microstructure and mechanical properties
3 describe the effects of alloying of steels on
   a heat treatment response
   b final properties
4 extend the iron-carbon diagram to cast irons
5 explain the effects of non-equilibrium cooling on morphology and properties
6 determine the effect of alloying to produce stainless steel on
   a structure
   b corrosion resistance
7 explain carbide formation in stainless steel when joining by welding
8 explain stainless steel stabilisation to avoid carbide formation when welding

Non-ferrous alloys

9 ascertain the properties of cast and wrought aluminium alloys
10 select aluminium alloys to suit particular applications
   a aeronautical
   b ship and boat building
   c lightweight structures
   d automobile
11 describe heat treatment processes and their effect on properties
   a age hardening
   b precipitation treatment

Composite materials

12 assess fibre reinforced plastics for properties and applications
13 explain reinforcing techniques and fibre-matrix reaction

14 assess cement, concrete and aggregates for properties and applications
   a types and treatment
   b chemical composition
15 determine the influence on hardening of cement and concrete of chemical admixtures
16 describe the properties of fresh concrete
   a setting process
   b hardening process
17 describe the properties of hardened concrete
   a chemistry
   b microstructure
   c effect of curing
   d strength
   e creep
   f shrinkage
   g durability
18 conduct standard tests on concrete specimens
19 determine the mechanical properties of bitumen – aggregate mixes

Unit 208 Properties of materials for engineering applications

Outcome 3 Discuss the interaction between the physical properties of materials and their behaviour during manufacture and in-service

Knowledge requirements
The candidate knows how to:

1 analyse the effect deformation processes on metals
   a line and point defects
   b effect of grain boundaries
   c multiphase structures
2 assess the results of work hardening
3 describe the deformation characteristics of
   a rolling
   b extrusion
   c forging
   d deep drawing
4 describe the effects of deformation processes on mechanical properties
5 describe the effect of in-service activity on materials
   a fatigue
   b creep
   c tensile strength
6 explain the influence of bad design or accidental defects on the setting up of stress concentrations when in service
7 analyse fracture mechanics concepts
8 determine the origins of brittle behaviour in advanced ceramics
9 determine remedies for brittle behaviour in ceramics
10 perform electrochemical corrosion tests on materials
11 assess corrosion prevention treatment techniques and treatments
12 explain how corrosion prevention treatments affect the microscopic structure of materials
13 explain the degredation of polymeric materials in
   a processing
   b in service

Unit 208 Properties of materials for engineering applications

Outcome 4 Describe how the microstructure of a material can be controlled and modified to optimise performance during manufacture.

Knowledge requirements
The candidate knows how to:

1 describe the casting of metals and metal alloys
   a cast iron
   b concast steel
   c cast aluminium
2 analyse the structure of cast metals and the influence of casting conditions
3 describe casting mould design
4 recognise cast faults and soundness
   a burning
   b inclusions
   c porosity
5 develop models of cast metal nucleation
6 analyse the effects of super-cooling on cast metal microstructures
7 describe powder technology in the production of advanced ceramics
8 the role of diffusion in the manufacture of advanced ceramics

Unit 208 Properties of materials for engineering applications

Outcome 5 Demonstrate the use of simple analytical techniques and models to predict the characteristics of materials

Knowledge requirements
The candidate knows how to:

1 use model and use analytical techniques in support of Outcomes 1 to 4

Unit 208 Properties of materials for engineering applications

Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Elements of Materials Science and Engineering	Van Vlack	Addison-Wesley	0201093146
Engineering Materials, Vol 1 An Introduction to their Properties and Applications	Ashby, Jones	Butterworth-Heinemann	0750630817
Engineering Materials, Vol 2 An Introduction to Microstructures, Processing and Design	Ashby, Jones	Butterworth-Heinemann	0750640197
Manufacturing with Materials	Edwards, Endean	Butterworth-Heinemann	0750627549
Materials Science and Engineering	Callister	John Wiley	0471320137
Materials, Principles and Practice	Newey,Weaver	Butterworth-Heinemann	0750603909
Structural Materials	Weidmann, Lewis, Reid	Butterworth-Heinemann	0408046589
Other useful texts			
Civil Engineering Materials	Jackson,Dhir	Palgrave	033363683
Concrete, Timber and Metals	Illston	Chapman & Hall	0412380803
Introduction to Composite Materials	Hull, Clyne	Cambridge University	0521388554
Materials in Construction	Taylor	Longman Higher Education	0582368898
Plastics	Mills	Butterworth-Heinemann	0340560436
Selection and Use of Engineering Materials	Crane, Charles	Butterworth-Heinemann	0750615494