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Design & Technology

TEACHER'S GUIDE

Also for Cambridge O Level

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3.1 Types of materials

Learning objectives

By the end of this unit students should:

- understand the common physical and working properties of materials
- understand the common factors that should be considered when selecting materials that are fit for purpose.

Key terms

force, physical property, prototype, stiffness, stress or strain, working property

Resources

Student Book pages 166–169
Activity sheets A–D (available online on Collins Connect)
Samples of old products, e.g. old toys; photos of different products; samples of woods, metals, plastics, composites and smart/modern materials; samples of products showing wear and tear; samples of used products showing damage that renders them unusable
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.1.

It is suggested that one introductory lesson is devoted to this unit. This could be followed up by lessons involving practical work, e.g. a small-scale design and make activity or a focused task and homework assignments. The actual number of lessons will depend on your approach, the purpose of the lessons and/or the ability level of your students. However, to achieve the learning objectives for this unit and to help students to consolidate their understanding, it is suggested that the follow-up activities are done over three to six lessons, alongside or with referral to practical activities.

The most important purpose of this unit is to help students to understand how and why appropriate materials are chosen in order to enhance the functionality of products. As an introductory lesson, you could select one of the **Lessons starter** and one of the **Plenary** activities.

Lesson starter suggestions

Product disassembly: Before students do this activity, ask them to read pages 167–168 of the Student Book. Provide a range of small products (old toys are ideal). Put students in small groups and give each group one of the products. Ask them to use appropriate tools to disassemble the products and sort the parts into different material groups. The activity can be differentiated according to students' ability, e.g. metals could be sorted by group, using a magnet to test them. Alternatively, metals could be grouped into those that can be recycled and those that cannot.

Material replacement: Print and hand out Activity sheet A. Provide students with photos of different products and ask them: a) to identify the materials used to make them; b) to classify the materials by group (wood, metal and plastic); and c) to suggest a material from a different group that could replace it. If it is not possible to replace the material, students should explain why this is the case. They should record their answers on Activity sheet A.

Interactive activity: Students work individually to do the Interactive activity if they have their own devices. Alternatively, this can be done at the front of the class, or individually for homework.

Material properties: Choose a product in the room and ask students to identify the parts of the product and the material the parts are made from. Then ask them to list the properties of the materials that make them suitable for the parts in question. Depending on students' ability, ask them to describe the property rather than use the terminology.

Main lesson activities

Product investigation: This activity could be undertaken either as part of a design and make project or as a stand-alone lesson. Tell students that they have to investigate a product in detail. The product could be one they have made themselves or one made by you or another student. Students draw and/or photograph the product from different points of view. This could be an opportunity for them to demonstrate technical drawing skills (isometric or orthographic projections), or they could use CAD to draw and render a 3D image. Ask students to focus on details, taking into consideration wider aspects of the product, e.g. an analysis of the materials used, how the product was manufactured, and how was it constructed or assembled. They could even consider how material choice can be used to brand and market the product. Further evaluation should focus on the properties of the materials used to make the product, and students could present a rationale for the manufacturer's choices. As an extension, refer students to pages 210–221 of the Student Book and ask them to identify material joining techniques, paying special attention when materials of different types are joined together.

Product specification: Provide students with a product and ask them to take a reverse engineering approach to disassemble it safely into its component parts and list the properties of the materials used to make each part. Students then compile a speculative product specification, defining the essential and desirable features relating to materials, which may have led to the selection of the materials.

Testing: If there are suitable facilities, ask students to test a range of material samples spanning the different material groups. They could devise their own tests to help them to distinguish between different material types. Alternatively, write a list of tests on the board, e.g.:

- *Can the material be marked easily with a nail/file/scriber?*
- *Can a nail be hammered into the sample?*
- *Does the material float?*
- *Is the material magnetic?*
- *Does the material conduct electricity?*
- *Does the material absorb water?* (Weigh the samples; immerse them in water until the next lesson; move them from the water and reweigh them, noting if they have absorbed water.)
- *Does the material burn or melt?* (Take care with Health and Safety and make sure everyone follows the relevant guidance. The safest option is for students to observe as you perform the test.)

The answers should be tabulated in a form that enables students to use the end piece of work to be used as a reference work in the future.

Analysis of worn samples: Provide students with a range of worn material samples and ask them to draw, sketch or photograph the 'wear' on the sample. They then label the image where and how they think the wear occurred, noting if the material played a part in the deterioration of the product and suggesting how this could have been avoided, e.g. by using a coating or a different material. You could constrain students' answers by asking them to consider only alternative material choices. Students could then relate this knowledge to any product they are making at the moment.

Failure Mode Analysis (FMA): Provide students with a number of broken products and ask them to draw, sketch or photograph them. They then describe how they think the product failure took place and identify the material(s) that failed. Ask students to relate this to material properties and identify which property caused the failure, e.g. the material is too brittle, too rigid, not flexible enough. Ask students how they could ensure this does not happen in the future and what advice would they give someone making the product when they came to specify the materials being chosen.

Knowledge check (page 169): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Material choice: Students take turns to point to and name an item in the room, name a material used in its construction or manufacture and cite the reason for the choice of the material. This activity re-caps students' understanding.

Skills activity (page 168): Print and hand out Activity sheet B. Students can record their answers to the activity on this. They can refer to page 167 of the Student Book for the correct terms to explain their understanding of the material choices.

Tip: *Students could also record their responses in a sketchbook or an online blog or journal to build a resource for reference and revision.*

Define it: Print and cut out Activity sheet C, enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Team quiz: Put students in two groups. As quiz master ask the questions in Activity sheet D and record scores. You could give a prize to the winning team.

Answers to Student Book activities

Skills activity (page 168)

Responses will vary.

Knowledge check (page 169)

Design a folding worksurface that could be used by a teenager when doing homework.

1. Communicate your idea using an annotated sketch. (4)

Responses will vary.

Award 4 marks for a three-dimensional sketch or multiple views clearly indicating the main features.

Award 2 marks for a two-dimensional sketch clearly indicating the main features.

2. Identify all materials used in your design and list the specific physical and working properties which make them suitable. (6)

Students should identify at least two appropriate materials, describe their properties and give reasons for their choice, e.g. Acrylic was chosen for its chemical stability and water resistance in a bathroom. Stainless steel was chosen for its durability and wear and tear outdoors.

Award 1 mark for identifying an appropriate material, 1 mark for describing a key property of the material and 1 mark for indicating the reason for the choice of material (to a maximum of 6 marks)

Total: 10 marks

3.2 Smart and modern materials

Learning objectives

By the end of this unit students should:

- be aware of a range of 'smart and modern materials', including: thermochromic materials; polymorph; shape memory alloy (SMA); shape memory polymer
- understand the key properties of common 'smart and modern materials'.

Key terms

biomimicry, memory; nanoparticles, polymer

Resources

Student Book pages 170–172
Activity sheets A–C (available online on Collins Connect)
Samples of smart and modern materials; products made from smart and modern materials
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.2.

Smart and modern materials can be introduced in a number of ways. One one-hour lesson could be devoted to introducing the range of materials in this unit. Alternatively, individual materials could be introduced alongside designing, making and/or evaluation activities.

Lesson starter suggestions

Design in action: Ask students to read **Design in action** on page 170 of the Student Book. Write the following questions on the board and ask students to discuss them in small groups:

- *What are the properties of shape memory alloy that made this medical development possible?*
- *What are the potential risks involved with this kind of medical development?*

Demonstration: Source a range of samples of smart materials, e.g. polymorph, shape memory alloy, thermochromic inks, to demonstrate material properties and illustrate what smart and modern materials are. Follow the guidance provided by the supplier.

Interactive activity: This activity could be used at the beginning of an introductory lesson, as a comprehension activity or as a plenary to gauge students' knowledge and recall.

Main lesson activities

Product analysis: Ask students to investigate a product that utilises a smart or modern material such as those in the table on page 171 of the Student Book. They can use either the ACCESS FM (aesthetics, cost, customer, environment, size, safety, function, materials – see Activity sheet A) or CAFÉ QUE (cost, aesthetics, function, ergonomics, quality, user, environment – see Activity sheet B) design acronyms to structure labels, annotations and descriptions.

Micro-teach (smart and modern materials): Put students in groups of three or four and ask them to investigate a different smart or modern material. They should use the Student Book and the internet to prepare a five-minute presentation describing the material, explaining how it works and how it can be used to enhance products.

Micro-teach (biomimicry): Put students in groups of three or four. Ask them to investigate a natural phenomenon, e.g. the streamline nature of shark skin, the adhesive properties of gecko feet, or the ability of animals like the chameleon to change colour. They should use the internet to investigate the natural properties of the phenomenon and find examples of how it has inspired the development of materials such as Speedo's 'fastskin' swimsuit inspired by sharkskin. Students then prepare a five-minute presentation of their findings.

Mini design and make: Students work in pairs or small groups. Ask them to use polymorph to model a handle or grip for a tool (e.g. a spanner) that can be used in cold environments; the user should be able to pick up and use the tool while wearing thick gloves. This activity could be done during a lesson on anthropometrics and ergonomics.

Skills activity (page 172): Students can do this activity as part of research for a design and make assignment or as revision. Sources of information include smart and modern materials sample boxes; these are available from educational suppliers for design and technology resources.

Knowledge check (page 172): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Define it: Print and cut out Activity sheet C enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

The 'brick test': The 'brick test' is a common activity used to assess creativity: people are presented with an everyday object such as a brick or a paperclip and challenged to come up with as many uses for it as they can. You could give students a smart or modern material and give them five minutes to brainstorm as many different uses as they can to which it could be put. They could use a flipchart pad to make notes of their ideas, which they can then present to the rest of the class.

Ethical challenges: Provide students with a product manufactured using smart or modern materials, e.g. the Speedo 'fastskin' swimsuit worn by USA swimmer Michael Phelps at the 2004 Athens Olympics, where he won eight gold medals. In groups, students discuss the following questions:

- *What advantages does the product give the user?*
- *What concerns would people who do not have access to the product have?*

Answers to Student Book activities

Skills activity (page 172)

Responses will vary.

Knowledge check (page 172)

1. Explain how a smart and modern material differs from a natural material. (2)

A smart or modern material has properties that alter in response to environmental conditions or external stimuli. (1) It is designed and manufactured to perform a particular function. (1)

2. Describe the properties of a smart and modern material and give examples of how these could be used to add functionality to a product. (4)

Award 1 mark for the identification of a smart or modern material, e.g. thermochromic pigment; 1 mark for an appropriate property of the material, e.g. changes colour in response to heat; 1 mark for a suitable product, e.g. a baby spoon; 1 mark for an appropriate reason for the choice, e.g. to indicate whether food is too hot.

Total: 6 marks

3.3 Plastics

Learning objectives

By the end of this unit students should:

- have a working knowledge of the following thermoforming plastics and their properties: nylon, low and high density polyethylene (LDPE and HDPE), polyethylene terephthalate (PET), polyvinyl chloride (PVC), acrylic (PMMA), polystyrene (PS), polypropylene (PP), acrylonitrile-butadiene-styrene (ABS)
- have a working knowledge of the following thermosetting plastics and their properties: polyester resin including GRP, melamine formaldehyde (MF), urea formaldehyde (UF), phenol formaldehyde (PF) and epoxy resin.

Key terms

elastic state, plastic state, thermoforming, thermosetting

Resources

Student Book pages 173–176
Activity sheets A–C (available online on Collins Connect)
Samples of thermoforming and thermosetting plastics; a range of low quality plastic objects (e.g. promotional toys from a fast food restaurant) and a range of high quality plastic products
Access to animations or videos of plastics manufacturing processes, for example, British Plastics Federation (BPF): www.bpf.co.uk/plastipedia/processes/Default.aspx
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.3.

In order to develop students' knowledge and understanding of the full range of thermoforming and thermosetting plastics, a variety of approaches is required, including focused practical tasks. You could introduce the unit at the beginning of a design and make project, where students explore the range of materials outlined in the Student Book, and supplement it with practical activities that explore methods for forming plastics, such as line bending or vacuum forming.

Lesson starter suggestions

Match the sample (page 174): Source samples of thermoforming plastics and cut them into similar sizes. Then print one copy of Activity sheet A for each student or group of students and cut out the cards. Attach the sample number cards to the plastic samples and ask students to match the plastic samples with the names of the materials and the descriptions. Students can refer to the descriptions on page 174 of the Student Book.

Teacher demonstration (page 173 to 176): You could introduce the unit with a demonstration of a plastics forming process, e.g. local line bending or vacuum forming. Encourage students to refer to the Student Book if they have questions about the process; this will encourage learner independence. If they are still unclear, however, they can ask you to clarify or explain.

Main lesson activities

Product analysis: Ask students to investigate a product that utilises plastic materials, such as those in the tables on pages 174 and 175 of the Student Book. They can use either the ACCESS FM or CAFÉ QUE design acronyms to structure labels, annotations and descriptions. You can print and hand out Activity sheet A (ACCESS FM) or Activity sheet B (CAFÉ QUE) from Unit 3.2.

Focused practical task (1) (local line bending): Have students do a simple making task, e.g. a pencil stand, using 3 mm sheet acrylic, which will be formed using local line bending. You could prepare the materials yourself ahead of time using a laser cutter (or other CNC device) or a template; this will allow more time for the making element of the task.

Focused practical task 2 (vacuum forming): Have students do a simple making task, e.g. a stationery tray, using high impact polystyrene sheet (HIPS), which will be formed using a vacuum former. A standard former (or plug) could be used; this will allow more time for the making element of the task.

Destruction testing: You need to carry out appropriate risk assessment and precautions/controls prior to conducting this activity. Use two samples of 3 mm sheet acrylic and a plastics forming oven set to 150°C. Place each sample on a sheet of aluminium foil. Heat one for approximately five minutes and leave the other in the oven for a further five minutes (or until you hear a popping noise). Try this out before the lesson to confirm the temperature and timings. Carefully remove the first sample using appropriate PPE, drape it over a former with a gentle convex profile, and allow it to cool naturally. Remove the second sample and put it in a safe place to cool. Compare the two samples when they have cooled and note the bubbles on the surface of the second sample. Encourage students to speculate why there are bubbles (i.e. tiny pockets of air expanding in the material) in the second sample. They should also note the difference between the first sample (elastic state) and the second (plastic state).

Skills activity (page 175): Students could disassemble the product and photograph the parts/components or photograph the product from multiple angles to identify the key features and recycling symbols/codes. (Products could include promotional toys from fast food restaurants.) Students could then create a research or revision sheet, with labels and annotations explaining how easy it is to disassemble and recycle each part.

Knowledge check (page 176): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Define it: Print and cut out Activity sheet B enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

The six Rs: Put students in groups of three or four. Provide them with a range of plastic products, including inexpensive and low quality objects (e.g. promotional toys from a fast food restaurant) as well as high quality products. Print one copy of Activity sheet C for each group and give students five minutes to decide whether they would rethink, refuse, reduce, reuse, recycle or repair the product(s), explaining their reasoning to the rest of the class.

Design in action: Ask students to read **Design in action** on page 176 of the Student Book. They then work in pairs to find and identify the plastic(s) used in an object in the workshop by the 'triangle loop' symbols imprinted on them. You could check the workshop before the lesson to ensure that there are suitable objects located in the room.

Interactive activity: Students do the activity to check their knowledge of thermoforming or thermosetting plastics.

Answers to Student Book activities

Skills activity (page 175)

Responses will vary.

Knowledge check (page 176)

Giving examples of products and specific plastic materials:

1. Explain the advantages of plastics when designing and making everyday products. (3)

Possible answers: easy to mould into complex shapes; lightweight (high strength to weight); resistant to water and other chemicals; durable

Award 1 mark for each correct answer (to a maximum of 3).

2. Explain the disadvantages of plastics when designing and making everyday products. (3)

Possible answers: made using non-renewable sources; some are toxic; take a long time to degrade; harmful to the environment

Award 1 mark for each correct answer (to a maximum of 3).

3. Explain why plastics are commonly used in everyday products. (3)

Possible answers:

Everyday product made from a plastic: kitchen utensil, pen, car dashboard

Advantages: can be formed into complex shapes; do not require a surface finish; chemically stable; water resistant

Award 1 mark for an appropriate example and 1 mark for each advantage (to a maximum of 2).

Total: 9 marks

3.4 Wood

Learning objectives

By the end of this unit students should:

- be able to state the classifications of natural timbers and understand how natural timbers are classified
- understand why timber is seasoned and how to care for it
- understand the process of timber steaming and bending, and have knowledge of adhesives, curing times and strengths
- have a working knowledge of manufactured boards, and be able to assess advantages and disadvantages of working with them in comparison to natural timbers.

Key terms

hardwood, manufactured board, seasoning, softwood, timber, veneer, warping

Resources

Student Book pages 177–183
Activity sheets A–D (available online on Collins Connect)
Sample of a range of hardwoods; samples of a range of (hardwoods,) softwoods and manufactured boards; samples of small pieces of hardwoods and softwoods; a sample of a warped piece of timber; thin strips (e.g. 22 mm × 200 mm) of 3 mm thick plywood, PVA
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.4.

It is suggested that two or three hours are devoted to this unit. However, the actual time will depend on the length of time devoted to individual elements and your students' ability.

Lesson starter suggestions

Is hardwood hard (1)?: This activity is designed to introduce students to the topic of the unit. Source a range of hardwoods that have different colours and different densities. If possible, include a sample of balsa wood *(Ochroma pyramidale)*. Ideally, select some hardwoods that are native to your country. Ask students to say which samples they think are hardwoods and why. Then explain that they are all hardwoods and go on to define what characterises a hardwood. You can refer students pages 177–179 of the Student Book.

Is hardwood hard (2)?: This activity can be used as an alternative introductory activity. Source samples of the following hardwoods prior to the lesson: ash, beech, birch, cherry, holly, mahogany, oak and sycamore. Print Activity sheet A, cut out the cards and hand a set of cards and a sample of each wood to each student. (This activity can be done in pairs or groups if resources are limited.) Then ask them to match each card with the corresponding sample of hardwood.

Interactive activity: Students work individually to do the Interactive activity if they have their own devices. Alternatively, this can be done at the front of the class, or individually for homework.

Main lesson activities

Wood or timber?: Refer students to page 177 of the Student Book. Explain that the way a tree is cut into planks determines how the wood grain appears in the piece of timber. Use this as an opportunity to discuss how wood differs from timber as this is often an area of confusion for students. Source samples of hardwoods and softwoods and cut them into small pieces that can be handled easily (suggested size: 80 mm × 50 mm × 20 mm). Ensure that the samples show different sections of wood grain. Print and hand out Activity sheet B and ask students to draw on the cross sections of the tree where they think each piece of timber comes from.

Seasoning and drying: While you are discussing the differences between wood and timber in the 'Wood or timber' activity, introduce the concept of seasoning. If you have a sample of a warped piece of timber, use it to illustrate one of the reasons for seasoning. If no physical sample of warped timber is available, you could use a suitable image. Discuss with students why warping is undesirable in the building and construction industry and in the construction of furniture or an artefact.

Drying: Ask students to read page 178 of the Student Book and introduce the concepts of natural drying and forced drying in a kiln. Once students have understood the concepts, check their knowledge. Print and hand out Activity sheet C and ask them to label the diagram (Student Book closed). Then ask them to list the advantages and disadvantages of kiln drying to produce seasoned timber. See the Activity sheet C notes for the answers.

***Tip:** If applicable, the process of drying in a kiln could be related to the process of drying clay in a kiln or leaving it to dry naturally.*

Classification of timber: Students need to understand that there are three different classifications of timber. They also need to be able to state what these are and identify the characteristics of each type. Give students a blank sheet of paper and ask them to list as many different types of wood as they can (e.g. Scots pine, ash, teak, MDF, plywood, beech, mahogany, cedar). Then ask them to identify which ones come from trees, and explain that the other types are manufactured and do not exist in that state in the natural world. Ideally, provide students with handling samples of common types of wood, e.g. blockboard, chipboard, hardboard, medium density fibreboard (MDF) and plywood. These can be passed around and discussed. Get students to look for differences and similarities between samples. Once they have done this, correctly identify the samples for them and ask them to add any missing ones to their list of woods.

Next, discuss the advantages of manufactured boards:

- Sustainability: Manufactured boards make effective use of offcuts and waste products from other timber manufacturing processes, irrespective of the size of that timber. Draw students' attention to the fact that MDF is made from very fine wood dust and resin pressed into a board. Hardboard is made from pulped wood fibres, and blockboard is manufactured with a central core of softwood strips bonded together with adhesive and covered with a sheet of plywood on either side. Refer students to page 180 of the Student Book to help illustrate this.
- Size: Define the standard sheet size for manufactured boards (1220 mm × 2440 mm / 8 feet × 4 feet) and ask students if they have ever seen a tree that size.
- Properties: If possible, source a sample of aeroply or flexiply. Discuss how this is very flexible, and that because it is a manufactured piece of timber, its properties could be changed during the manufacturing process, e.g. by using different adhesives, different layers or different thicknesses of layers.
- Cost: Low-grade timber with imperfections in it can be used to make manufactured boards for purposes where appearance is not an issue. Typically, these types of manufactured boards are used in the construction industry.

***Tip:** If there are examples of students' work in the room, ask students if they can identify manufactured boards in them.*

Now refer students back to the list of different types of wood they were asked to generate. Ask them to work in pairs and identify all of the trees on their lists that shed their leaves in the autumn (the deciduous ones). Tell them that these should be hardwoods. The others listed on their sheets should all be

evergreen tree species, likely to have needles and be coniferous; as such they are softwoods. Take care to explain that even though holly is an evergreen tree, it is a hardwood and is an exception to the classification system.

***Tip:** Compare the lists generated by students with the examples on page 179 of the Student Book. Did students note all of the examples listed?*

Shaping timber and manufactured boards without joining or wasting (cutting) process: The easiest way to teach this is by example. Source some thin strips (e.g. 22 mm × 200 mm) of 3 mm thick plywood and use a simple former to laminate them together using PVA as an adhesive. If possible, clamp the former with the strips of plywood inside it in a vice until the following day. Alternatively, clamp it together using G-clamps as this will allow the whole unit (two pieces of the former and the bonded strips of plywood) to be moved elsewhere while the adhesive sets. Then get students to describe what you did, step by step. Once you have established the steps, ask them to work in small groups to determine why each step was necessary. In a 'flipped learning' style, get groups to present their reasons for each step; randomly choose different groups to articulate the rationale behind each step.

Ask students what would happen if the timber could not be laminated together to form a shape. Provide them with a piece of cardboard and ask them to try to make it take and hold a form (e.g. a simple curve) over a former. Then take a piece of cardboard and soak it in water. Once it is saturated, place it over the former and ask students if they think the cardboard will hold its shape once it dries out. Put the cardboard to one side to dry and show students the result in the next lesson. Discuss if this could be done with timber and ask students to explore the reasons why it would or would not work. If you have access to a steam bender, show it to students and discuss how the heated steam works in a similar, more effective, way. Explain that the heat helps to soften the timber and make it more susceptible to holding a shape once formed. Also point out that the piece of timber has to fit inside the steam chamber, which imposes a practical limitation on the process.

***Tip:** Ask students to write down the steps for laminating in their work journal or blog.*

Skills activity (page 183): Students work individually, in pairs or in small groups to do the activity.

***Tip:** Students could record their responses in a sketchbook, an online blog or a work journal to build a resource for reference and revision.*

Knowledge check (page 183): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Define it: Print and cut out Activity sheet D enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Answers to Student Book activities

Skills activity (page 183)

An appropriate response will take the form of an annotated drawing. Most likely a low- to medium-cost product will be made mostly from manufactured board. A high-cost item is more likely to be made of different types of timber or it may be made from a single type of timber, e.g. oak.

Knowledge check (page 183)

1. When is wood referred to as timber? (1)

once it has been machined

2. What type of trees do softwoods come from?
Give three examples and suggest uses for them. (7)

Softwoods come from coniferous trees. (1)

Any three softwoods, e.g. Scots pine, Parana pine, spruce, yellow cedar, redwood (3)

Any three appropriate uses, e.g. furniture, construction work, simple joinery, window frames, staircases, bedrooms, boat building, veneers (3)

3. What type of trees do hardwoods come from?
Give three examples and suggest uses for them. (7)

Hardwoods come from deciduous trees. (One exception is holly, which is evergreen.) (1)

Any three hardwoods, e.g. ash, beech, elm, mahogany, oak (3)

Any three appropriate uses, e.g. sports equipment, wooden ladders, tools, furniture, toys, high-quality interior woodwork (3)

4. Why are manufactured boards used? (1)

Possible answers: They are made from waste materials; they are available in sizes larger than those usually found in natural timbers; their properties can be altered for a specific reason, e.g. aero-ply or flexi-ply.

5. State two processes that can be used to bend and shape timber or manufactured boards. (2)

steam bending and laminating

6. Suggest two types of adhesive that can be used to bond timber. (2)

Possible answers: PVA, powdered synthetic resin

Award 1 mark for each correct answer (to a maximum of 2).

7. How would you know if timbers have come from a sustainable forest? (1)

They display the Forest Stewardship Council (FSC) logo.

Total: 21 marks

3.5 Composites

Learning objectives

By the end of this unit students should:

- understand the term *composite*
- be able to name a range of composite materials
- understand the advantages of using composite materials
- be aware of the practical applications of a range of composite materials.

Key terms

composite, cure, matrix, reinforcement

Resources

Student Book pages 184–187
Activity sheets A–D (available online on Collins Connect)
A range of composite material; materials that can be combined to make composites; samples of products made of different types of composite material
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.5.

At least one one-hour lesson should be devoted to this unit; the actual number of lessons will depend on your circumstances and approach, and/or the level of your students' ability. You could introduce the unit in one lesson and follow up with lessons involving practical work or other tasks.

Lesson starter suggestions

Composite identification: Use pages 184–186 of the Student Book to introduce the key concepts of composites. Source a range of composite materials. You could use photos if physical materials are not available. Hold up each material/photo and ask students to decide if it is a composite or not.

Interactive activity: Make sure students have familiarised themselves with pages 184–186 of the Student Book before they do the activity, which is designed to introduce the topic of composites.

Main lesson activities

What is a composite?: This activity is designed to help students to understand the difference between a composite and a mixed material. Facilities permitting, students could conduct the activity themselves. Alternatively, you could demonstrate it to the class. Print and hand out Activity sheet A. The teacher's instructions for the activity are in the Activity sheet A notes. Throughout the activity, ask students to consider if combining a particular set of materials will create a composite. Students should record their findings on Activity sheet A using notes and sketches.

***Tip:** Students often confuse composites with other types of 'mixed' material, so take this opportunity to reinforce the concept of composites.*

***Tip:** During the activity, reinforce the lesson by giving students additional information about composites, e.g. early examples.*

Modern composites (class discussion): This activity is designed to reinforce students' understanding of the application of the three main composite groups, i.e. Carbon-fibre Reinforced Polymers (CFRP), Glass-fibre Reinforced Polymers (GRP) and Aramid products (Kevlar®). Students can do the activity individually or in pairs. Print and hand out Activity sheet B. Ask students to read **Design in action** on page 187 of the Student Book**.** They then consider each composite material group and discuss their advantages and disadvantages. They should also think of some common uses and applications of the material and record their responses on the activity sheet.

Skills activity (page 186): Students work individually, in pairs or in small groups to do the activity.

Tip: *If the activity has been done in pairs or groups, the outcome could be an oral presentation.*

Knowledge check (page 187): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Define it: Print and cut out Activity sheet C, enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Peer presentations: Students take turns to point to or name an item in the room, name the materials used in its construction or manufacture, and say which ones are composite materials.

Team quiz: Put students in two groups. As quiz master, ask the questions in the Activity sheet D notes and record scores. You could give a prize to the winning team.

Answers to Student Book activities

Skills activity (page 186)

An appropriate response would be: An example of a composite material is reinforced concrete. The individual materials utilised in its construction are a steel rod and concrete. Concrete is poured onto the steel rod, encasing the steel within it. The steel is the reinforcement and the concrete is the matrix. Reinforced concrete creates a stronger material for use in buildings such as skyscrapers.

Knowledge check (page 187)

1. Give an example of an early composite and name the individual materials used. (3)

Possible answer: Mud (1) and straw (1) to produce bricks (1).

2. Using your example from Question 1, state which material is the matrix and which is the reinforcement. (2)

Possible answer: In this example, the mud is the matrix (1) and the straw acts as the reinforcement (1).

3. Give three benefits of using composite materials. (3)

Possible answers: Composites may be lighter in weight (1). They are stronger than the individual materials from which they are made (1). They may have increased rigidity or flexibility (1).

Total: 8 marks

3.6 Metals

Learning objectives

By the end of this unit students should:

- understand where metals come from and how they are categorised
- be able to show a working knowledge of a range of metals and provide examples of their uses
- understand how processes can change the molecular structure of a material making it more or less suitable for the task it has to perform.

Key terms

alloy, ferrous, non-ferrous

Resources

Student Book pages 188–194
Activity sheets A–F (available online on Collins Connect)
A range of small wood, metal and plastic fasteners, e.g. nuts, bolts, pins, nails, screws, washers, wooden dowels; samples of metal products, e.g. copper wire, an aluminium strip, a tool made of high-carbon steel; a thin strip of aluminium (around 1–2 mm thick)
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.6.

It is suggested that two or three hours are devoted to teaching this unit. The actual number will depend on the ability of your students.

Lesson starter suggestions

Classification: This is a quick and simple task that students can do in groups. Source a selection of small fasteners, e.g. nuts, bolts, pins, nails, screws, washers, wooden dowels. Ask students to sort the fasteners by material type, i.e. wood, metal and plastic. Then have them further sort the fasteners by material properties, e.g. when it comes to the metal components, you could ask students to try to differentiate types of metals – they could use a magnet to separate ferrous and non-ferrous metals, for example.

Main lesson activities

Properties of materials: Source samples of metal products and ask students to list the properties of the metals. Suitable samples would include metals that can undergo deformation and alteration at normal atmospheric temperatures (i.e. they require no heat treatment). Examples include copper wire, an aluminium strip and a tool made of high-carbon steel. Make sure you do not include metals that are brittle because they have been hardened. It is unlikely that students will know all of the terms that describe each property, but they can describe the properties using their own words. They can record their responses in a blog, journal or workbook.

Tip: *Ensure that the samples are safe to handle and that they have no burrs, sharp edges or corners.*

Classification of metals: As a class, discuss the concept of material properties and ensure students understand that a material has more than one property. It is important to explain that properties alone do

not define and classify metals. Show students an example of a non-ferrous metal, e.g. aluminium, and an example of a ferrous metal, e.g. mild steel, and ask them if they can determine the defining characteristic of the metal. Use a magnet to illustrate that one of the metals is magnetic and the other is not. Explain that this is due to the fact that one contains iron and is, therefore, ferrous, whereas the other does not and is non-ferrous. This is an ideal opportunity to introduce the concept of an alloy, which is a mixture of two or more pure metals. Discuss the idea that the properties of metals can be changed when different metals are mixed together.

Next, put students in small groups. Print one copy of Activity sheet A for each group and cut out the cards. Ask students to classify the different metals; are they ferrous or non-ferrous? As an extension, print and hand out Activity sheet B and ask students to identify which metals are alloys. They can record their responses on the activity sheet.

Tip: *You could put the two metal samples in two containers with a small amount of water. Make sure the containers are open to the air. In a later lesson, you can ask students to look at the metals again and discuss corrosion.*

Ferrous and non-ferrous metals: Refer students to pages 189–190 of the Student Book and discuss the metals in the two tables. Point out that the metals are arranged in order according to their melting point and go through their properties and uses. Ask students if they can add other uses for the metals; alternatively, add more examples to the tables yourself. Having previously discussed the idea of ferrous and non-ferrous metals and the relevance of iron in categorising them, it is important now to take time to discuss how the inclusion of iron in an alloy can greatly affect the properties of the alloy. Discuss the following:

- Cost: It is relatively cheap to extract iron from the ground and it is also abundant worldwide; this makes it an ideal base metal for an alloy, or for use in its own right.
- Sustainability: Extracting iron ore from the earth and smelting it to release the useable metal from the rock in which it naturally occurs requires a lot of energy. Once iron has been used for purpose (e.g. making parts or girders), it can easily be melted and recast as a new part at a fraction of the energy cost it takes to extract raw iron from its ore.
- Corrosion: Make sure students know that metals that rust contain iron. Point out that the correct name for rust is ferric oxide and note the similarity between ‘ferric’ and ‘ferrous’.

Tip: *As an extension, ask students if they have studied the periodic table in science lessons and if so, ask them what the chemical symbol for iron is (Fe).*

Changing the structure and properties of metal: Recapitulate the idea that the properties of a metal can be changed by alloying it with another metal. Go on to explain that there are a number of other treatments and processes that can change the properties of a metal without the need to melt them down and combine them with other metals. These include work hardening and heat treatments.

Work hardening: Take a thin strip of aluminium (around 1–2 mm thick) and start to work harden it in front of the class. (Simply bend it back and forth at the same site on the strip.) Ask students:

- *What do you think is happening to the metal?* Elicit that it is getting hotter – the temperature is increasing at the site of the flexing and the metal is getting thinner where it is being flexed.
- *What do you think will happen if I continue flexing the metal?* (Continue until the metal fractures and snaps, or at least until it starts to split.)
- *When do you think this might be a desirable thing?* (Components can be designed to fail in order to save more expensive components; this can be a means of separating pieces if no tools are available.)
- *When do you think this might be undesirable?* (When the metal is a vehicle part or anything structural; any time it is not anticipated or wanted.)

Pass around the aluminium strip and let students examine the point of flex/tear/failure (depending on what stage you choose to pass the strip around). Explain that this is different in each metal and that it only applies to non-ferrous metals. Use a video clip to introduce ‘planishing’ as a way of work hardening copper.

Tip: *There are some suitable YouTube clips that can be sourced using the key word 'planishing'. They can be used to add variety to the lesson.*

Heat treatment: Students need to understand that as materials are heated, their properties change. A good analogy is ice cream: when it is taken out of a freezer and it starts to warm up in the atmosphere of a room, it changes from a solid state to a liquid state. Ask students what they think generally happens to a metal when it is heated. Elicit that it becomes softer and easier to work with. Refer students to pages 191–193 of the Student Book and go through the differences between annealing, hardening and tempering, and case hardening. Then print and hand out Activity sheet C and ask students to complete it. You can refer to the Activity sheet C notes for answers.

Skills activity (page 193): Students work individually to do the activity. Print and hand out Activity sheet D, where students can record their responses. You should familiarise yourself with the tools your students have access to in order to ensure that you mark this activity accurately.

Knowledge check (page 193): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Define it: Print and cut out Activity sheet E, enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Interactive activity: This activity is designed to help students to revise the properties of metals.

Hardening: Hardening, and the different methods used for different metals, is probably the hardest concept for students to understand in this unit. Print and hand out Activity sheet F and ask students to demonstrate and consolidate their knowledge of hardening. The completed sheet can be entered into their portfolios, workbooks or blogs.

Answers to Student Book activities

Skills activity (page 193)

This activity can be tailored to virtually all classrooms, workshops and settings. As such, responses will vary greatly. Typically most metals in tools will be some form of steel derivative unless they are specialist tools, e.g. copper hammers. Frames on saws tend to made from mild steel or stainless steel with an appropriate protective coating. Blades, as well as hammer heads and files, tend to be made from a high carbon steel or tool steel so that they can hold an edge and remain sharp and hard during use.

The properties of metals used in tools include: hardness and toughness for any blades; hardness, ductility and toughness for metal saw frames.

Knowledge check (page 193)

1. Explain how to determine if a metal is ferrous or non-ferrous. (2)

Ferrous metals contain iron, so they can be tested for magnetic properties. (1)
They can also be exposed to the elements to see if they rust/oxidise. (1)

2. Describe in simple terms what an alloy is. (2)

It is a mixture of two or more (1) pure metals (1).

3. Put these metals in order according to their melting points; aluminium, bronze, cast iron, copper, duraluminium, lead, mild steel, stainless steel, tin, zinc. (10)

lead	(160°C)	Lowest
tin	(230°C)	
zinc	(420°C)	
duraluminium	(630°C)	
aluminium	(660°C)	
bronze	(950°C)	
copper	(1080°C)	
cast Iron	(1200°C)	
stainless steel	(1400°C)	
mild steel	(1600°C)	Highest

Award 1 mark for each metal in the correct position.

4. What is the purpose of annealing metals? (1)

Annealing is often undertaken after a piece of material is work hardened and it is in a state where it can no longer be worked. Annealing reverses the effect of work hardening.

5. When and why would a metal be tempered? (2)

Tempering is used to make a brittle metal less so while retaining its strength and hardness. (1)
Examples include screwdriver blades, knives and saw blades. (1)

6. Typically, how thick is the hardened layer on mild steel that has been case hardened? (1)

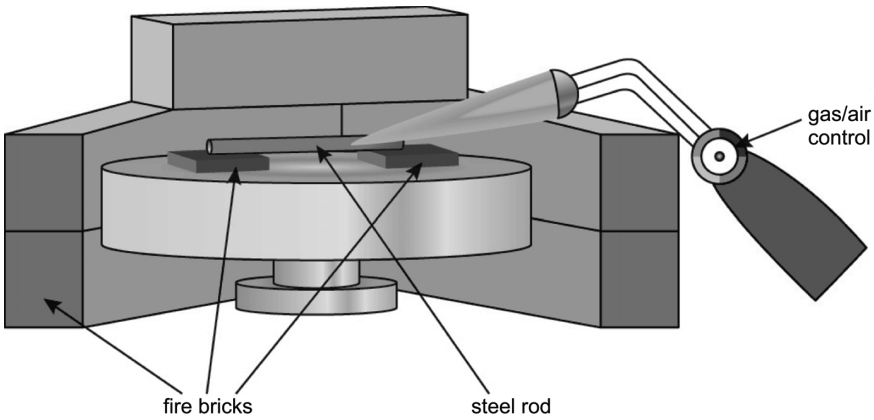
0.05 mm

7. Identify four steps in the process of case hardening, in sequence.
Draw a picture of each step, labelling the parts in each drawing. (8)

The four steps are:

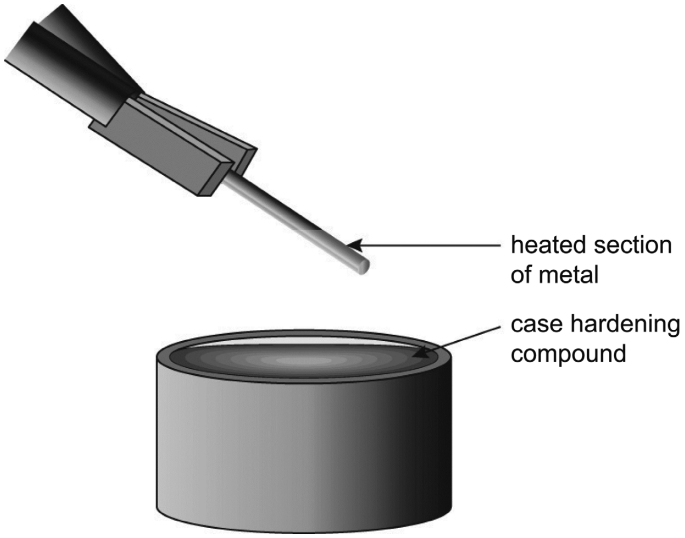
Step 1

Heat the metal (mild steel) to a red colour.



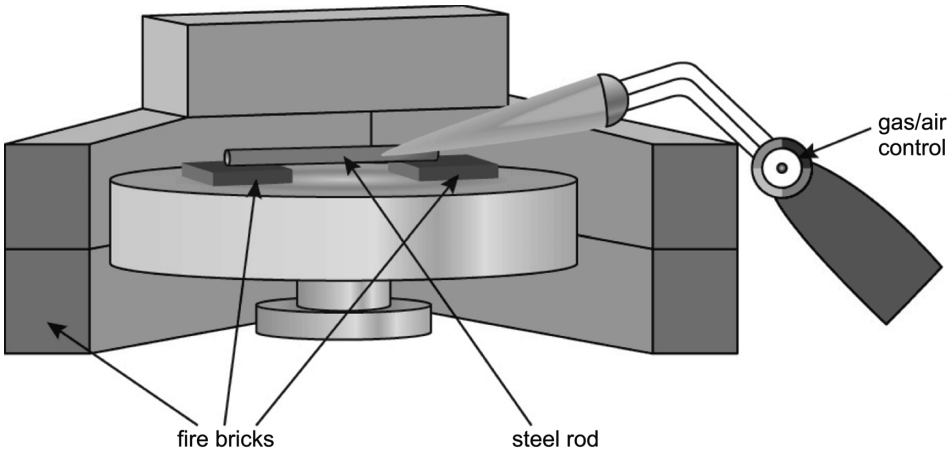
Step 2

Remove the metal from the heat and plunge it into a high carbon case hardening compound.



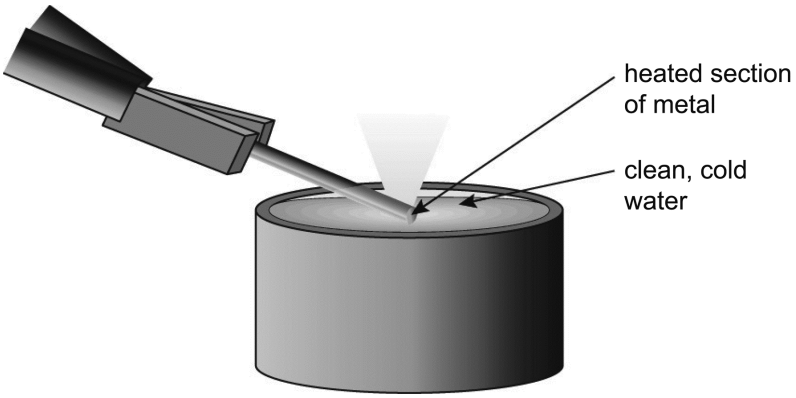
Step 3

Heat the metal again until it glows red.



Step 4

Remove the metal from the heat and plunge it into clean cold water.



Award 1 mark for each correct drawing and 1 mark for each correct description of a step.

Total: 26 marks

3.7 Preparation of materials

Learning objectives

By the end of this unit students should:

- be able to demonstrate knowledge of available market forms, types and sizes
- understand different methods of cutting
- understand the use of datum surfaces, lines and edges and know how to produce them
- be able to explain the preparation needed for machine processes and safe methods of securing materials to work surfaces.

Key terms

datum, market form, PAR (Planed All Round), perpendicular

Resources

Student Book pages 195–198
Activity sheet A (available online on Collins Connect)
A range of samples of market form materials; material and equipment required to create a datum surface
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.7.

A minimum of two one-hour lessons should be devoted to this unit; the actual number will depend on your circumstances and approach, and/or the level of your students' ability. There could be one introductory lesson and one or more follow-up lessons involving practical work or other activities.

Lesson starter suggestions

Identifying preparation equipment: Ask students to read pages 195–196 of the Student Book. Provide students with a range of resistant materials. Hold up a piece of cutting and shaping equipment (or a photo of one) and ask students to decide which resistant material would be best cut or shaped with it.

Interactive activity: Make sure students have read pages 195–198 of the Student Book before they do this activity.

Main lesson activities

What is market form?: This activity is designed to help students to understand the importance of market form. Provide students with a range of market form materials (metal, wood and plastic). Make sure there are no sharp or rough edges on the samples. Ask students to work in groups to discuss the advantages and disadvantages of using market form materials.

Tip: *Students could record their responses in a journal or blog to build a resource for reference and revision.*

Creating a datum surface: This activity is designed to develop students' ability to use setting and marking out tools to create a datum surface. Provide students with the materials and equipment required to create a datum surface: pine (or other soft wood), metal or plastic; a surface plate; (depending on the

material) a sharp pencil, scriber, marking knife or sliding bevel, permanent marker pen; a straight steel edge; a try square, marking gauge or engineers square; a plane (if creating a datum on wood) / file (if creating a datum on metal or plastic); equipment to secure the material safely; PPE equipment. Make sure there are no sharp or rough edges on the material samples. Also make sure that students are aware of the correct and safe use of all tools and equipment, including the use of vices, cramps, jigs and PPE before they do any practical work. Demonstrate the correct method of creating a datum surface. Then encourage students to create their own datum surface. Support and guide students as they work.

Safe methods of securing materials: Ask students to read page 197 of the Student Book (again). Ask them to explain why safe and secure methods of holding are necessary.

Knowledge check (page 198): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Skills activity (page 196): Students work in pairs or small groups to do the activity.

Tip: *Students could record their responses in a sketchbook or work journal. Encourage them to include thumb nail sketches to accompany their written notes.*

Define it: Print and cut out Activity sheet A, enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Team quiz: Put students in two teams. As quiz master, ask each team the following questions and record scores:

- *What are the benefits of having a good working knowledge of market form materials?* (You purchase the correct amount of material; it saves time. / Purchasing the correct amount of material helps to reduce waste.)
- *What are the potential consequences of poor preparation?* (injury to oneself or others; damage to equipment and/or the material)
- *How can you hold material securely while cutting or shaping?* (by using cramps, vices or jigs)
- *Name two pieces of PPE equipment you can use when you are cutting or shaping materials.* (ear defenders; goggles)

You could give a prize or reward to the winning team.

Answers to Student Book activities

Skills activity (page 196)

The tools you need to create a datum on a piece of timber are: a sharp pencil or marking knife, a suitable surface plate, a try square, a marking gauge and a wood plane.

Step 1: Ensure the surface on which you are working is completely level or flat. To do this, you can work on a surface plate.

Step 2: One of the edges of the timber will be the datum. Place the timber on the surface plate to make sure it is flat. Use the try square and marking gauge to mark the timber with a sharp pencil or marking knife to indicate where excess material needs to be removed in order to produce the flat datum edge. This will be the edge from which all measurements will be taken.

Step 3: Secure the timber firmly using a vice or cramp and take all the necessary safety precautions. Use the wood plane to carefully remove excess or unwanted material.

Step 4: Use the surface plate and try square to check that the edge is flat and can be used as the datum.

Knowledge check (page 198)

1. List two things you should wear to protect yourself when preparing or cutting materials. (2)

Possible answers: goggles, gloves, face mask, ear defenders, apron, overalls

Award 1 mark for each correct answer (to a maximum of 2).

2. Give two methods of holding material securely while cutting and shaping. (2)

Possible answers: cramps, vices, jigs

Award 1 mark for each answer (to a maximum of 2).

3. Give two potential consequences associated with poor preparation. (2)

Possible answers: damage to the material or equipment; personal injury; injury to others working in the vicinity

Award 1 mark for each answer (to a maximum of 2).

Total: 6 marks

3.8 Setting, measuring, marking out, testing

Learning objectives

By the end of this unit students should:

- understand the importance of accurate measurement
- understand setting, measuring, marking out and testing key terms
- be aware of the following tools and equipment: rule, pencil, marking knife, marker pen, scriber, try square, bevel, mitre square, centre square, dot/centre punch, dividers, inside/outside/odd-leg calipers, template, marking/cutting/mortise gauge
- be able to accurately produce datum lines
- understand why testing is important.

Key terms

marking out

Resources

Student Book pages 199–203
Activity sheet A (available online on Collins Connect)
Tools and equipment for setting, marking out and measuring, resistant material samples, e.g. MDF/chipboard, pine or other soft wood, oak or other hard wood, iron/steel, plastic;
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.8.

A minimum of two one-hour lessons should be devoted to this unit; the actual number will depend on your circumstances and approach, and/or the level of your students' ability. There could be one introductory lesson and one or more follow-up lessons involving practical work or other activities.

Lesson starter suggestions

Why are accurate measurements important? Ask students to read **Design in action** on page 199 of the Student Book to stimulate class discussion. Students then work in pairs to consider why accuracy is important. They could respond by giving an oral presentation.

Select it: This activity is designed to help students to select the correct items of equipment to set and mark out different types of lines and shapes on a variety of materials. Ask students to read page 201 of the Student Book. Provide them with a range of setting, marking out and measuring equipment: sharp pencil, marking knife, sliding bevel, permanent marker pen, straight steel edge, scriber, odd-leg calipers, try square, engineer's square, mitre square / combination square, dot/centre punch, centre square, pair of compasses, dividers, template, micrometer, inside and outside calipers, Vernier gauge and a digital Vernier calliper.

Hold up a resistant material sample, e.g. MDF/chipboard, pine or other soft wood, oak or other suitable hard wood, iron/steel, plastic. Ask students to hold up an appropriate piece of equipment that could be used to set, mark or measure it and explain their choice. Use photos if you do not want students to handle tools and equipment. Students can record their responses on Activity sheet A.

Main lesson activities

Interactive activity: Make sure students are familiar with page 201 of the Student Book before they do this activity.

Precision instruments for measurement: Source a range of precision measuring equipment. You could use photos if physical items are not available. Hold up each item/photo. Ask students to say what the specific use of each instrument is and state its advantages and disadvantages.

Tip: *Students could record their responses in a journal or blog to build a resource for reference and revision.*

Skills activity (page 203): Students work individually to do the activity.

Plenary suggestions

Class discussion: Use page 200 of the Student Book to support this activity. Students share their **Reflective log** outcomes with their peers.

Knowledge check (page 203): Students can complete this at the end of the unit or for homework.

Team quiz: Put students in two teams. As quiz master, ask each team the following questions and record scores:

- *Why are accurate measurements important?* (to ensure that individual parts of a product fit together properly; to help ensure a high quality outcome; to help save material wastage)
- *Why are instruments like calipers and micrometers used?* (to ensure absolute precision)
- *Which material would you use with an engineer's square?* (when marking out on a material like steel)
- *Which piece of equipment would you use to mark the centre of a hole?* (a dot punch and a centre punch)
- *What are odd-leg calipers used for?* (to mark out parallel lines)
- *What piece of equipment would you use to mark out a parallel line on timber?* (a marking gauge)
- *What is a template used for?* (to mark out an irregular shape)
- *What equipment is used to mark an angle of 45°?* (a mitre square or a combination square)
- *What is a centre square used for?* (to mark the centre of a round piece of material)
- *What equipment would you use to mark out a sharp straight line on metal?* (a straight steel edge and scriber)

You could give a prize or reward to the winning team.

Answers to Student Book activities

Skills activity (page 203)

The tools you need to mark out a straight line on a piece of mild steel are: a suitable surface plate, a straight steel edge, a scriber and an engineer's square. To mark out the centre of a round piece of material, you need a centre square. The centre of a hole requires a dot or centre punch. To mark out a parallel line, you use odd-leg calipers. To mark out arches and curves, you use dividers.

Step 1: Use a surface plate to ensure the surface on which you are working is completely level or flat.

Step 2: Place the mild steel on the surface plate to make sure it is flat, and take all measurements from the datum.

Step 3: Use an engineer's square and a straight steel edge to mark the mild steel using the scriber.

Knowledge check (page 203)

1. Explain why accurate measurement is important. (2)

Possible answers: to ensure high quality outcomes; to ensure the individual parts of a product fit together properly; to ensure aesthetic appeal; to ensure the product functions correctly and is fit for purpose

Award 1 mark for each correct answer (to a maximum of 2).

2. Give two methods of setting and marking out wood, and list the tools required. (2)

Possible answers: To produce a sharp, straight line, the tools required are a sharp pencil, a marking knife and a sliding bevel. To create a parallel line, the tool required is a marking gauge. To create a 45° angle, the tools required are a sharp pencil and a mitre or combination square.

Award 2 marks for each correct answer.

3. Give two methods of setting and marking out metal, and list the tools required. (2)

Possible answers: To produce a sharp straight line, the tools required are a straight steel edge and a scriber. To create a parallel line, the tool required is a pair of odd-leg calipers. To create a 90° angle, the tools required are an engineer's square and a scriber.

Award 2 marks for each correct answer.

4. Give two potential consequences of inaccurate measurement. (2)

Possible answers: wastage of material; poorly fitting parts that reduce the product's function; diminished aesthetic appeal

Award 1 mark for each correct answer (to a maximum of 2).

Total: 8 marks

3.9 Shaping

Learning objectives

By the end of this unit students should:

- understand common wastage and addition processes
- understand common deforming and reforming processes.

Key terms

addition, deforming, reforming, resistant material, wastage

Resources

Student Book pages 204–209
Activity sheets A–C (available online on Collins Connect)
Access to Collins Connect for Interactive activity
Access to videos and animations to illustrate making and manufacturing processes, e.g. www.sciencechannel.com/tv-shows/how-its-made/

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.9.

Students should have the opportunity to carry out design and make activities and focused practical activities using a range of materials and processes in order to learn how to use wastage, addition, deforming and reforming processes. The principles of shaping outlined in this section could be introduced at the beginning of the course, across one or two lessons, and revisited/reinforced when new materials and processes are introduced.

Lesson starter suggestions

Categorisation (1): Ask students to read pages 204–208 of the Student Book. Make sure they have understood the principles of wastage, addition, deforming and reforming. Put students in groups of four, and give each group a sample of sawn timber (wastage), a piece of plywood (addition), a vacuum formed or line bent plastic (deforming) and a cast metal or injection moulded plastic (reforming). Ask students to categorise the samples (wastage, addition, deforming or reforming) and explain why they have done so.

Categorisation (2): Put students in groups of four and ask them to find two pieces of equipment in the workshop that utilise wastage (e.g. saws, files), two that utilise addition (e.g. adhesive, screws), two that utilise deforming (e.g. a bag press for lamination, a vacuum former) and two that utilise reforming (e.g. metal casting equipment).

Main lesson activities

Microteach: Put students in groups of three or four and ask them to investigate a shaping process that cannot be replicated easily in the workshop, e.g. injection moulding. They should use the Student Book and the internet to prepare a five-minute presentation to their peers, describing the material and explaining the process.

Skills activity (page 209): Students could incorporate this activity into their design portfolio work as part of their analysis and evaluation of either alternative ideas or the final design. They should focus on the

methods that could be used to make the product in the proposed materials. Alternatively, use the activity as revision to review the products that students have designed and made during the course. Encourage students to think analytically about the making process that they have used throughout the course.

Plenary suggestions

Pros and cons: Print and hand out a copy of Activity sheet A to each pair of students. Provide each pair with a different item of equipment (include hand, machine and computer-based tools) and ask them to analyse the benefits and limitations of using the equipment in manufacture, e.g. the use of saws (wastage) is efficient and quick (benefit), but the waste material may not be reusable (limitation), whereas the use of 3D printing (addition) is expensive to set up (limitation), but only uses the material needed to model the desired shape (benefit). When students have finished, they can share their responses with the rest of the class.

Team quiz: Put students in two groups. As quiz master, ask questions and records scores. A prize or reward may be given to the winning team. See the Activity sheet B notes for questions.

Define it: Print and cut out Activity sheet C, enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Interactive activity: This activity will helps students to revise deforming and reforming processes.

Answers to Student Book activities

Skills activity (page 209)

Responses will vary.

Knowledge check (page 209)

1. Explain the differences between wastage, addition, deforming and reforming. (8)

- wastage: the process of cutting away material to leave the desired shape, for instance using saws, files and abrasives
- addition: the process of shaping material by combining or joining them, for instance by using screws, nails, nuts and bolts, and adhesives. Joining methods can be classified as temporary and permanent, with particular methods being used with different materials.
- deforming: the process of subjecting a material to stress that changes its shape. Methods include bending and the use of jigs and formers. Typically heat is applied to materials to bring them into their 'elastic' zone.
- reforming: the process of changing the shape of a material, typically by melting or pouring or injecting the molten material into a mould, for example when injection moulding plastics or sand casting non-ferrous metals

Award 2 marks for a correct description of each process.

2. Choose one example each for wood, metal, plastics and composite, and describe in detail a process using each of the four principles of shaping (wastage, addition, deforming and reforming). (4)

Possible answer: Injection moulding is a reforming process for thermoplastics.
First, clamp the plastic sheet in the vacuum-forming machine. (1)
Then heat the sheet to its plastic state. (1)
Next, blow air to stretch the plastic and raise it onto a platform (1).
Finally, evacuate the air from below the mould to form around the plastic (1).

This can be repeated for each material and process.

Total: 12 marks

3.10 Joining and assembly

Learning objectives

By the end of this unit students should:

- be able to define both permanent and temporary methods of joining materials and provide examples of both
- be able to use holding devices, jigs and formers to aid construction
- understand the process of soldering, brazing, welding, riveting / pop riveting
- understand methods of constructing artefacts using timber
- recognise the use of knock-down fittings for use with manufactured boards
- understand methods of carcase, stool and frame construction including different types of joints
- describe how screws, nails, nuts and bolts are specified and understand how different sizes are described and defined
- give examples of different types of adhesives and list their uses and limitations.

Key terms

permanent joining, temporary joining

Resources

Student Book pages 210–221
Activity sheets A–G (available online on Collins Connect)
A rivet snap and set, some rivets, small pre-drilled strips of metal; nails, screws, nuts, bolts, panel pins, machines screws, wood screws; a range of hinges
Access to Collins Connect for Interactive activity

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.10.

Given the volume of material in this unit, it is likely that it can be covered in two to three hours.

Lesson starter suggestions

Seating: Ask students to look at the chair, stool or bench they are sitting on. Then ask them to sketch the seat on a piece of paper and identify each joint between the components used to construct the seat. Get them to identify if the joints join two pieces of the same material (e.g. wood to wood, or metal to metal) of if they join dissimilar materials. If they know the name of the joint or joining process, they should record that also. As an extension, ask them if they think the joint is temporary or permanent. This could be extended to other objects in the room, e.g. tables, bookcases, tool cupboards or shelving units.

Main lesson activities

Interactive activity: Ask students to identify which items can be used to form permanent joints and which ones can be used to form temporary joints. The activity can be supplemented using appropriate products and visual stimuli from the room the students are working in. When students have completed the activity, ask them to define a permanent joint and a temporary joint. As an extension, ask them if they can think of any other temporary or permanent fasteners.

Jigs and holding devices: This activity will help to ensure that students appreciate the advantages and issues associated with using jigs and holding devices. Ask students to think of products they have manufactured, draw an illustration of one of these products and list the jigs and holding devices they used when making it. (Students tend to overlook the obvious holding devices, e.g. machine vices to hold components on a pillar drill, sash clamps, G and C clamps, and woodwork and engineer's vices.) They then discuss and record the advantages of using jigs and holding devices. (Possible responses: they provide a safe way of holding components in position while they are being joined; using a jig or work holding device is sometimes the only way to hold complex or delicate components securely; jigs and work holding devices allow easy repetition of a job, so it is easy to produce multiple identical assemblies or joints; they can speed up the process of joining materials and components, so saving time.)

Joining processes specific to metal: There are many processes that can be used to join metals together, but the ones that often cause confusion are the heat-based ones: brazing, soldering and welding. Go through the information on page 211 of the Student Book with students. Then print and hand out Activity sheet A, which will help them to understand the differences between the three heat-based joining processes. Ask them to work individually to answer the questions. You can refer to the Activity sheet A notes for the answers.

Riveting: Riveting is a process best understood by observation. If possible, a practical demonstration is the best way for students to understand how riveting works. You will need a rivet snap and set, some rivets and some small pre-drilled strips of metal to join. You could demonstrate pop-riveting at the same time (you do not need to be in a workshop to demonstrate this). If you do not have access to facilities, you could use online video resources to illustrate these processes; there are many available on YouTube. Once students have observed demonstrations of the process, print and hand out Activity sheets B and C and ask students to answer the questions to check their understanding of riveting and pop-riveting. You can refer to the Activity sheet B and C notes for the answers.

Joining parts to construct an artefact: By now, students should be familiar with a broad range of corner joints, as well as fixtures and fittings that allow components to be joined together to form artefacts. Print and hand out Activity sheet D. Ask students to identify suitable joints and explain why they think those joints are suitable for the purposes they have selected. You can refer to the Activity sheet D notes for the answers.

Tip: *Where possible, get students to make small samples of wood joints, especially if they are likely to replicate these in any manufacturing they will be undertaking in the future.*

Knock-down (KD) fittings: Make sure that students understand that KD fittings are used in order to aid mass production of so called 'flat pack' furniture. Explain that manufacturers try to minimise the number of parts in such items of furniture so as to reduce the costings associated with machining and manufacturing. It also means that they are able to use one type of fitting on many different types of furniture. Ask students to read about KD fittings on pages 214–216 of the Student Book. Then ask them to think of examples they are familiar with. If necessary, show them pictures from the internet, instruction books or catalogues, and discuss the advantages and disadvantages of each. The following table gives some examples that can be used as a starting point:

	Advantages	**Disadvantages**
wooden corner blocks	relatively cheap; can be manufactured from offcuts of material; easy to colour match product	can split if over-tightened or used over a period of time; really designed for one-off use; requires access with a screwdriver at a certain angle for assembly
plastic corner blocks	often used across a range of products that need two parts to be joined perpendicular to each other; lightweight; strong in a number of directions; can be reused and/or recycled	more costly than wooden corner blocks, often in a colour that does not match the base product (unless it is coated or painted); requires access with a screwdriver at a certain angle for assembly

	Advantages	Disadvantages
two-piece corner blocks	can be added to parts prior to final assembly, which enables easier access to close pieces; allows easy separation of joint and removal of one (or more) pieces	more costly than either of the other two corner block options; mixed materials so harder to recycle
scan fittings	components to be joined can have holes for fitting inserted using a single sized drill; withstand a lot of force; can be tightened or loosened after installation; possible to reuse parts	requires more preparation to components to be joined than other techniques; can be quite fiddly to install, dependent on the application; comparably expensive compared to other KD fittings; can leave obvious holes that may need concealing, depending on application
cam lock	easy to fit and install; very quick to use and make two parts secure; can be tightened or loosened after installation; possible to reuse parts	one of the stronger KD fittings; most expensive KD illustrated here (comparatively); requires precise alignment of two pieces to work; needs access with a screwdriver to tighten once in place; needs a large hole to locate in cam in one piece being joined, leaves obvious holes which must be hidden by design (or capped and concealed).

Tip: *Students could record the advantages and disadvantages in a table similar to the one above. As an extension, you could ask them to analyse a product in the room and explain how it could be assembled using KD fittings.*

Pre-manufactured components: The most common types of pre-manufactured component that students are likely to have encountered are nails, screws and nuts and bolts. Provide students with a range of such components (include nails, panel pins, nuts, bolts, machines screws and wood screws) and ask them to sort them. More able students will often sort different types of screws by head type (domed or countersunk) or by the screwdriver needed to install them (slotted, Philips, posidrive or even specialist types like star drive). You could also provide students with a range of hinges and ask them what the advantages and disadvantages of each type are. A good way to illustrate the difference between rebate and surface mounted hinges (and locks/fastenings) is to get students to analyse products found in the room or in the home. Alternatively, you could show students images from the internet.

Adhesives: It is essential to emphasise that using any kind of adhesive has a number of health and safety risks associated with it. These include fumes, allergic reactions, physical harm to the user (chemical burns), irreversible damage to the materials being joined, storage considerations and flammability. You should also stress that the adhesives used at school are safe providing the correct procedures for use, storage and handling are adhered to. Print and hand out Activity sheet E and ask students to record what the different adhesives can be used for. They can refer to the table on page 220 of the Student Book. As an extension, ask them to consider any product they have made that required the use of an adhesive, identify what they think the likely adhesive is and explain how it is used to bond two pieces of material together.

Tip: *If different adhesives are available, students could view the labels on the containers and identify the health and safety requirements specific to each type of adhesive. They could then add notes about them in the last column of the table in Activity sheet E.*

Skills activity (page 221): Students work individually to do the activity. Print and hand out Activity sheet F to scaffold the activity; this has a basic carcase design for students to work from.

Tip: *Students could be asked to do this activity more than once with different criteria for the end users, e.g. the first design could be flat pack furniture, the second could be for storing items in a garage and so on.*

Knowledge check (page 221): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Define it: Print out Activity sheet G, enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Answers to Student Book activities

Skills activity (page 221)

Responses will vary considerably but are likely to include a description along these lines:

The frame would be assembled using suitable corner joints. These include dowel joints, mortise and tenon joints and knock-down fittings (corner blocks or cam locks). The sides, top and bottom could be joined using cam locks, dowels and adhesive, or even panel pins and adhesive, depending on whether the assembly is to be considered permanent or temporary, and also on the thickness of the panels on the sides, top and bottom. The door frame is likely to be assembled using halving joints and adhesive in the corners; the front panel is likely to be affixed using panel pins and adhesive although it could be located in a rebated groove to keep it captive. The door itself would be fixed to the cupboard by means of hinges (at least two); these could be butt hinges or rebated hinges. Any suitable lock or catch could be applied as well as a handle.

Knowledge check (page 221)

1. Describe the differences between permanent and temporary fastenings. (2)

Permanent fastenings are designed to be difficult to disassemble. (1) Temporary fastenings are designed to join parts for a short, limited amount of time and/or to be easy to disassemble. (1)

2. What is the principal difference between welding and brazing? (2)

Welding involves melting the surfaces of the two pieces of material being welded together; as such it changes the shape and properties of each piece. A welding rod of some material (this differs depending on the type of welding process being used) is used to accelerate the process and provide a stronger joint. Brazing operates at a lower temperature and involves using only the brazing rod to stick the two pieces of material together. The original pieces of material (the parts) do not get deformed, the brazing rod melts and cools as a solid form joining the pieces together.

3. List three different types of corner joints that can be made from wood. Suggest two alternative KD fittings that could be used in their place. (5)

Possible answers: dovetail joint, comb joint, butt joint, lap joint, mitre joint, mortise and tenon joint

Award 1 mark for each correct joint (to a maximum of 3).

Possible answers: corner blocks (wood or plastic), cam lock, scan fittings

Award 1 mark for each correct KD fitting (to a maximum of 2).

4. What does the gauge of a screw represent? (1)

its thickness (the diameter of the threaded portion)

Total: 10 marks

3.11 Finishes

Learning objectives

By the end of this unit students should:

- understand what a finish is
- understand why finishes are important
- understand which type of finish to use
- understand how finishes are applied, both for one-off and industrial production methods.

Key terms

exterior, interior, preparation, self-finishing, smart finish, special finish, surface finish

Resources

Student Book pages 222–227
Activity sheets A–G (available online on Collins Connect)
Samples of various types of finishes; samples of products that illustrate the application of different types of finish
Access to Collins Connect for Interactive activity
Creative homework 3.11 (available online on Collins Connect)

Lesson ideas

The Student Book and Teacher resources have been designed to be used flexibly, either off-the-shelf in their printed format, or they can be easily adapted and customised by the teacher to better meet the needs of individual classes. In this unit, you will find an outline of lesson ideas and suggestions for learning activities for Unit 3.11.

A minimum of two one-hour lessons should be devoted to this unit; the actual number will depend on your circumstances and approach, and/or the level of your students' ability. There could be one introductory lesson and one or more follow-up lessons involving practical work or other activities.

Lesson starter suggestions

Identifying finishes: Focus students' attention on artefacts or products in the room and ask them to identify all the materials used in their construction. Then ask them to identify the type of finish applied and explain why it has been applied.

Tip: *Include examples of products that exhibit decay to illustrate the potential consequences of not applying a finish or applying it incorrectly. If circumstances allow, this activity could be conducted on a 'learning walk' around the grounds of your institution.*

Inside and out: This activity is designed to help students to understand the difference between interior and exterior finishes and their application. Ask students to read pages 222–227 of the Student Book. Then print and hand out Activity sheet A. Show students physical examples or images of products with interior and exterior finishes:

- products with interior finishes: kitchen equipment and utensils (e.g. kettles, pans, cutlery), seats, tables and other household furniture, including period and antique furniture
- products with exterior finishes: wooden fencing, tables, seats, garden ornaments, bird feeders, hanging baskets, planters, plastic plant pots, wrought iron garden furniture, statues, wheelie bins, boats, children's outdoor play equipment, vehicles, bicycles.

Ask students if the finish of the product is suitable or has been designed for either internal or external use. Initially, they should be able to tell just by looking at the product, but they will gradually develop understanding as they will have to think about why a finish is necessary. They can record their answers on the activity sheet. As an extension, ask students to choose a product and explain why they think the finish used on it was chosen and applied.

Define it: Print and cut out Activity sheet B, enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Main lesson activities

Types of finish: Make sure students have read pages 223–225 of the Student Book before they do this activity. Print and cut out Activity sheet C and hand a set of cards to each student or pair of students. You can remove any cards that you do not wish to include in the set. Place a range of products that have a range of finishes around the room. Then ask students to move around, placing the cards on the products. As an extension, students could add notes to describe or explain how the finish was applied.

Interactive activity: Make sure that students have read pages 223–225 of the Student Book before they do this activity.

Practical activity: This activity is designed to help students to explore a range of materials and types of finish. Print and hand out Activity sheet D. Then put students in small groups and ask them to apply a range of finishes to each material, making careful notes about the finish they have applied. They should record their ideas/answers on the activity sheet. Refer to the Activity sheet D notes for instructions about how to conduct the activity. As an extension, discuss students' findings and consider the impact of correct and incorrect usage of the finish.

Tip: *Student outcomes can be photographed and fixed into workbooks to build a resource for reference and revision.*

Health and Safety: Make sure students have read page 226 of the Student Book before they do this activity. Print and hand out Activity sheet E and ask students to create a step-by-step work plan for the safe use of their chosen finish. Emphasise to them that preparation is not just about ensuring the surface of the material they are applying a finish to is clean and free from dust; it also means thinking about themselves and the environment they are working in. It is vital that they adhere strictly to the manufacturer's instructions to ensure that the working environment is safe, and that PPE is used if necessary. Refer to the Activity sheet E notes for instructions about how to conduct the activity.

Skills activity (page 226): Students work individually to do the activity. They could refer to reference material in the room and/or do internet searches if necessary.

Knowledge check (page 226): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Class discussion: Students share their **Reflective log** outcomes with their peers.

Action quiz: This activity is designed to reinforce students' understanding. Put students in small groups and provide each group with a range of artefacts. Refer to the Activity sheet F for instructions about how to conduct the activity. Ask the questions and get students to point out or hold up an item that answers the question.

Team quiz: Put students in two teams. As quiz master, ask each team questions from the Activity sheet G notes and record scores. You could give a prize or reward to the winning team.

Creative homework: Students read the Creative homework and do the task.

Answers to Student Book activities

Skills activity (page 226)

Possible answer for a chair: The construction materials are plastic and metal. The chair body is injection moulded plastic and self-finishing to provide strength, durability and aesthetic appeal. The legs are galvanized tubular steel and their finish prevents corrosion.

Knowledge check (page 226)

1. Give four reasons a finish is applied. (4)

Possible answers: to protect the material from water, liquid, flame, fire or heat; to help make the materials stronger; to help make the material last longer by preventing corrosion (rust), mould or fungus growth; to help enhance the material's aesthetic appeal

Award 1 mark for each correct answer (to a maximum of 4).

2. Name a finish that can be applied to wood, and state how and why it is applied. (3)

Possible answers:

- finishes: varnish (interior and exterior), wax, French polish, wood stain or wood paint
- methods of application: brushes, rollers, soft clean cloth, spray
- reasons for application: to improve the visual appearance (French polish, varnish on furniture, coloured wood stain); to protect the materials from the elements

Award 1 mark for an appropriate finish, 1 mark for a correct method of application and 1 mark for a correct reason for application.

3. Give an industrial method of finishing metal. Give the type of metal and a reason why the finish is applied. (3)

Possible answers:

- industrial methods of finishing metal: galvanizing, anodizing, electroplating, plastic dip coating, powder coating
- types of metal: iron, steel, (specific to the process of anodisation) aluminium, titanium and magnesium
- reasons for application: to apply a protective rust resistant coating to help prevent corrosion; to add colour; to improve the product's visual aesthetic appeal

Award 1 mark for a correct industrial method, 1 mark for an appropriate type of metal and 1 mark for a correct reason for application.

4. Name one example of a self-finishing material and give one advantage. (2)

Possible answers:

- self-finishing material: injection moulded and shaped plastic
- advantage: an additional finish is not required, so manufacturing time and production costs are reduced

Award 1 mark for an appropriate self-finishing material and 1 mark for a correct type advantage.

Total: 12 marks