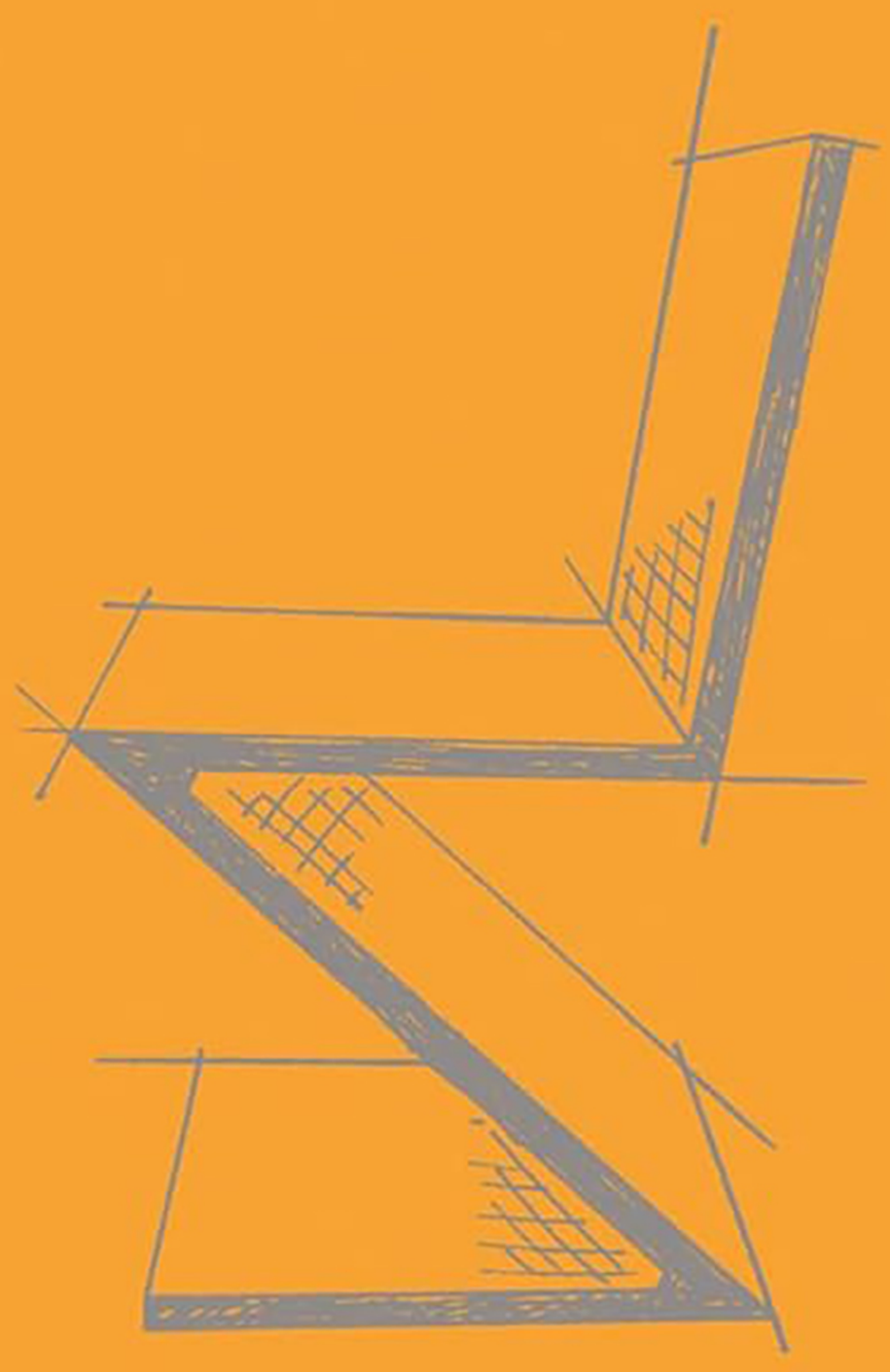
Collins

Cambridge IGCSE®

Design & Technology

TEACHER'S GUIDE

Also for Cambridge O Level



Stewart Ross, Dawne Bell, Justin Harris,
Chris Hughes, Matt McLain and David Wooff

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Contents

Introduction 4

Section 1

Product Design 6

1.1 Getting started 6
1.1.1 Observing a need 6
1.1.2 Design brief and specification 8
1.1.3 Research 10
1.1.4 Initiating and developing ideas, and recording data 12

1.2 Design ideas and techniques 14
1.2.1 Generating possible ideas 14
1.2.2 Use of media for mock-ups 16
1.2.3 Generation of possible ideas 19
1.2.4 Communicating design ideas 21

1.3 Making 23
1.3.1 Selection and organisation 23
1.3.2 Implementation and realisation 26

1.4 Evaluation 29
1.4.1 Evaluation in design 29

1.5 Health and safety 32
1.5.1 Safety for all 32

1.6 Use of technology 35
1.6.1 Use of technology in designing and making 35
1.6.2 Systems 38

1.7 Design & Technology in society 41
1.7.1 Design in society 41

1.8 Product design application 44
1.8.1 Meeting the needs of users 44
1.8.2 Considering production manufacturing 46
1.8.3 Design ideas 48
1.8.4 Identifying constraints 50
1.8.5 Evaluating against the specification 52
1.8.6 Understanding the relevance of function 54
1.8.7 Aesthetics 56
1.8.8 Style and design movements 58
1.8.9 Using models to test proposals 60
1.8.10 Modelling 62

1.9 Environment and sustainability 64
1.9.1 Forms of energy 64

Section 2

Graphic Products 68

2.1 Formal drawing techniques 68
2.2 Sectional views, exploded drawings and assembly drawings 71
2.3 Freehand drawing 74
2.4 Drawing basic shapes 76
2.5 Developments 78
2.6 Enlarging and reducing 81
2.7 Instruments and drafting aids 84
2.8 Layout and planning 86
2.9 Presentation 90
2.10 Data graphics 93
2.11 Reprographics 97
2.12 Materials and modelling 99
2.13 ICT 102
2.14 Manufacture of graphic products 104

Section 3

Resistant Materials 107

3.1 Types of materials 107
3.2 Smart and modern materials 110
3.3 Plastics 112
3.4 Wood 115
3.5 Composites 119
3.6 Metals 121
3.7 Preparation of materials 126
3.8 Setting, measuring, marking out, testing 129
3.9 Shaping 132
3.10 Joining and assembly 134
3.11 Finishes 138

Section 4

Systems and Control 141

4.1 Systems 141

4.2 Structures 144

4.2.1 Basic concepts 144
4.2.2 Types of frame structure members 147
4.2.3 Strengthening frame structures 150
4.2.4 Nature of structural members 152
4.2.5 Applied loads and reactions 154
4.2.6 Moments 156
4.2.7 Materials 158
4.2.8 Testing 159
4.2.9 Joints in structures 161
4.2.10 Forces 162

4.3 Mechanisms 164

4.3.1 Basic concepts 164
4.3.2 Conversion of motion 167
4.3.3 Transmission of motion 170
4.3.4 Energy 174
4.3.5 Bearings and lubrication 176

4.4 Electronics 177

4.4.1 Basic concepts 177
4.4.2 Circuit building techniques 180
4.4.3 Switches 182
4.4.4 Resistors 184
4.4.5 Transistors 187
4.4.6 Diodes 189
4.4.7 Transducers 191
4.4.8 Capacitors 193
4.4.9 Time delay circuits 195
4.4.10 Logic gates and operational amplifiers 198

Section 5

The Project (Component 2) 201

Using this resource to teach O Levels 205

Scheme of work 209

Introduction

Welcome to the *Collins Cambridge IGCSE® Design & Technology Teacher's Guide*, which has been devised and written by experienced authors and teachers to help you to deliver an effective and successful IGCSE course that covers not only the core Common content (Product Design), but also the Specialist option content: Graphic Products, Resistant Materials and Systems and Control. It also includes guidance on preparing your students for the project (Component 2).

The teacher resources are made up of two components – this **Teacher's Guide** and the material on the Collins online learning platform, **Collins Connect**.

This suite of resources has been designed to be used flexibly, either off-the-shelf in its printed format or adapted by the teacher to better meet the needs of individual classes. Lesson ideas and support material utilise a wide range of pedagogical approaches and are intended to support the teacher's individual approach in the effective delivery of high quality, innovative lessons that meet individual learning needs and engage students' interest. Used in conjunction – fully or in part – with the resources available, the materials in the Teacher's Guide (and online at Collins Connect) can be used to introduce a new topic, to support learning over a period of time, or as a re-cap tool to aid revision.

Overview

Teacher's Guide

Every unit of this **Teacher's Guide** provides ideas to support lesson planning and delivery. It includes:

- **Lesson plans** mapped against the **Cambridge syllabus**, with clear **Learning objectives**, **Key terms** and a list of **resources** (e.g. relevant pages in the Student Book, Activity sheets, Interactive activities and suggested products, tools or materials for students to handle)
- **Lesson starter, Main lesson** and **Plenary activity ideas** designed to support differentiation, address individual learning needs and engage students' interest
- **Ideas for practical activities** and teacher demonstrations that can be safely planned and executed, and that help students to embed their knowledge
- **Ideas for discussion** to stimulate students' interest and understanding of key concepts
- **Skills activity** guidance to support outcomes from the Student Book, with sample answers
- **Knowledge check** answers to all of the exam-style practice questions in the Student Book

Collins Connect online content

The **online content** on Collins Connect offers the full Student Book for front-of-class access or for students to refer to at home. There is also a 'Teacher Only' section where the Activity sheets and notes referred to in the Teacher's Guide are available to download. The Activity sheets and notes are provided in editable and printable Microsoft Word format, so that you can tailor lesson ideas and activities to meet the individual needs of your students. The Activity sheets and notes are located within each of the main sections (Product Design, Graphic Products etc.) so that you can quickly and easily find the material you need and prepare for your lessons. The Collins Connect online content includes:

For teachers to download

- **editable Activity sheets** for use by students
- **editable Activity sheet notes** (where necessary, these include **technical notes** with equipment lists, resources and information to support the safe execution of practical activities)

For teachers and students to access

- **the full Student Book** for teachers to project at the front of class or for students to access outside the classroom and at home to support independent study
- **Interactive activities** and **Creative homework activities** designed to support students' development both within and beyond taught lessons

Lesson plans

Each unit of the Student Book is introduced sequentially in the Teacher's Guide. The lesson plans have been designed to mirror the Student Book to ensure easy cross-referencing and are supported by **Activity sheets** and **Activity sheet notes**.

Activity sheets and Activity sheet notes

The **Activity sheets** have been designed to support students' learning. Each activity has been tried and tested and there are instructions on how to use the Activity sheets within the lesson plans. For the more complex Activity sheets, there are instructions and answers in Activity sheet notes. Those Activity sheets that feature practical work have step-by-step guidance to ensure that students carry out their investigations safely and successfully. Where necessary, **technical notes** list the resources required for practical activities and/or demonstrations. To ensure compliance with current **Health and Safety Information**, please always refer to the appropriate legislation and your employer's Health and Safety guidelines. You are strongly advised to try out a practical activity in advance of a lesson in order to ensure that all aspects have been considered.

All Activity sheets are available in editable and printable Microsoft Word format via Collins Connect.

Using this resource to teach O Levels

This Teacher's Guide includes information on using this resource to teach Cambridge Assessment International Education O Level Design & Technology (6043) and O Level CDT: Design & Communication (7048).

Scheme of work

There is a detailed **Scheme of work** that provides a comprehensive overview of the Cambridge IGCSE course. This includes the learning outcomes for each unit, provides a summary of resources required and lists the materials available on Collins Connect to accompany each topic.

Student Book features

The Student Book has been written to provide students with a thorough grounding in Design & Technology. It is a huge subject that requires students to grasp both practical and theoretical concepts of which they may have little prior knowledge. It has been designed with the needs of learners of **English as an Additional Language (EAL)** or **English as a Second Language (ESL)** in mind. As experienced international teachers, we know how important it is to make resources accessible to all students.

The Student Book includes the following useful features:

- **Design in action** boxes contain case studies showing the ideas students are learning about in a real-life context. It is not necessary for students to learn the content of these boxes as it does not form part of the syllabus. However, these case studies do provide inspiring examples of design in action.
- **Top tips** provide students with practical advice on how to develop key skills. They also help students to recognise misconceptions and prevent them from making simple, common errors. It is a good idea to focus students' attention on them and ensure that they have understood them.
- **Reflective logs** provide a scaffold within which students can consider and reflect upon aspects of their own work and consider whether there is anything they should do differently or re-visit.
- **Key terms** boxes include simple definitions of technical or difficult terms.
- **Skills activities** are open tasks that help students to develop key skills.
- **Knowledge checks** are exam-style practice questions that check students have understood and learnt the main concepts being taught in a particular topic.

We hope you enjoy using the *Collins Cambridge IGCSE® Design & Technology Teacher's Guide* and online resources as much as we have enjoyed developing them. Our aim was to create a high quality resource that would save you time and help you to prepare lessons that your students will understand and enjoy. It is our sincerest hope that we have achieved those aims.

1.1 Getting started

1.1.1 Observing a need

Learning objectives

By the end of this unit students should:

- understand a design need or situation
- understand the importance of having a client.

Key terms

client, design brief, design process, end user, feedback, life cycle, outcome, sustainability, target market, user group

Resources

Student Book pages 8–10
Activity sheets A–B (available online on Collins Connect)
Access to Collins Connect for Interactive activity

Product design overview

Ideally, the theoretical content for this section should be integrated alongside the practical aspects of the Student Project (Paper 5). This will allow the content to be learnt and consolidated through practical tasks that are relevant to each student's own direction in the project. The material and activities in the **Product Design** section are best used at your discretion, when and where required, as students progress through the course, rather than be taught in a linear fashion. In addition, it is recommended that you use some of the material from the **Graphic Products**, **Resistant Materials** and **Systems and Control** sections even if students are not studying these options. Relevant units from these sections are pointed out in this Teacher's Guide when appropriate. It is also worth noting that many activities in the **Product Design** section require students to look at and interact with a range of different products. This is good practice in general and it is worth sourcing a good body of different types of products to use when required as a handling collection. Previous student work should also be kept whenever possible to be used for activities.

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 1.1.1.

This unit is designed to offer students the tools for observing a need. Students can find this difficult to do, so a minimum of three one-hour lessons should be allowed for students to plan, observe a genuine need and record their findings.

Lesson starter suggestions

What is product design? Write this question on the board for students to discuss; it makes for a good introduction to this unit. Feed back as a class and record any good words or terms that arise, in particular the key terms for this unit. You could also get students to read the introduction to **Product Design** on page 6 of the Student Book.

Main lesson activities

Skills activity (page 10): Ask students to look at the photo on page 10 of the Student Book and discuss the questions with a partner. Feed back as a class.

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.

Tip: *This activity could also be used as a plenary.*

Brainstorm: This activity will get students thinking about what area they could investigate for their project. In pairs, students discuss what they do in their daily lives, including weekends and leisure time. Encourage them to discuss interests and hobbies as well as daily activities involving school. Then ask them to brainstorm these different activities and consider the key people involved in each and any equipment involved.

Methods for collecting feedback: Ask students to read pages 8–9 of the Student Book. Make sure they understand the terms *client*, *feedback* and *user group*. Ask them to choose one of the activities they are particularly interested in from the brainstorm session and identify the potential user group and/or client (these may be one and the same). Print and hand out Activity sheet A. Students consider the table headings and develop a plan for observing and identifying a need. In the Activity sheet A notes, there is an example that you could discuss with students before they do the activity.

Tip: *This activity includes key terms from later in the Products Design section, e.g. 'user trial', 'field test', 'focus group' and 'questionnaire'. You could check students' understanding of these terms before they complete the table.*

Observing a need: Students will need time to collect evidence of a need, so allow them to try some of the methods they outlined in the previous activity. They may want to create and issue a questionnaire, organise a focus group, bring in a product or piece of packaging to disassemble, interview a user group or perform an activity and record findings.

Tip: *Encourage students to record everything they do in this unit. Photographing evidence of tasks being performed is important for future reference.*

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.

Charades: Students take turns to mime an activity. The rest of the class guess the activity and state the user group.

Tip: *This activity could be done as a whole class or in groups.*

Answers to Student Book activities

Skills activity (page 10)

Responses will vary. Possible answers:

What is the problem? Wires and cables get mixed up and tangled.

Why do we have this problem? People have wires and cables for different appliances.

Who does the problem involve? People who own many different electrical appliances.

How can I make it better? Design a storage or labelling system for wires and cables. Redesign appliances so that they do not need cables or wires.

1.1 Getting started

1.1.2 Design brief and specification

Learning objectives

By the end of this unit students should:

- understand the importance of a design brief and what it should include
- be able to analyse the brief to fully understand what they need to do.

Key terms

constraint, research, specification

Resources

Student Book pages 11–13
Activity sheets A–B (available online on Collins Connect)
Selection of commercially made products or projects previously made by students
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 1.1.2.

Normally, the brief and specification for a product are written after a need has been observed and identified and some research has been undertaken. The specification should be used to inform design ideas and to evaluate ideas. Therefore, this unit is best delivered before students begin designing for their project. Two discrete lessons are required for this topic: one for developing a brief, and one for the specification. Encourage students to develop and refine their brief and specification as they collect data and their project progresses.

Lesson starter suggestions

Introducing the brief: Refer students to pages 11–12 of the Student Book and ask them to read the example brief. In groups or in pairs, students should conduct a ‘P’s analysis on the brief using the guidelines on pages 11–12. They can guess any points that are not in the brief. This activity should be followed by the Main lesson activity ‘Writing a brief’.

Introducing the specification: Use page 12 of the Student Book to introduce the concept of the specification. Stress to students that the points listed are there for guidance and that a specification normally contains only the most relevant specification points for the product. Provide a selection of products or past projects and allow groups of students to choose one. Ask them to refer to the list of specification points on page 12 of the Student Book and ask them to note down which points would be relevant and which would not be relevant to the product they have chosen. For example, relevant points for a desk lamp would include: where the product may be used, the user group, aesthetics, safety, mass/height, materials, packaging, costs, shelf-life and standards. Feed back as a class and ask students to explain why they chose some specification points and disregarded others.

Main lesson activities

Writing a brief: Refer students to the 'P's on pages 11–12 of the Student Book and ask them to write or type a brief for the product they are going to make. You may wish to have students peer review and give feedback on each other's briefs.

Bad spec: Explain to students that a good specification contains specific points, such as function, materials, sizes, anthropometric data and styles. Put students in pairs. Print and hand out Activity sheet A to each pair. Ask students to read the specification and discuss why it is not good. They have to rewrite the specification in the table with some more specific and quantifiable specification points. You can refer to the Activity sheet A notes for a guide to possible answers. It would be worth sharing this with the students.

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.

Writing a specification: Refer students to the 'P's on page 12 of the Student Book and ask them to use the list of specification points to support the activity. Students should consider their design brief and discuss in pairs which specification points are most relevant for the product they intend to make. They can then write an initial specification.

Tip: *Stress to students that a specification is just that: specific. Encourage them to revisit their specification at a later stage after research such as materials testing and user trials has been conducted, and add specific data to refine and improve their specification.*

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.

Eye spy: This plenary works well in groups or as a whole class. Ask one student to identify an object in the room and describe the product using specification points. The rest of the group or class have to guess what the object is. Whoever guesses correctly can choose the next object. Encourage students to phrase sentences as they would in the specification, e.g. *The product must/should/will ….*

Tip: *You could ask the students to use the ACCESS FM or CAFÉ QUE acronyms as a model.*

1.1 Getting started

1.1.3 Research

Learning objectives

By the end of this unit students should:

- be able to put together a research plan
- be able to identify different research methods
- be able to identify constraints imposed by knowledge, resources and external sources
- be able to gather, order and assess information relevant to the solution
- be able to produce and interpret data (for example, diagrams, flow charts, tests, graphs, test results).

Key terms

anthropometrics data, brainstorming, finish, primary research, qualitative data, quantitative data, secondary research, surveys

Resources

Student Book pages 14–17
Activity sheet A (available online on Collins Connect)
A3 paper, marker pens
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 1.1.3.

Research is important in design, and students should be aware that research needs to be carried out at all stages of the design process. Two lessons should be devoted to this unit: one to learn about types of research and produce a research plan, and one for product analysis. However, students should continue to identify, conduct and analyse appropriate research throughout their project.

Lesson starter suggestions

Types of research: In groups, students discuss any research they have completed so far in the course, including user trials, product analysis, disassembly, focus groups, brainstorming, surveys, interviews, observations and questionnaires. Feed back as a class and write students' ideas on the board. Ask them to discuss any other types of research that are useful for a designer and write these on the board too.

Main lesson activities

Categories of research: Ask students to read pages 14–15 of the Student Book. Then put students in groups and hand out a piece of A3 paper and marker pens to each group. Ask students to divide the page into four quadrants and title each quadrant: 'primary', 'secondary', 'quantitative' and 'qualitative'. Then ask them to write the types of research noted on the board and on page 15 of the Student Book in the correct category on their sheet of paper. Feed back results as a class.

Tip: *Some research fit into more than one category, e.g. product analysis could be primary, secondary, quantitative or qualitative, depending on the method undertaken.*

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.

Research plan: Students look at the research plan on page 15 of the Student Book, which identifies the type of research tasks a designer may carry out, and why and how these tasks may be performed. Ask students to draw a table with the same headings and complete this for the research they feel is useful for their own project. Encourage them to identify a good mix of research types. A group discussion before this task may help students.

Existing product analysis: Provide a range of products or ask students to bring in products that are related to the project they are undertaking. Refer students to the headings on page 16 of the Student Book and ask them to use sketches, notes and photography to analyse the product under the headings. Give them time to present their findings and refer them to the example of student work on page 17.

Tip: *Encourage students to disassemble the product. Provide them with tools such as screwdrivers to do so, but remember to allow time for reassembly afterwards.*

Plenary suggestions

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.

Research in other subjects: Ask students to consider the other subjects they study. Ask them to discuss and note down the types of research they have conducted in these subjects. Feed back as a class. Are any of these types of research useful in design and technology?

Research in our lives: Ask students to discuss what research they have done in the past week that has no relation to school or study, e.g. using YouTube to find out how to play a video game, sourcing a bus or train timetable, looking up reviews about a film, reading about a new band, researching holiday destinations on the internet or reading a manual to find out how to operate an appliance. Feed back and ask them if this research was quantitative or qualitative, primary or secondary.

Knowledge check (page 17): Students can complete this at the end of the unit or for homework.

Answers to Student Book activities

Knowledge check (page 17)

Young people often carry items in their bags when they go to school and walk to their classrooms.

1. List four functions a designer must consider for his product. (4)

What does the carrying system need to contain?

How will it be carried?

Are there any special features?

Where will it be stored when not in use?

Do not accept 'Who will use it?' This is not a function.

2. List six types of research the designer could carry out to fully understand the problem. (6)

Possible answers: user trial; survey of user group; focus group; interview with user group; observation of people using existing solutions; product analysis of existing solutions; disassembly of an existing solution; anthropometric data of shoulder width / back length or strength of user; research into standard components used for opening and closing; internet search for popular products; materials testing; dimensions of products likely to be carried; mass of books likely to be carried

Award 1 mark for each answer (to a maximum of 6).

Total: 10 marks

1.1 Getting started

1.1.4 Initiating and developing ideas, and recording data

Learning objectives

By the end of this unit students should:

- be able to extract relevant information from sources, interpret and record information and data.

Resources

Student Book pages 18–19
Activity sheet A (available online on Collins Connect)
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 1.1.4.

When students have completed a good range of initial research, they are expected to be able to analyse the data and interpret it. One lesson is sufficient to deliver this unit.

Lesson starter suggestions

Types of research: Ask students to list as many types of research from Unit 1.1.3 as they can remember.

Methods of presenting data: Ask students to consider the subjects they study at school and list the different ways they present data. Feed back as a class and encourage specific answers, e.g. bar charts, line graphs, pie charts, scatter graphs, tables and histograms.

Main lesson activities

Skills activity (page 19): Students look at the diagram and work in pairs or in groups to add to it.

Data analysis and interpretation: Ask students to read page 18 of the Student Book. Print and hand out one copy of Activity sheet A to each pair of students. Then ask students to cut out the boxes, read the design scenario at the top of the activity sheet and discuss the types of research undertaken. They have to consider which information is relevant and which is irrelevant, and record this in a table. Feed back as a class. You can refer to the Activity sheet A notes for possible answers.

Tip: *As an extension, students could consider how to present the relevant information.*

Presenting data: Unit 2.10 has some useful information and activities that students can complete to improve their awareness on how to present the data they have collected.

Presenting data: Give students time to analyse and present their findings from Unit 1.1.3. They should select an appropriate method for presenting data. A good page would include plenty of photographic evidence, data in tables or charts, and key transcripts from focus groups or interviews.

Tip: *This activity could be given for homework.*

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.

Plenary suggestions

Google it: An internet search can be useful, but only if used properly. Show students a product and ask them to phrase a search term under the headings of ‘aesthetics’, ‘environmental issues’ and ‘materials’ that would yield important information for the designer.

Answers to Student Book activities

Skills activity (page 19)

Accept any additional relevant information.

1.2 Design ideas and techniques

1.2.1 Generating possible ideas

Learning objectives

By the end of this unit students should:

- be able to generate and record a range of design ideas
- be able to identify what resources are needed to solve problems.

Key terms

dimensions, orthographic projection, rendering, scale

Resources

Student Book pages 20–25
Activity sheets A–B (available online on Collins Connect)
Blank A4 or A3 paper; paper or card, tape or adhesives for sketch modelling; pencils, fine liners, markers for sketching
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 1.2.1.

At least two lessons should be devoted to this unit to allow students enough time to generate ideas through sketching and modelling. You could also refer to Unit 1.8.3, where there are more ideas and activities for generating design ideas.

Lesson starter suggestions

Random shapes: This activity introduces the topic. When generating ideas, designers start with the overall shape or form of the item they are designing. Ask students to let their pencils ‘do the walking’ and draw random lines on paper. Pick out interesting shapes that could form the basis for a design.

Main lesson activities

Skills activity (page 22): Display or print and hand out Activity sheet A, which has images of products. Ask students to choose a product, or assign a product to each student or group of students. Ask them to refer to the SCAMPER technique on page 21 of the Student Book. Working individually or in groups, students sketch a redesign of the product on blank paper using the SCAMPER technique.

Tip: *This is potentially a lengthy activity, so you may want to assign one or two aspects of SCAMPER to each group of students. In addition, setting a time limit for ideas would be a good idea.*

Moodboard: You could devote some class time for students to compile a moodboard. Alternatively, this can be set for homework. Provide resources for compiling a moodboard, e.g. books, magazines, flyers or leaflets, and students could also do an internet search.

Tip: *Encourage students not to include too many images of examples of their intended product. This can lead to ‘fixation’, a preconceived idea of what a product should look like. Instead, a moodboard should be themed and could include a mix of things like patterns, colours, nature, design movements, architecture, target market interests and typography. Moodboards with a cultural or nature focus are particularly effective.*

Freehand sketches: Use pages 22–23 of the Student Book to introduce freehand sketching. Students can use the random shapes they drew in the starter activity and the SCAMPER technique to generate 3D ideas for their project on paper or in a sketchbook. Explain that at this stage quality of drawing is not as important as ideas and creativity. However, you may want to introduce the concept of rendering.

Tip: *Some students draw too large, which slows the thinking process. Encourage them to sketch ideas quickly and small.*

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.

Skills activity (page 25): Students work individually, in pairs or in small groups to do the activity.

Tip: *This activity could be given for homework.*

Modelling: Use page 24 of the Student Book to introduce modelling. Provide some simple modelling materials such as card or paper and adhesives. Give students time to sketch model some of their ideas, which will help them to begin visualising their ideas in three dimensions.

Tip: *Encourage students to keep the size of models small. Scale is not important at this early stage.*

Tip: *Encourage students to make photographic records of all models, even at this early stage.*

Knowledge check (page 25): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Peer evaluation: Ask students to swap the sketches they made in the 'Modelling' activity and note down two aspects that are effective and one possible improvement for one selected idea.

Self evaluation: Students can begin evaluating their ideas against the specification they wrote when they did Unit 1.1.2. These should just entail simple annotations next to their sketches indicating how their designs do or do not meet some of these specification points.

Define it: Print enough copies of Activity sheet B for each student or pair of students and cut them out. 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 22)

Responses will vary, but praise good ideas and creativity.

Skills activity (page 25)

Responses may or may not include a design of the logo, but they should include annotated sketches of merchandising or advertising, such as clothing, pencil cases, posters and flyers.

Knowledge check (page 25)

1. Name three techniques to help you generate ideas. (3)

Possible answers: moodboards, random shapes, freehand sketches, modelling, SCAMPER

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

2. Explain why it is important to record and keep the ideas you generate. (5)

Possible answers: for reference at a later stage; for use in portfolios as evidence in coursework

Award 4–5 marks for a good detailed answer that includes an explanation of both points.

Award 3 marks for an answer that explains one of the points.

Award 2 marks for identifying two reasons. Award 1 mark for identifying one reason.

Total: 8 marks

1.2 Design ideas and techniques

1.2.2 Use of media for mock-ups

Learning objectives

By the end of this unit students should:

- be able to use a variety of media and equipment to produce models and mock-ups as a means of testing a solution.

Key terms

life-size model, polymorph, scale model, sketch model *or* mock-up

Resources

Student Book pages 26–29
Activity sheets A–B (available online on Collins Connect)
A range of modelling materials (refer to page 26 of the Student Book); appropriate modelling tools and adhesives (refer to page 27 of the Student Book); A5 paper, tape and scissors
Access to Collins Connect for Interactive activity
Creative homework 1.2.2 (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 1.2.2.

Modelling ideas takes time, so several lessons should be devoted to this unit. The actual number is at your discretion. If students have limited experience of modelling or using modelling materials, consider devoting time for students to 'play': experiment with materials and processes, and model ideas and test them over the course of this unit. You could also refer students to Unit 1.8.10 for more information on modelling.

Lesson starter suggestions

Class discussion: Why model? This is a good question to ask students to discuss. Feed back as a class and look for answers such as visualising ideas in three dimensions, presenting ideas to others and testing or evaluating ideas.

Discussion and note-taking: This activity introduces the unit. In groups, students discuss materials that can be used for making models. They can then work individually to make a list of as many modelling materials as they can. At this stage, you could introduce the terms *sketch model* or *mock-up*. Feed back as a class.

Identifying materials: Provide groups of students with bags of various modelling materials. Then ask them to try to identify as many of the materials as possible. Refer to page 26 of the Student Book for ideas on what you can include, although this will depend on the availability of resources.

Tip: *For a bit more fun, provide the materials in an opaque bag. Ask students to identify the materials through touch only.*

Main lesson activities

Materials and equipment: Ask students to read about mock-ups, materials and equipment on page 26 of the Student Book and take notes.

Skills activity (page 29): Students work individually, in pairs or in small groups to build a chair using A5 paper, tape and scissors. You could discuss the appropriateness of the material for modelling a chair and ask students for ideas on alternatives.

Tip: *Turn the activity into a competition. Set a time limit and have students practise their evaluation skills by rating each of the chairs on aesthetics and performance. A small doll, scaled ergonome or toy can be used to test structure.*

Materials and adhesives enquiry: It is always a good idea to allow students time during a lesson for 'play' before they begin modelling ideas. Give them time to experiment with materials and equipment without any pressure to produce a finished product or working model. This will build their confidence in using equipment and is an excellent way for them to begin to understand modelling material properties. For some ideas on 'play' activities for students, you can refer to the lesson plan for Unit 2.12.

Tip: *It is important to demonstrate proper use of modelling materials. Depending on your resources, demonstrate safe, accurate and proper use of craft knives, saws, adhesives (including tape), hot wire cutters, thermoforming equipment, etc.*

Modelling ideas: Give students time to model ideas for their project. These models should be a progression of their ideas from Unit 1.2.1. To allow enough time for students to model several ideas, this activity should take place over the course of several lessons. Encourage students to test their designs throughout the process.

Tip: *Encourage students to make and keep photographic records of all models and testing.*

Evaluating and testing: It is important that students understand that evaluation and testing should occur throughout the design process, not just at the end. It may be useful to introduce them to some evaluation and testing techniques from Unit 1.4 during the modelling phase.

CAD modelling: Students can use 3D CAD to visualise designs alongside physical modelling. SketchUp is a free and accessible software tool that can be used to produce quick CAD models. Allow students access to this software in class or at home to model some of their ideas. There are tutorials on how to use the software online.

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.

Knowledge check (page 29): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Evaluation against specification: Print and hand out Activity sheet A. Refer students to page 27 of the Student Book for guidance on how to complete the five points of the star diagrams with specification points from their specification (e.g. aesthetics, safety, performance). They then rate each model they have created for each of the criteria to create star diagrams for each design. These can be included next to photographs of models in their portfolio.

Tip: *This activity could also be used as a peer evaluation.*

Tip: *Issue a digital copy if students are creating a digital portfolio. They can use tools in the software to create the star diagram and paste this into their portfolio.*

Other design considerations: Topic theory is learnt and consolidated more effectively when taught alongside practical tasks. It is good practice to have students consider wider issues while designing. In the middle or at the end of a practical lesson, ask students to consider one of the following aspects:

- Safety: Is their design safe? Does it contain small parts or toxic materials? Have they followed health and safety guidelines during production in the lesson? Are there any standards that need to be met for this product?
- Environment and sustainability: What materials could be chosen for the design that minimise impact on the environment? Can the design be disassembled so that each material can be recycled?

What would happen if the design were disposed of? Could the design be flat-packed for efficient transportation?

- The needs of users: Is the design ergonomic? What anthropometric data could be used to improve the design? Is it a suitable size and shape for the target market? How can the design be improved to make it more psychologically and physiologically ergonomic?
- Production manufacturing: How can this product be made in a large quantity? What materials could be used in the final production? What scale of production is required?

Tip: *Having students annotate design ideas with the information above demonstrates the ability to apply design theory to a practical design task and can greatly improve the presentation of design ideas.*

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.

Creative homework 1.2.2: Students read the Creative homework and complete the research task on commercial testing.

Answers to Student Book activities

Skills activity (page 29)

There is no set answer for this activity. Designs can be tested in groups.

Knowledge check (page 29)

1. Name a material that is commonly used in car design to model the initial shape of the vehicle. State why you think the material is used. (2)

Possible answer: Clay is commonly used because it is soft, it can be easily shaped and changed, and it can have a fine smooth finish.

Award 1 mark for identification of a suitable material and 1 mark for an explanation.

2. A school stationery shop wishes to sell a range of common stationery as a promotional set for your school. Outline a method of producing a prototype of your solution. (4)

Responses will vary. Accept notes and sketches if communicated well.

Award 3–4 marks for an excellent outline of method of production, including appropriate modelling materials, equipment and adhesives.

Award 2 marks for a list of possible methods of production; the answer may omit modelling materials / joining methods.

Award 1 mark for a vague or confused attempt at an answer.

Total: 6 marks

1.2 Design ideas and techniques

1.2.3 Generation of possible ideas

Learning objectives

By the end of this unit students should:

- be able to recognise the need for continual appraisal and evaluation
- be able to relate appraisal and evaluation to the specification.

Resources

Student Book pages 30–31
Activity sheet A (available online on Collins Connect)
A range of product examples
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 1.2.3.

This unit introduces students to a range of evaluation techniques that can be used when required in their project. Encourage students to select the most appropriate evaluation technique when conducting an evaluation. One lesson can be devoted to this unit. However, encourage students to use these evaluation techniques throughout the design process, not just at the end.

Lesson starter suggestions

Group discussion (SWOT analysis): Source a range of products previously made by students or products made commercially if no previous work is available. Give one product to each group of students and ask them to consider the following:

- Strengths: What advantages does the product have? What does it do better than anything else? What would make you buy it?
- Weaknesses: What could you improve? What could prevent the product from selling?
- Opportunities: Could new technology be used to improve the product? Could the product be made more cheaply? Could it be made more pleasing aesthetically?
- Threats: Are there better products available? Do any safety standards or legislation have to be met?

Hand out blank sheets of A3 paper and ask students to draw a SWOT table as on page 30 of the Student Book. Groups record any findings under the relevant sections on their SWOT analysis.

Main lesson activities

Skills activity (page 31): Students work in pairs for this activity. They could use a product in the classroom or in their bags. The activity should lead to a discussion about why evaluation should occur at all stages of the design process.

Evaluation techniques: Ask students to read pages 30–31 of the Student Book to familiarise themselves with different evaluation techniques. Give them the opportunity to use as many evaluation techniques as possible on their own designs and also use them to get feedback on their designs

from other users. Print and hand out Activity sheet A, which has templates for these evaluation techniques for students to use when and where evaluation is required.
Tip: *Evaluation can be used as a plenary for any lesson during the design and make process. Have students use one of the evaluation techniques to evaluate their own designs or the designs of others in the middle or at the end of any lesson that involves a design aspect.*

Plenary suggestions

Team Quiz: Put students in two teams. As quiz master, ask each team questions from the Interactive activity and record scores. A prize or reward may be given to the winning team. Alternatively, students can work independently to drag and drop the words in the gaps to complete the text.

Answers to Student Book activities

Skills activity (page 31)

conduct physical tests in terms of strength and fitness for purpose; make comparisons with other products; get a range of people to assess the product through a questionnaire

Every stage should be checked, questioned and justified to ensure the product is meeting the brief and specification. Evaluation allows the designer to gain feedback from other users as well as themselves.

1.2 Design ideas and techniques

1.2.4 Communicating design ideas

Learning objectives

By the end of this unit students should:

- be aware of a range of methods for communicating design ideas.

Resources

Student Book pages 32–35
Student Book pages 112–123 (for practising drawing)
Activity sheet A from Graphic Products, Unit 2.1; relevant activity sheets from Graphic Products, Units 2.1–2.3 and drawing aids
A3 or A4 sheets of foam board, mounting board or any other suitable material; spray adhesive
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 1.2.4.

The methods for communicating ideas outlined in this unit should be taught at relevant points during the design process. It is difficult to teach all of these methods in one lesson, so several lessons may be necessary, when and where relevant. If you wish to teach any of these communication techniques in more detail, or if you need further guidance on drawing techniques such as orthographic, isometric, freehand, exploded, sectional and perspective drawing, you can refer to the **Graphic Products** section for lesson ideas, resources and activities. If students are studying **Graphic Products** as an option, they can omit this unit altogether, and you can teach these skills using the **Graphic Products** section.

Lesson starter suggestions

Methods of communication: Display or print and hand out Activity A from Unit 2.1 of the **Graphic Products** section. Ask students to discuss in pairs or groups where they may have seen these types of drawings before. Feed back as a class and ask students if they know the correct names of any of the drawings. Answers may include: a floor plan produced by an estate agent, an exploded drawing in assembly instructions for furniture or an isometric drawing in a sketchbook.

Main lesson activities

Practising types of drawing: If you wish your students to practise any of the types of drawing in this unit, you can refer to the following in the **Graphic Products** section:

- Orthographic, isometric and perspective drawing: Student Book, Unit 2.1, pages 112–116
- Sectional, exploded and assembly drawing: Student Book, Unit 2.2, pages 117–121
- Freehand drawing: Student Book, Unit 2.3, pages 122–123.

There are activity sheets for these units that will be useful in providing practice for the different types of drawing.

Skills activity (page 35): Students should already have produced freehand sketches for this activity. Give them time to produce a quick concept model for one of these ideas from appropriate materials.

They could also choose a drawing technique such as orthographic or isometric and add dimensions for a more formal type of drawing. If time allows, a 3D CAD drawing would also be good. Provide students with A3 or A4 sheets of foam board or mounting board and ask them to compile their work neatly as a presentation board.

Tip: *Spray adhesive can be used to mount and display work as a presentation board.*

Tip: *This activity is likely to take some time, so preparation for this could be done for homework.*

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.

Plenary suggestions

Group presentation: This is a good opportunity for students to practise communicating their ideas verbally to a client or group of people. A few individual students can show their presentation boards to the class or a smaller group of students and explain their ideas.

Answers to Student Book activities

Skills activity (page 35)

There are no right or wrong answers here but stress good presentation skills, alignment of work on the board, titling, etc.

1.3 Making

1.3.1 Selection and organisation

Learning objectives

By the end of this unit students should:

- be able to select and develop a solution based on time, cost, skill and resources
- understand that making needs to be planned and organised in detail.

Key terms

costs, facilities, fixtures and fittings, flow chart, skills

Resources

Student Book pages 36–40
Activity sheets A–B (available online on Collins Connect)
Samples of manufacturing plans and sequential instructions; fixtures and fittings from Unit 1.3.2
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 1.3.1.

Materials testing can be conducted by students according to its relevance to a project; it can be a good addition to their development work. Any cutting lists and plans for manufacture should also be included in their portfolio as evidence. Materials testing should be conducted over the course of two lessons and there should be one additional lesson for planning manufacture.

Lesson starter suggestions

Materials and cutting list: This activity introduces the topic. Ask students to use their own project to create a list of all the materials they intend to use in their product construction. They should not just write non-generic terms such as ‘metal’, ‘wood’ or ‘plastic’, but aim to be more specific, depending on their level of knowledge.

Material properties: It is useful for students to learn some specific terms for material properties, e.g. *density, tensile strength, hardness, conductivity, thermal properties, impact resistance*, before they design and perform material testing activities. More on the properties of materials can be found in Unit 3.1 of the **Resistant Materials** section. Print and hand out Activity sheet A and ask students to cut out the cards. They then work in groups to match the terms to the definitions. Feed back as a class and get students to consider which properties are important for the product they are designing. You can refer to the Activity sheet A notes for the answers.

Main lesson activities

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.

Skills activity (page 37): Ask students to source samples of three materials they could use to make their product. Alternatively, provide them with a box of material samples. Ask them to design and then conduct a series of tests on the material samples relevant to the product they are designing.

Tip: *This activity is dependent on facilities. An oven or strip heater could be used to test thermal properties; a scribe, compass or sandpaper to test hardness; a multimeter to test conductivity; a drop test to test impact resistance, etc. Give students the freedom to design their own tests. However, some guidance may be required, depending on the resources available and the safety of the tests being conducted.*

Tip: *Students should photograph all tests and present evidence of testing, results and analysis in their project portfolio. Data should be presented as graphs, tables or charts.*

Material selection and cutting list: Following on from the results of the Skills activity on page 37 of the Student Book, students can produce a cutting list. Refer them to page 37 of the Student Book for an example.

Tip: *Exact amounts and sizes of materials can be difficult for students to get right. The cutting list can be amended at a later stage if necessary.*

Skills activity (page 40): This is a good activity to introduce the concept of flowcharts. Introduce the concept using page 38 of the Student Book and make sure students understand what each of the different shapes means. Students then work individually, in pairs or in groups to produce a flowchart for brushing their teeth.

Planning for manufacture: A natural progression from the Skills activity on page 40 of the Student Book would be for students to produce a flowchart outlining the planned stages of production of their product. They could also use a manufacturing plan or sequential instructions. Ask them to read pages 37–39 of the Student Book to familiarise themselves with these different types of planning and to select the method that they think best shows the planning of manufacture of their product.

Tip: *Software and websites are available for students to produce flowcharts quickly and easily.*

Knowledge check (page 40): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Fixtures and fittings: It would be useful to introduce students to a range of fixtures and fittings at this stage even though the topic is covered in more detail in Unit 1.3.2. You could provide groups of students with a bag of different fixtures and fittings from Unit 1.3.2 and ask them to name them and say what they are used for. Alternatively, you could have a whole class discussion about different types of fixtures and fittings. Yet another way to introduce the subject would be to show students any commercially made products or products made by students and ask them to identify the fixtures and fittings used in their production.

The things around me: Ask students to look at a chair, the table they are working at and any other objects in the room. They have to identify a property that was important for the designer to consider when designing these products. Try to get students to use the material property terms they have learnt.

Tip: *This activity could be given for homework. Ask students to find some products at home and identify the properties that were important for the designer to consider.*

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.

Answers to Student Book activities

Skills activity (page 37)

The success of this task can be determined by the quality and relevance of the tests, the photographic evidence supplied, the presentation of findings as graphs, charts or tables and the analysis of the findings in relation to students' own design intentions.

Skills activity (page 40)

Outcomes may differ. Typical mistakes are: wrong shapes of boxes used, no feedback loop from decisions, and flowcharts that do not run from top to bottom. Point out any mistakes and correct them as a class.

Knowledge check (page 40)

1. Name five things to consider when making your material selection. (5)

Possible answers: availability, aesthetics, cost, facilities, fixtures/fittings, skills

Award 1 mark for each answer (to a maximum of 5).

2. List five types of fixtures and fittings you may include in a design. (5)

Possible answers: handles, hinges, locks, brackets, nuts and bolts, screws, hooks, knock-down fittings

Award 1 mark for each answer (to a maximum of 5).

Total: 10 marks

1.3 Making

1.3.2 Implementation and realisation

Learning objectives

By the end of this unit students should:

- be able to demonstrate the correct procedures in preparation for making
- be able to draw accurately, mark out and test
- be able to select appropriate methods for manipulating a variety of materials.

Key terms

datum, knock-down fittings, standard components, tolerance

Resources

Student Book pages 41–47
Activity sheets A–C (available online on Collins Connect)
Products for disassembly; digital cameras
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 1.3.2.

Two lessons should be devoted to this unit although the actual making process will take much longer; the actual time will depend on your students, the facilities available and the complexity of the outcomes. You could use the activities in this unit when and where required during the making process, as opposed to delivering this unit as one stand-alone lesson. In addition, you may feel it is necessary to demonstrate skills such as marking out, joining materials, the safe and proper use of hand tools and machines, and finishes, when and where relevant. There is more information on tools, equipment, processes and making in general in the **Resistant Materials** section.

Lesson starter suggestions

Joining and fixing techniques: When a product is made, different parts have to be joined together. There are two main ways of joining parts: permanently or non-permanently. Source a range of products or previously made outcomes that include permanently and non-permanently joined parts. Ask students to list the parts or standard components used and say if the joint is permanent or non-permanent. They can refer to Unit 3.10. They should also consider if the materials are the same or different, and if the product needs to be taken apart for maintenance or recycling. Product disassembly could be useful here. Ask students to re-assemble the products afterwards. There is a template in Activity sheet A and an example answer in the Activity A notes. There is more information on disassembly in Unit 1.4.1.

Tip: *Students could include this investigation in their portfolios.*

Tip: *Instead of printing Activity sheet A, you could supply it digitally.*

Main lesson activities

Get out of class task: Products are made from a huge variety of materials that are cut, shaped, formed, joined, fitted together, finished and tested by a variety of machines and equipment. This is an inquiry

activity. Put students in groups. Print and hand out one copy of Activity sheet B to each group of students. Tell them to work together to identify as many of the products on the activity sheet as they can and take a photograph of them, checking them off as they do so. Set a time limit for this activity. Students can refer to page 43 of the Student Book for help with this activity.

Tip: *You may want to contain this activity within the classroom or workshop, depending on your students or school policy. However, the best results will be achieved by allowing students to explore products outside the classroom setting.*

Tip: *Instead of printing Activity sheet B, you could supply it digitally.*

Marking out: Students may require practice in marking out. If so, ask them to read Unit 3.8. Provide a range of different materials and encourage students to look at the table on page 201 of the Student Book for information on selecting the correct tools.

Interactive activity: This is an interactive version of the table on page 42 of the Student Book. It can be used to test students on the tools used for marking out.

Making diary: Get students into the habit of recording each stage in their making by photographing it. Ask them to create a table with the following headings: 'Making evidence', 'Description', 'Quality control' and 'Health and safety'. Set aside some time in the lesson for students to add photos and complete the sections in the making diary.

Tip: *Students could complete this table when required for homework.*

Skills activity (page 46): Students work individually, in pairs or in small groups to complete the first Skills activity on page 46 of the Student Book.

Tip: *This activity could be given for homework.*

Skills activity (page 46): Students work individually, in pairs or in small groups to complete the second Skills activity on page 46 of the Student Book.

Tip: *This activity could be given for homework.*

Knowledge check (page 47): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Quality assurance: For one lesson assign the role of quality assurance manager to an able student or students. They have to walk around the class during or towards the end of the lesson, inspecting the other students while they are working and giving them advice on quality assurance, marking out and tolerances.

Tip: *Give the 'quality assurance managers' glasses and an overall or lab coat to get them into the role.*

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 teams. As quiz master, ask each team questions from the Interactive activity and record scores. A prize or reward may be given to the winning team.

Answers to Student Book activities

Skills activity (page 46)

Possible answers: plastic corner blocks, square section batten, two-block fitting or lock-joint, rigid joint, scan fittings, cam locks

Skills activity (page 46)

1. scriber, ruler, try square, hacksaw, metal vice

2. mark out; use a fret saw, coping saw, tenon saw, files, sand paper and sanding block

3. Any two of the following: linseed oil, polyurethane varnish, teak oil, Danish oil, paint, sanding sealer

4. interference fit (tight), epoxy resin

Knowledge check (page 47)

1. What are the benefits to the user of standard components and KD fittings? (2)

They are easy to assemble (1) and take apart (1).

2. Why are KD fittings and standard components beneficial to manufacturers? (2)

The customer puts the product together (1),
which reduces labour and transport costs (1).

3. What is a material tolerance? (1)

It is the accuracy to which the dimensions of a product are made.

4. Why is marking out so important? (2)

It is important to ensure the parts are the correct size and shape (1)
so that they fit with other components accurately (1).

5. What tools and equipment would you use to mark out a sheet of aluminium? (2)

Possible answers: scriber, ruler, engineers square

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

Total: 9 marks

1.4 Evaluation

1.4.1 Evaluation in design

Learning objectives

By the end of this unit students should:

- be able to evaluate existing products/systems
- be able to test the performance of a product or solution against a specification
- be able to use different strategies to assess effectiveness of products
- be able to suggest possible modifications to a design.

Key terms

commercial testing, disassembly, field test *or* user trial, formative evaluation, summative evaluation, sustainability

Resources

Student Book pages 48–54
Activity sheets A–E (available online on Collins Connect)
Mystery object or product; student products and objects to evaluate
Access to Collins Connect for Interactive activity
Creative homework 1.4.1 (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 1.4.1.

Evaluation is an important aspect of the project. Students should be given time after making to plan testing and evaluation to help them evaluate against their specification. This unit should be delivered after making is complete. However, it may be worth covering the content earlier so that students are aware of the different types of evaluation techniques and where they may occur in the design process. A minimum of three lessons should be given to students to complete a thorough evaluation. A suggested guide would be: one lesson for planning testing, one for conducting tests and one for evaluation and modifications. There is more detail on evaluation techniques in Units 1.8.5 and 1.8.9.

Lesson starter suggestions

Mystery object: This activity encourages curiosity and questioning. Show students an object or objects that they are likely to be unfamiliar with, e.g. a product/artefact from another culture or a wine glass holder that clips to the edge of a plate. Encourage them to speculate about the function of the product by examining the materials and features.

Evaluation techniques: In pairs, students discuss what evaluation techniques they have conducted so far during the course. They are likely to refer to evaluation against specification. Try to guide their thinking towards some of the other activities they may have done, such as disassembly, product analysis and user trials on products.

Evaluation in design: Print and hand out Activity sheet A to groups of students. Students can use sticky notes or write where the evaluation techniques are likely to appear in the design process. There are no

right or wrong answers for this activity and it should be used as a starting point for discussion. There are suggested answers in the Activity sheet A notes.

Tip: *If students are unfamiliar with any of the evaluation techniques covered in this unit, ask them to read pages 48–53 in the Student Book first.*

Main lesson activities

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.

Product analysis (existing or own products): Print and hand out either Activity sheet B (ACCESS FM) or Activity sheet C (CAFÉ QUE). Students can use these to structure labels, annotations and descriptions on a) sketches or photos of an existing product; b) alternative or final design drawings; c) photos of models; d) photos of a final product.

Planning for testing: It is important for students to plan their testing and evaluation techniques so that they can provide evidence of evaluating against the specification. Print and hand out Activity sheet D and give students time to consider their specification points, which evaluation techniques and testing they could perform, and how they could go about it.

Evaluating against specification: This is an important aspect of the project and should not be overlooked. When students have finished making and testing, refer them to the table on page 51 of the Student Book. Ask them to make a similar table to evaluate their product. They could also use a traffic light system to highlight which specification points have been met, which have been partially met, and which have not been met at all.

Modifications: Get students to use the evaluation against specification, and in particular the highlighted specification points that have not been met, to identify possible modifications to their product. Ask them to produce some sketches to communicate any modifications required. You could refer back to Unit 1.2.4 for possible techniques for communicating any modifications.

Tip: *As an extension, more able students could consider modifications for commercial manufacture. This is difficult to do, so you may wish to use the Creative homework 1.4.1 first to help students to develop an understanding of commercial manufacture.*

Knowledge check (page 54): Students can complete this at the end of the topic or for homework.

Creative homework 1.4.1: This is a research task for students to build an understanding of how their type of product can be commercially manufactured. It would be a good homework task to set before they consider modifications for commercial manufacture.

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.

Peer review: Put students in pairs, preferably with someone they are not used to working with. They then review each other's products using ACCESS FM or CAFÉ QUE and suggest modifications.

Tip: *These comments can be recorded and used in students' evaluation.*

Skills activity (page 54): Students should discuss all the tests that may have been carried out on a bicycle. They should try to apply the knowledge and evaluation skills they have acquired in this lesson.

Tip: *It would be ideal if you could show students a picture of a bicycle, or even better, have one on hand in class for students to look.*

Answers to Student Book activities

Skills activity (page 54)

Possible answers: performance or materials testing to meet safety regulations; tests on the wheels or gears to get data on performance; materials testing for rusting / wear rate of tyres and impact resistance; user trials for ergonomics; field test on different surfaces and in different weather conditions; questionnaire or survey on aesthetics

Knowledge check (page 54)

1. What type of technique would be best for checking the function of a prototype? (1)

Depending on the type of prototype being evaluated: visual/aesthetic evaluation; functional or performance testing; user trials

Award 1 mark for any appropriate response.

2. Explain the term *peer evaluation*. (2)

asking a friend, colleague or expert to use the product (1); feedback on a product (1)

3. Make a list of different methods used to test product effectiveness. (4)

Possible answers: user trials, field testing, questionnaires, commercial testing, physical testing rigs, peer review, evaluation against specification

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

Total: 7 marks

1.5 Health and safety

1.5.1 Safety for all

Learning objectives

By the end of this unit students should:

- be able to show correct use of hand tools, machine tools and equipment
- be able to demonstrate proper regard for mandatory and other safety precautions
- understand the responsibilities of the designer to ensure that products are safe
- understand the importance of personal safety and that of others
- be able to recognise basic safety symbols used in the workshop.

Key terms

Control of Substances Hazardous to Health (COSHH), off-shoring, out-sourcing, Personal Protective Equipment (PPE), risk assessment

Resources

Student Book pages 55–62
Activity sheets A–B (available online on Collins Connect)
Departmental risk assessments, safety signs, PPE and guards
Access to Collins Connect for Interactive activity
Creative homework 1.5.1 (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 1.5.1.

It is recommended that issues relating to health and safety in the workshop be addressed in context, e.g. by introducing safe working practices for each process and item of equipment before students use them. One lesson should be devoted to teaching the theory of this unit although it is good practice to regularly review these concepts when required during practical activities.

Lesson starter suggestions

Interactive activity: This would make a good starter or plenary activity. It can be done as a class competition. Nominate students to select a box that disappears when clicked, revealing a symbol below. They have to try to guess the symbol from the revealed image.

Tip: *Warn students that they must not shout out beforehand.*

Tip: *Some students may be able to guess the symbol from the colour alone. This could be a good opportunity to discuss the effectiveness of colours in symbols.*

Skills activities (pages 56–57 and page 60): These activities could be used as starter or plenary activities at the beginning of the course, when you introduce general concepts and develop students' awareness of hazards, risks and control measures for the workspaces and equipment that they will be using. It is more effective to develop students' awareness of their design and technology environment and the reasons for safety rules and safe working practices than to explain them.

Main lesson activities

Turning the table: When you give a demonstration to model the safe use of design and technology equipment, rather than provide explanations for health and safety on every occasion, ask students to explain aspects, such as what PPE should be used and why, what hazards there are and how they should be avoided. They should explain the benefits that control measures have for the user (e.g. clamping work whilst drilling). You could assign certain students to be in charge of health and safety of different machines or processes.

Skills activity (page 56): Print and hand out Activity sheet A. Put students in pairs or small groups and ask each pair/group to risk assess a different process or piece of equipment. Once the risk assessments have been completed, students could explain them to their peers.

Plenary suggestions

Skills activity (page 61): This could be used as an orientation activity at the beginning of the course or when students are working at a workspace for the first time. Students work in pairs or in small groups to list the hazards and risk assessments. Alternatively, the activity could be used alongside a risk assessment activity where students are learning how to identify hazards, risk and control measures.

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.

Creative homework 1.5.1: Students use the BSI, ISO, ANSI or CE websites, which detail safety standards for products, to investigate what legislation is in place for the particular product they are designing or have designed.

Tip: *This information could be added to the students' specification if they have a safety or standards point.*

Answers to Student Book activities

Skills activity (page 56)

Possible answers for employees: may suffer life-changing injuries; may not be able to work or earn money; may suffer from depression; may have to take painkillers or need to be cared for; may affect family life

Possible answers for employers: may have to review procedures, causing expense; may need to retrain staff; may be sued by the injured party; may lose reputation

Skills activity (pages 56–57)

Responses may relate to the use of hand tools or machinery, processes involving heat, CAM machinery or general workshop behaviour.

Skills activity (page 60)

Students should be able to identify and understand a variety of symbols relating to PPE, hazard symbols, chemical symbols and warning symbols.

Skills activity (page 61)

Possible answers:

Eye injuries: Wear goggles and use guards on pillar drills.

Burns from using the oven or strip heater: Wear gloves to prevent burns to hands.

Electric shock: Ensure there is no water near power outlets or machines; ensure equipment has undergone an electrical test.

Knowledge check (page 62)

1. Describe two safety factors that need to be considered when using adhesives to join two pieces of acrylic together. (2)

Possible answers: toxicity when in contact with skin, inhaled or ingested; flammability in the presence of naked flames; irritation to exposed skin – should be used in well ventilated area

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

2. List five items of PPE. (5)

Possible answers: safety goggles or safety spectacles, visor, ear plugs, ear defenders, gloves, gauntlets, apron, lab coat

Award 1 mark for each answer (to a maximum of 5).

3. Explain what PPE and safety precautions you should consider when soldering an electronic circuit. (2)

Possible answers: wearing safety goggles to avoid eye injuries from pieces of material or fumes; wearing an apron to avoid hot solder or flux burning clothes or skin

Award 1 mark for identifying an appropriate PPE and 1 mark for an explanation.

4. How can a designer influence the health and safety of workers in a factory? (4)

Possible answers: ensuring that risk assessments are undertaken for processes; health and safety training is given to all employees; appropriate PPE is made available; all machines are checked and certified safe; appropriate signs are clearly displayed

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

5. In school, why are health and safety rules put in place? (2)

Possible answers: to protect individual students; to protect other students and staff; to promote safe working practices; health and safety legislation

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

Total: 15 marks

1.6 Use of technology

1.6.1 Use of technology in designing and making

Learning objectives

By the end of this unit students should:

- understand the need to research existing products (internet)
- understand the benefits of CAD/CAM in different production systems
- understand how CAD can be used to generate 2D and 3D images
- understand how CAD/CAM is used in industry
- be aware of the variety of machines that are computer controlled
- understand how computers can enhance stock and quality control.

Key terms

Computer-aided design (CAD), Computer-aided manufacture (CAM), Computer-integrated manufacturing (CIM), Flexible Manufacturing Systems (FMS), jigs (also templates, patterns and moulds), packaging net, PCB circuit layout, point of sale display, quality control, rapid prototyping

Resources

Student Book pages 63–68
Activity sheets A–B (available online on Collins Connect)
Flipchart pads and pens; access to CAD software and proprietary tutorials; simple objects to draw using CAD software; smartphones (if allowed)
Access to Collins Connect for Interactive activity
Creative homework 1.6.1 (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 1.6.1.

It is suggested that two lessons are devoted to the theoretical content of this unit. However, students should use CAD and CAM throughout the design and make process for their project.

Lesson starter suggestions

Is it valid?: Print and hand out Activity sheet A. Individually or in pairs, students generate a definition for one of the terms on the activity sheet. They should first use an internet search engine to find definitions from three sources and evaluate the validity of each. They then write their own definition and present it to their peers for feedback. This activity could also be set as a homework or revision task.

Advantages and disadvantages: Put students in groups of three or four and provide each group with a sheet of flipchart paper and a pen. Assign a different area to each group: Computer-aided design (CAD), Computer-aided manufacture (CAM), Computer-integrated manufacturing (CIM), rapid prototyping and Flexible Manufacturing Systems (FMS). Ask them to list the advantages and disadvantages of their area. Students should refer to pages 63–66 of the Student Book whilst doing this activity. When they have finished, they present their lists with explanations.

Main lesson activities

Tutorials: Use the relevant tutorials provided by your CAD software package of choice, e.g. Autodesk Inventor® and Fusion 360™, Solidworks, Pro/ENGINEER, to develop students' knowledge of the basic tools and processes, including using planes, drawing and extruding shapes, cutting holes, using construction lines, and mirroring and rotating elements of drawings. Before students use a new software package, demonstrate it to them. Alternatively, you could create your own tutorials or get expert students to create tutorials showing each step or stage of the process (to be used as electronic or printed documents) or use screen capture software, e.g. Camtasia®, CamStudio™, Screencast-O-Matic, Jing® or Snagit®.

Focused tasks: Source a simple object such as a Duplo block, which students can handle and measure. Then set students a challenge: to model the object using your CAD software of choice, e.g. Autodesk Inventor® and Fusion 360™, Solidworks or Pro/ENGINEER.

Designing and making: The ideal way to consolidate knowledge of CAD/CAM is to use it as part of the design and make process. When designing units of work, identify opportunities to introduce aspects of CAD/CAM skills. CAD/CAM can be used in a variety of ways: rendering to present ideas; to create working drawings such as orthographic and exploded isometric, to rapid prototype ideas or to perform tests such as force testing or drop tests. Encourage students to explore these possibilities.

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.

Skills activity (page 67): Students pick an object in the room and make notes on the scale of production used to produce it. They should try and justify their decisions. They can also consider where CAD may have been used in the process. Students tend to focus just on design and production when they think of CAD, so encourage them to think about the whole process: design and development, testing, production, evaluation, stock control, packaging and distribution.

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.

Acronyms: Write the following on the board: CAD, CAM, CIM, CNC, FMS, QC, RFID and RP. Ask students what the acronyms stand for. Do not allow them to refer to the Student Book.

Student instructions: Students work individually, in pairs or in groups to create a set of instructions on how to use a piece of CAM available in the department, e.g. a vinyl cutter, a laser cutter, a 3D printer or a CNC machine. They could do this digitally using graphics software such as Adobe Illustrator or Adobe Photoshop. These instructions could be printed and placed near the relevant machines.

Tip: *Alternatively, students could create a video outlining the steps required to use a CAM machine. This could be uploaded to the school virtual learning environment for other students to watch.*

Barcode scanning: There are many barcode scanning apps available for smartphones. A fun plenary could be for students to source some packaging from around the room and use an app to scan it and see what information comes up. The first group to download a suitable app, find a barcode, scan it and announce the findings can leave the classroom first.

Tip: *This activity is dependent on school policy towards the use of mobile phones in class*

Creative homework 1.6.1: Technology is changing all the time, so the content of this unit will no doubt be outdated by the time a new syllabus is written. It is good to develop students' interest in technology and its impact on society through open-ended research tasks on current and future technologies. This homework is designed to encourage curiosity and an interest in technology and the future.

Answers to Student Book activities

Skills activity (page 67)

There is no right or wrong answers for this. However, the scale of production will be suited to demand and also influences the materials chosen. Students should refer to these aspects. When considering CAD, students should consider the whole process, including CIM.

Knowledge check (page 68)

The use of CNC machines in industry is very common.

1. What are four advantages and four disadvantages of CNC machining? (8)

Possible advantages: accuracy (i.e. it can work to high tolerances); repeatability (i.e. many parts can be manufactured with the same degree of accuracy); speed (i.e. machines can be set to operate at the optimal speed and feed rate for the material); editability (i.e. drawings can be edited to adapt or improve the design); continuous manufacture (i.e. machines can operate 24 hours a day, 7 days a week, although time must be allowed for maintenance); efficiency (e.g. one operator can monitor/supervise multiple machines); simulation (i.e. parts and the CNC process can be simulated prior to manufacture)

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

Possible disadvantages: it is expensive to set up (i.e. a high volume of parts would need to be manufactured to cover the initial outlay, compared to hand and machine tools); it requires time to set up (i.e. draw the parts and set up the machine prior to manufacture); it requires semi-skilled operators (i.e. operators trained to use specific machines, which means they are less able to respond to the unexpected, as an engineer could do); it contributes to unemployment because fewer workers are required; there is a skills gap (i.e. the accuracy and speed of CNC reduce the need for skilled workers); it requires costly maintenance and repair

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

2. How does rapid prototyping help a designer and design team? (2)

Possible answers: by evaluating the aesthetics/appearance or a produce/part; by testing the functionality of a product/part; by presenting a concept to a client/users

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

3. What are the advantages of CAD over traditional drawing methods? (4)

Possible answers: accuracy (i.e. precise measurements can be made, reducing human error); 3D modelling is possible (i.e. in modern CAD packages, multiple views and types of drawing can be generated from one drawing, including presentation and production drawings); editability (i.e. drawings can be adapted, improved or copied and redesigned); simulation (i.e. parts and manufacturing processes can be tested virtually before a prototype is machined); storage (i.e. files can be stored electronically); communication (i.e. files can be shared electronically with colleagues and clients in different locations around the world); scalability (i.e. the scale of drawings can be altered for printed drawings)

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

4. How can bar codes help with quality control of products? (4)

Possible answers: They help in manufacture (i.e. it is possible to have real-time and retrospective computer-based monitoring of progress through a manufacturing process). They help in distribution (i.e. products can be tracked once they leave the factory for the retail outlet). They enable data retrieval (i.e. the retailer or customer can access data about the product, e.g. its cost and origin). They help in stocktaking (i.e. product numbers can be monitored and the product restocked as required). They enable automated stocktaking (i.e. some or all of the stocktaking process can be undertaken by computerised systems).

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

Total: 18 marks

1.6 Use of technology

1.6.2 Systems

Learning objectives

By the end of this unit students should:

- be able to identify the features of a control system
- understand the features of a control system and applications.

Key terms

feedback, input, operation (*or* control), output

Resources

Student Book pages 69–71
Activity sheets A–B (available online on Collins Connect)
Construction kits (e.g. LEGO® Technic or Fischertechnik)
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 1.6.2.

Systems and control is best taught through practical tasks; some tasks are outlined below. Alternatively, you can source additional ideas for activities and focused practical tasks in Unit 4.1. Ideally, two lessons should be devoted to Unit 1.6.2.

Lesson starter suggestions

System analysis: Ask students to use the internet or books to find examples of common hydraulic, pneumatic, mechanical and electronic systems. They can share their examples with the class to generate a discussion on the input, process/control and output (as well as feedback) elements. As an extension, you could ask them to draw a system diagram for each example. This activity could also be set as homework or repeated at different times, depending on the unit being taught or the project being done.

Matching input and output components: Put students in groups. Print one copy of Activity sheet A for each group of students, cut out the cards and shuffle them. Give each group a set of cards and ask them to place each component on either the ‘Inputs’ or ‘Outputs’ card, as appropriate.

Main lesson activities

The systems approach (design and make – electronics): When designing a new system or analysing an existing one, it can be helpful to consider the output of the system (i.e. what it does) first, and then consider the input(s) (i.e. what triggers the output). The process is the means by which the input makes the output happen. This is a systems approach. When students are designing their own systems, they could use input and output chooser charts, such as the Key Stage 4 Nuffield Foundation chooser charts, available for free at www.stem.org.uk. They start with the desired output(s) and then follow up with the input(s) to make their system produce the desired function(s). At this stage, the process (or control) element should be treated as a ‘black box’ (i.e. an as yet unidentified process). The development of the

process/control ('black box') element could be the focus of research and should build on focused tasks using a range of process devices such as amplifiers (including transistors), latches (including thyristors), timers and microcontrollers. This activity could be repeated at different times, depending on the unit or project being taught.

Systems modelling challenge (mechanics): Put students in groups of three or four. Ask them to use mechanical construction kits, e.g. LEGO® Technic or Fischertechnik, to model a moveable bridge such as a raising or swing bridge to span a distance of at least 400 mm. The bridge must be controlled using a gear or pulley mechanism. Set the task as a challenge over two lessons and get students to investigate existing moveable bridges as homework.

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.

Skills activity (page 71): Put students in groups and ask them to consider a product they are familiar with, e.g. a bicycle. Students brainstorm the inputs, controls/operations and outputs of the product. They can then neatly draw a systems diagram to show this.

Plenary suggestions

Sourcing video links: Put students in five groups and assign roles to each student in a group: 1) group pneumatic systems expert, 2) hydraulic systems expert, 3) electronic systems expert, 4) electrical systems expert and 5) mechanical systems expert. Each group has to work together to find the perfect video clip on the internet showing their area of systems expertise in action. These video links could be collated and posted on the school virtual learning environment or some other method of distribution and watched in a later lesson or viewed later for revision.

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.

Answers to Student Book activities

Skills activity (page 71)

The outcome for this should be a systems diagram for a product of the students' choice.

Possible answers from a systems diagram for a bicycle:

Inputs	Controls	Outputs
Pedalling force	Wheels turn	Bike is propelled forward
Moving handlebars	Wheels rotate on axis	Bike is steered to the left or right
Applying pressure to breaks	Brake pads make contact with wheels	Bike is slowed due to friction
Gears are shifted	Chain moves to a new position on chain wheel	More or less torque is required for momentum
Bell is pushed	Mechanism is activated	Sound is produced

Knowledge check (page 71)

1. Match the following systems: (4)

a steam train – mechanical
a telephone – electronic
earth-moving equipment – hydraulic
changing a Formula 1 racing car's wheels – pneumatic

2. Give one more example of each of the following types of systems:

- mechanical system (2)

Possible answers: bicycle drive system (sprocket and chain); bicycle braking system (levers and linkages); vehicle steering system (rack and pinion); vehicle power transmission (compound gears/gearbox)

- pneumatic system (2)

Possible answers: tools used where there are flammable liquids/gases; air brakes on large vehicles; air pumps for cars and bicycles

- electronic system (2)

Possible answers: computer/microprocessor; alarm systems; communication devices (including radios and mobile phones

- hydraulic system (2)

Possible answers: car brakes; dentist/barber's chair; rubbish/vehicle compacter

Award 1 mark for each appropriate system; 2 marks for more than one appropriate example of each system, or one example with an explanation or contextual information. No marks should be awarded for reusing the examples from question 1.

Total: 12 marks

1.7 Design & Technology in society

1.7.1 Design in society

Learning objectives

By the end of this unit students should:

- understand the role of designers, artisans and technologists in industry and society
- understand the effects of Design & Technology activity on social, moral and economic issues
- understand a range of human factors that need to be considered when designing.

Key terms

artisan, cradle to cradle, ergonomics, life cycle analysis, planned obsolescence

Resources

Student Book pages 72–77
Activity sheets A–D (available online on Collins Connect)
Samples of products with design features and/or that demonstrate manufacturing and processing methods that illustrate where the designer has considered sustainability; rulers for collecting anthropometric data; blank paper or sketchbooks and drawing aids; impairment aids, e.g. blindfolds, scratched goggles, Velcro
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 1.7.1.

Two lessons should be devoted to this unit: one lesson for sustainability issues and one for human factors. Encourage students to apply these concepts to their own design and making.

Lesson starter suggestions

The role of the designer: This activity introduces the unit. Source a range of products; alternatively, students choose one product or artefact in the room or workshop. Ask students to answer the questions on pages 72–73 of the Student Book to decide which factors would have been taken into consideration to design the product or artefact. They should make notes and sketches to support their findings.

Tip: *Student could record their answers in a sketchbook or on an online blog or work journal to build a resource for reference and revision. Alternatively, the outcome could be an oral presentation.*

Skills activity (page 73): This would make a good starter activity or plenary. Students list as many highly skilled artisans as possible. Feed back as a class.

Tip: *You may want to discuss if the skills these artisans have are becoming more or less in demand, and the impact of technology and manufacturing on traditional craft production.*

Main lesson activities

Skills activity (page 74): Students work in groups to analyse a product or to access websites with examples of sustainable products. Print and hand out one copy of Activity sheet A to each group. Ask them to consider the issues on pages 73–74 of the Student Book and make notes on the Venn diagram

for a product of their choice. Explain to students that some issues may overlap with more than one other issue and they should record these where the diagram overlaps.

Tip: *Refer students to trusted product design websites, e.g. fastcodesign.com, blessthisstuff.com, core77.com, inhabitat.com and theverge.com. They all have good examples of product design.*

Tip: *Since students are working on the computer, you could provide Activity sheet A digitally.*

Considering wider issues (life cycle analysis): Print and hand out one copy of Activity sheet B to each group of students. Explain that the life cycle of a product takes into account the environmental impact of the product throughout its life. Focus students' attention on the diagram on the first page of the activity sheet. Using the products they analysed in 'The role of the designer' activity, students consider the issues outlined on the activity sheet and conduct a life cycle analysis of the product using the table on the second page of the sheet.

Tip: *It may be useful to model this activity with the class before they begin.*

Considering wider issues (human factors): Introduce the concept of ergonomics and anthropometrics using page 75 of the Student Book. Tell students they are going to collect some anthropometric data for hand sizes in the class. Put them in groups. Print one copy of Activity sheet C for each group. Ask students to look at the diagram and collect anthropometric data for their group. Once the data has been collected, identify who has the smallest and who has the largest hands in the class. Discuss with students where these students may fall on the bell graph on page 75 of the Student Book.

Tip: *If time allows, students could practise accessing secondary anthropometric data from books or the internet to corroborate their findings.*

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.

Different types of ergonomics: Use page 76 of the Student Book to introduce the sociological, psychological and physiological study of ergonomics and interaction design. Give students time to source examples of bad designs on the internet. Ask them to identify what makes these designs bad and which of the categories (sociological, psychological or physiological) these aspects fall under. Students then redesign the products using some of the communication techniques from Unit 1.2.4.

Tip: *A good resource for this activity is baddesigns.com.*

Skills activity (page 77): Provide students with objects such as blindfolds, scratched goggles and Velcro (Velcro can be used to limit grip and hand movement). This will help them to begin to understand how people with a disability or physical impairment find it difficult to use everyday products.

Tip: *As an extension, get students to concept model potential solutions. This will take time, so you could set this activity for homework.*

Knowledge check (page 77): Students can complete this at the end of the topic 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.

Bad designer: Show students a product and ask them to redesign it as badly as possible. They should consider all the concepts they have learnt in the unit and use them to achieve the opposite. Encourage unsustainable practice and poor ergonomics. Students can do this activity using communication techniques such as quick sketching and notes. Feed back as a class and vote on the worst design.

Answers to Student Book activities

Skills activity (page 73)

Possible answers: stone mason, farrier, goldsmith, potter, furniture maker

Skills activity (page 74)

Possible answers: issues of fair trade; sustainability; the long term impact of planned obsolescence

Skills activity (page 77)

Responses will vary depending on the task and product but may include: difficulty reading instructions or seeing what to do; difficulty gripping or using fine motor skills to perform a simple task.

Knowledge check (page 74)

1. Name a company or organisation that you feel has a strong sustainability policy and explain why. (6)

Any relevant example, with an explanation of the organisation's vision, values and work, e.g. Practical Action and The Ellen MacArthur Foundation

Award 5–6 marks for an example with a good rationale of the company's sustainability credentials, including examples of any products, buildings or systems designed and made by the company.

Award 3–4 marks for an example with a good rationale of the company's sustainability credentials.

Award 2 marks for an example but a poor explanation.

Award 1 mark for identifying an organisation, but no explanation.

2. There are three R's we often use when thinking of the environment. What are they? (3)

reduce (1), reuse (1), recycle (1)

Students should also be encouraged to consider the following: rethink (1), refuse (1) and repair (1).

Total: 9 marks

Knowledge check (page 77)

1. Students study in many different ways and some have nowhere to work comfortably. If you were to design a study unit, list four points you would consider to be important in terms of ergonomics. (4)

Possible answers: height, area of space available, space to keep items such as stationary, reach

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

2. Explain the 5th to 95th percentile. (4)

Below the 5th percentile and above the 95th are deemed extremes and designers will design in between these figures.

Award 4 marks for an excellent description with an example of a measurement given.

Award 3 marks for a good description but no example.

Award 2 marks for an adequate description but no example.

Award 1 mark for an attempted but confused answer. 4

3. Give two examples of considerations you would make when taking into account physiological and psychological design. (4)

Psychological: touch, taste, hearing, sight

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

Physiological: sizes of items and distances of functioning items relating to the body

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

Total: 12 marks

1.8 Product design application

1.8.1 Meeting the needs of users

Learning objectives

By the end of this unit students should:

- understand how existing products meet the needs of the users.

Key terms

human factors, interaction design

Resources

Student Book pages 78–79
Activity sheets A–C (available online on Collins Connect)
A range of drinking vessels; blank paper or sketchbooks, drawing aids

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 1.8.1.

One lesson should be devoted to this unit, but encourage students to consider human factors throughout their project work. They should certainly consider them when testing their models or final products.

Lesson starter suggestions

User needs: Display or print and hand out Activity sheet A. Ask students to look at the photos of the users and consider what their needs are and how they differ. Feed back as a class. There are possible answers in the Activity A notes.

Main lesson activities

Brainstorm: Students read page 78 of the Student Book. Using the diagram as a starting point, they work in pairs to discuss what designers need to think about when considering human factors and add others, expanding upon those shown. They could copy this diagram and add to it in their sketchbooks.

Meeting the needs of users (1): Source a range of drinking vessels, e.g. cups, mugs, plastic/paper cups, refillable water bottles, baby cups/bottles, sports bottles, soft drink/water bottles, wine glasses and flasks. Have a class discussion about who these products are aimed at and how they have been designed to meet the needs of these users. Encourage students to consider sizes and shapes, the situations in which the products are used, materials, how they are held, convenience, storage and transportation.

Meeting the needs of users (2): Put students in groups and ask each group to choose one of the vessels. Print and hand out Activity sheet B. Students analyse and interact with the vessel and make notes on the table. When they have finished, students choose another vessel until the table is filled in.

Meeting the needs of users (3): Ask students to design a vessel to encourage teenagers to drink more water at school. As a class, discuss the needs of the user and write students' ideas on the board. Encourage students to use some of the communication techniques from Unit 1.2.4 and add notes or annotation to their design ideas.

Tip: *Students could swap designs with a partner and evaluate them using the criteria on the board.*

Interaction design: This will be a form of human factors design that students can relate to but may not have thought about. Ask students to look at their mobile phone or tablet and discuss with a partner how the interface has been designed. Is it easy to use? Are wrong things pressed by accident? Do they need to shift the position of the phone to access certain functions or apps? Feed back as a class.

Knowledge check (page 79): Students can complete this at the end of the topic 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.

Skills activity (page 79): Students work individually, in pairs or in small groups. They should consider the users' physical needs, ergonomics and anthropometrics, as well as material choice and the visual or aesthetic appeal of the product.

Answers to Student Book activities

Skills activity (page 79)

Responses will vary.

A wheelchair: The user is a person who experiences difficulty walking or who is unable to walk and requires assistance to become mobile. The designer needs to consider the user's physical impairment and upper body strength, ergonomics, anthropometrics for a range of users, seat shape and material for comfort, tyre material and the different environments where it may be used.

An aeroplane cockpit: The users are a pilot and co-pilot. The designer needs to consider the comfort of seats for long-haul flights, the adjustability of seats for different pilots, easily recognisable display icons and colour coding, the shape and size of windows and the reach of the user.

Toothbrushes: The user is a person who needs to clean their teeth. The designer needs to consider the humid environment in which a toothbrush is used, grip, safety, ergonomics and the range of users.

Glasses: The user is a person with a visual impairment who requires help to see clearly. The designer needs to consider the anthropometrics of the head and ears, ergonomics, aesthetics, colour and style according to user tastes, and different lens functions to deal with different types of impairment (physics).

An office work station: The user is an office worker. The designer needs to consider ergonomics, seat comfort, adjustability of the seat, the height of the work desk, the reach of the user, the clearance or space under the desk for legs, and durable materials that are water resistant in case of any spillages.

A hearing aid: The user is a person with a hearing impairment who requires help to hear (clearly). The designer needs to consider ear anthropometrics, ergonomics and comfort, non-assuming aesthetics, and volume control for comfort.

Crutches: The user is a person who experiences difficulty walking and requires support to become mobile. The designer needs to consider the anthropometrics of a range of users, adjustability, grip, the user's impaired physical function, and the different environments in which the crutches may be used.

Knowledge check (page 79)

1. Describe briefly four activities that you are familiar with that could be improved by applying good interaction design. (8)

Possible answers: using a smart phone interface; using ATM machines; using cameras – photography; using car music systems and dashboard controls; using a laptop

Award 1 mark for each of 4 correct activities and 1 mark for a short explanation of each.

Total: 8 marks

1.8 Product design application

1.8.2 Considering production manufacturing

Learning objectives

By the end of this unit students should:

- understand one-off, batch and mass production techniques.

Key term

bespoke

Resources

Student Book pages 80–82
Activity sheet A (available online on Collins Connect)
Samples of products that illustrate a variety of manufacturing methods: mass, one-off, batch and continuous production
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 1.8.2.

One lesson should be devoted to this unit. If students have completed a product or are near to completion, encourage them to think about which scale of production would be required for their product and why.

Lesson starter suggestions

Production methods: This activity introduces the unit. Source a range of products manufactured using mass, one-off, batch and continuous production methods. You could use photos if the products are not available. Hold up each product or photo and ask students to consider the production method and how many products have been made. At this stage, you may want to introduce the terms *one-off production*, *batch production*, *mass production* and *continuous production*. Encourage students to consider the reasons for these scales of production in terms of materials, production methods and level of demand.

Tip: *In addition to graphic, resistant material and electronic products, you could consider including food products in this activity.*

Main lesson activities

Production methods: Refer students to pages 80–81 of the Student Book. Ask them to read the section on one-off production and follow this up with questions, e.g. *Which products are only made as one-off products, and why? What are bespoke products?* Encourage students to give examples other than the products discussed in the starter activity. Repeat for batch, mass and continuous production.

Skills activity (page 82): Students work in pairs to discuss. No writing or note-taking is required.

Production methods: Print and hand out Activity sheet A. Students work individually or in groups to do the activity.

Interactive activity: This can be used to further consolidate scales of production or given for homework.

Class discussion: This discussion will help students to link concepts from different units and develop their thinking skills. Ask them to consider the impact of different scales of production on the environment. Encourage them to think about the number of products made, the energy required for each scale of production, and the resultant waste and pollution. You can then ask them about the impact of different scales of production on human factors. They should consider how bespoke one-off products are designed to meet specific user needs whereas mass-produced items need to suit a much wider range of users and therefore may need to have adjustability built in. Students could consider these points in groups before reporting back as a class.

Knowledge check (page 82): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Team Quiz: Put students in two teams. As quiz master, ask each team questions from the Interactive activity, e.g. *The efficiency of the process decreases as the scale of production increases. True or false?* Record scores. You could award a prize to the winning team.

Moodboard: Students could begin to prepare for Unit 1.8.3 by making a moodboard – a collection of images on a certain theme. Ask students to choose one of the following themes: organic shapes, geometry or nature. Images can be found on the internet and a moodboard can be created using ICT.

Answers to Student Book activities

Skills activity (page 82)

Students should be able to identify the type of production and the scale of production. Biro pens are injection moulded and mass produced (perhaps continuous). Magazines are printed using offset lithography and bound; they are batch produced for each edition.

Knowledge check (page 82)

Decide which production method would be most suitable for each of the following products: (4)

plastic school chair – mass production

poster to advertise a school production – batch production

fizzy drink can – continual production

unique piece of furniture – one-off or bespoke production

Total: 4 marks

1.8 Product design application

1.8.3 Design ideas

Learning objectives

By the end of this unit students should:

- understand different strategies for starting to create ideas.

Key terms

form, function

Resources

Student Book pages 83–85
Activity sheets A–D (available online on Collins Connect)
Samples of products that illustrate a variety of design; craft knives; simple modelling materials, e.g. modelling clay, Play-Doh, metal wire, card
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 1.8.3.

Ideally, one or two lessons should be devoted to this unit; lessons should be fast paced.

Lesson starter suggestions

Inspired by …?: Display or print and hand out Activity sheet A. Ask students to look at the designs and discuss what may have influenced the designer. There are no right or wrong answers for this activity; use it as a starting point for discussion. You could tell students that designers allow all sorts of things to influence their design thinking, and this has an impact on the overall form and sometimes the function of the design. Only one fast-paced lesson should be devoted to this activity and should allow for creative freedom as students generate and develop ideas.

Main lesson activities

Organic shapes, geometry and nature: Assign one of the following themes to students: organic shapes, geometry and nature. Students use the internet or ICT to create a moodboard with interesting patterns, textures and shapes on their theme. Print and hand out Activity sheet B. Ask students to cut out the viewfinders (a craft knife will be needed for the window). Alternatively, you could cut them out for students beforehand to save time. Students use the viewfinder window as a template to draw three boxes on paper or in their sketchbook. They then place the viewfinder on their moodboard (or stick it to their screen if they are using a computer) to frame interesting patterns, shapes or textures. They should use colour to sketch these textures, shapes or patterns in the three boxes they have drawn.

Tip: *If you cut the viewfinders out of durable card or plastic, they can be reused.*

Generating design ideas: Show students a product such as a lamp, mouse, pen or any nondescript item. Alternatively, put students in groups and give each group a different product. Tell them to use one of the patterns, shapes or textures they drew in the ‘Organic shapes, geometry and nature’ activity to

influence a redesign of the product. They should sketch a small redesign on paper or in their sketchbooks. It may be a good idea to set a time limit of about 10 minutes for this activity.

Tip: *Encourage students to be creative. Instead of just applying a texture to the original product, they can use their influences to alter the shape of the product.*

Skills activity (page 85): Put students in groups of five. Print one copy of Activity sheet C for each group and cut out the SCAMPER cards. Students put the cards face down on the desk and mix them up. When you say 'go', they each take one of the cards. They then have three minutes to sketch a redesign of the product they drew in the 'Generating design ideas' activity. They should use the card as a prompt for what to do. Refer students to pages 84–85 of the Student Book for ideas on how to use the cards. Repeat this process several times, with students choosing different cards until they have developed their original idea or drawn several variations.

Tip: *This activity is more effective if strict time limits are set to keep it fast paced.*

Interactive activity: Ask students to read the section on biomimicry on page 84 of the Student Book before doing this activity. They then do the activity individually. It is designed to get them thinking about biomimicry as a method for generating design ideas.

Form before function: Provide students with a box of simple modelling materials. This may include modelling clay / Play-Doh, metal wire and card. Ask students to play with the materials for 20–30 minutes to create an aesthetically pleasing structure without considering function. When they have finished their models, they should discuss as a group a possible functional product that they could develop from the model. Students can then refine their models into working prototypes whilst retaining the original aesthetic form of the model.

Tip: *This activity helps to teach form and function and it also provides good modelling practice. More than one lesson is required for it to be effective, so it could be set as a mini project over several lessons.*

Knowledge check (page 85): Students can complete this at the end of the topic or for homework. Encourage examples that are not mentioned in the Student Book, e.g. the Mini, the Eames chair, Juicy Salif and the original iPod.

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.

Presentation of design development: Students could present the work they have done in the lesson to a group or to the class.

Answers to Student Book activities

Skills activity (page 85)

There is no right or wrong answer for this activity.

Knowledge check (page 85)

1. From your understanding of iconic design, list five products, past and present, that you feel fit into this category. Explain your choices. (5)

Good possible answers include examples not mentioned in the Student Book, e.g. the Mini, the Eames chair, Juicy Salif and the original iPod.

Award 1 mark for each example (to a maximum of 5).

Total: 5 marks

1.8 Product design application

1.8.4 Identifying constraints

Learning objectives

By the end of this unit students should:

- understand how to plan the stages of manufacture.

Resources

Student Book pages 86–87
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 1.8.4.

One lesson should be devoted to this unit. It should be used to help students to plan for manufacture before they start making.

Lesson starter suggestions

Skills activity (page 87): Students should do this activity individually and then feed back to the class. Do not tell students how to format this task; this is a good opportunity to see how they approach it. Identify some of the methods students have used, e.g. flowchart, sequential drawings, tables, bullet points and Gantt charts, and share these with the class. Discuss which methods are the most effective.

Tip: *Possible activities or situations students will be familiar with are getting ready every morning or preparing a snack.*

Main lesson activities

Planning for manufacture: Ask students to write down all the materials, components and processes they require for making a successful product. Refer them to pages 86–87 of the Student Book, where they will read about different methods for planning. Give them time to choose an appropriate method to plan for production.

Tip: *The* ***Resistant Materials*** *section of the Student Book has some good information on a range of materials and sizes.*

Knowledge check (page 87): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Interactive activity: Students can work as a class to do the Interactive activity.

Answers to Student Book activities

Skills activity (page 87)

Possible chores: preparing a simple meal; getting ready to go out. Students can present this in any appropriate form.

Knowledge check (page 87)

1. What type of diagram would you use to give clear instructions of a component size? (1)

orthographic drawing

2. What type of drawing would you use to demonstrate the form of a final product? (1)

Possible answers: freehand sketch/render, perspective drawing, isometric drawing

Total: 2 marks

1.8 Product design application

1.8.5 Evaluating against the specification

Learning objectives

By the end of this unit students should:

- understand how to evaluate their design against its specification.

Resources

Student Book pages 88–89
Activity sheet A from Unit 1.2.2 (available online on Collins Connect)
Products made by students or students' design ideas
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 1.8.5.

You may wish to combine this unit with Unit 1.4.1, which has related activities for evaluating against the specification. Alternatively, you could use activities from each unit as you see fit. In addition, you could refer students to Unit 1.2.3, which also has some good strategies for evaluation. Make sure students are aware that they should evaluate their designs against the specification not only at the end of a project, but throughout. Therefore, this unit can be used to introduce this concept when students have completed their initial ideas, or whenever required.

One lesson should be devoted to this unit.

Lesson starter suggestions

Review: Ask students if they remember what a star diagram is and what it is for. Then ask them to try to use a ruler to draw a star diagram from memory.

Main lesson activities

Skills activity (page 89): Ask students to look at their own pencil case to help them to write a specification. You could limit the number of specification points and encourage students to sketch simple ideas quickly. Students then work together to evaluate one design against the related specification.

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.

Star diagrams for evaluation: Ask students to look at page 89 of the Student Book and draw a similar star diagram in the middle of a page in their books, leaving space around the diagram. Alternatively, print and hand out Activity sheet A from Unit 1.2.2, which has star diagrams. Students then choose five headings from their specification, add these to the star diagram, and complete the diagram by evaluating design ideas, models or their final product.

Tip: *Students could peer evaluate using this technique too.*

Developing critical thinking: Students sometimes find it difficult to criticise their own designs and the designs of others. This activity is designed to help them to develop these important skills. Ask students to make notes around the five specification points on the star diagram. The notes should address the

following three areas for each specification point: what is good about the design, what is not so good, and any improvements/modifications that could be made.

Tip: *Students could peer evaluate using this technique too.*

Using a table format: Ask students to draw either a pass–fail analysis or a score card-type table for evaluating against the specification. Then ask them to use the star diagram they have completed to help with this.

Tip: *There are examples of such tables in Unit 1.2.2. There are templates for them on pages 2–3 of Activity sheet A from Unit 1.2.3.*

Knowledge check (page 89): Students can complete this at the end of the topic or for homework.

Tip: *This activity could be given as homework.*

Plenary suggestions

Group game: Put students in groups and assign each group with a specification category such as aesthetics, function, performance, target market, materials and environment. Ask each group to list as many considerations as they can under that category. Set a time limit for this activity. The group with the most considerations is the winner.

Tip: *You could model this with a specification point on the board, e.g. some considerations under the category of aesthetics may include style, materials, finish, colour, texture, size and shape.*

Answers to Student Book activities

Skills activity (page 89)

Possible answers:

Aesthetics: reference to a particular style or theme

Function: reference to the length of pencils or a ruler; reference to the volume of the pencil case, which affects how much it can hold; reference to the opening and closing method of the pencil case

Materials: reference to durability

Performance: reference to whether the pencil case can hold the required items or whether it can fit in a school bag; reference to whether it can open and close easily; reference to whether it can hold items securely and protect them from damage

Knowledge check (page 89)

1. Explain why evaluation is an essential part of the design process. If designers did not evaluate, what would be the consequences? (2)

Every stage of the design process needs to be checked against the specification as well as the brief and client requirements. (1) If the design does not meet these and the evaluation of each stage is not carried out, the design may not meet clients' expectations and the designer may not be paid. (1)

Total: 2 marks

1.8 Product design application

1.8.6 Understanding the relevance of function

Learning objectives

By the end of this unit students should:

- understand the terms associated with aesthetics, and relate this to design ideas and the work of others
- understand the term *function* and how it relates to design.

Key terms

primary function, secondary function

Resources

Student Book pages 90–91
Activity sheets A–C (available online on Collins Connect)
Samples or photos of products that incorporate both primary and secondary functions
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 1.8.6.

One lesson should be devoted to this unit.

Lesson starter suggestions

Discussing function: Students discuss in groups what the intended function of the product they are designing is. Explain that the intended function is called the primary function. Ask them to ignore any additional functions their product will or could perform.

Main lesson activities

Primary and secondary functions: Ask students to read page 90 of the Student Book. Print and hand out one copy of Activity sheet A to each pair of students. Ask them to analyse the products on the sheet and state what the primary and secondary functions of the products are. They then compare notes and feed back as a class.

The functions of a product: Provide each student with a range of products at their workstation. You could use photos if products are not available. Ask students to study each product, listing the primary and any secondary functions.

Tip: *Students could follow up this activity by updating their specification with the primary and secondary functions of the product they are designing.*

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. This activity will further reinforce the differences between primary and secondary functions.

Skills activity (page 91): During this activity students study a group of products, each of which has the same primary function, but whose secondary functions result in very different outcomes aesthetically.

Students work in pairs or in small groups to compare products within a single product group. They could look at the footwear example on page 91 of the Student Book, architectural designs or any other suitable product range. They should make sketches of the products and notes to articulate their thoughts.

Form follows function: This activity helps students to put this concept into practice through design. Ask students to read the section 'Form follows function' on page 91 of the Student Book. Display or print and hand out Activity sheet B. Tell students that these products have been designed with form as the primary function. Ask them to redesign the products using the concept 'form follows function'.

Tip: *Remind students of the SCAMPER technique and encourage them to strip away any unnecessary decoration or aesthetics until only the function of the product remains.*

Knowledge check (page 91): Students can complete this at the end of the topic 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.

Team Quiz: Put students in two teams. As quiz master, ask each team questions from the Interactive activity:

Are the following primary or secondary functions:
A bass guitar should be easy to store. (secondary)
A refrigerator should keep food and drink cool and fresh. (primary)
A pair of sports shoes should look fashionable. (secondary)
A cereal bowl should be easy to clean. (secondary)
A travel plug should have multiple sockets. (primary)
A can opener should allow the user to open a can easily. (primary)
Luggage should be easily identified at the airport. (secondary)
A torch should allow users to see in the dark. (primary)
A games controller should be wireless. (secondary)
A child's cot should prevent the child from falling out of it. (primary)
A pencil sharpener should open to remove the pencil shavings. (secondary)

Record scores. You could give the winning team a prize.

Answers to Student Book activities

Skills activity (page 91)

Suitable products to compare include: footwear, kitchen knives, earphones and desk lights.

Students identify how the different secondary functions affect the aesthetics. In the footwear example in the Student Book the primary function is to protect the feet. The secondary functions of the different types of footwear include: providing comfort; breathability; moisture absorbency; elasticity; water resistance; impact resistance; raising the height of the user; and being easy to polish.

Knowledge check (page 91)

1. What is the primary function of a product? (1)

It is the main job it is designed to do.

2. What is the secondary function of a product? (1)

It is an additional function that may relate to cleaning, maintenance, styling and storage, etc.

3. Why do designers need to consider secondary functions? (1)

To give a product additional functionality or aesthetics, or to make it stand out from other products.

Total: 3 marks

1.8 Product design application

1.8.7 Aesthetics

Learning objectives

By the end of this unit students should:

- understand the relevance of aesthetics in terms of line, shape, form, proportion, space, colour and texture in their design solutions and in the work of others.

Resources

Student Book pages 92–93
Activity sheet A (available online on Collins Connect)
Cameras or smartphones for taking photos
Access to Collins Connect for Interactive activity
Creative homework 1.8.7 (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 1.8.7.

One or two lessons should be devoted to this unit.

Lesson starter suggestions

What is aesthetics?: Ask students to think of a product they use often or are passionate about. Ask them to discuss with a partner why this product is important to them. They should consider the following: What does the product look like? Does it have any secondary functions? What role did aesthetics play in their purchase of the product? You could write these questions on the board for students to refer to. Feed back as a class.

Main lesson activities

Interactive activity: Ask students to read about aesthetic elements in design on pages 92–93 of the Student Book before doing this activity.

Aesthetics moodboard: Ask students to read about aesthetic elements in design on pages 92–93 of the Student Book. Allow them to look for these aspects around the school, in the school grounds or in the classroom and to take photographs of these elements. Demonstrate good visual skills such as looking at detail, framing detail and standing back and seeing ‘the big picture’. Students then collate images as a moodboard.

Tip: *It is good practice to encourage students to source their own material out of class, but you may want to limit this to an internet image search if school policy or logistics make the activity difficult.*

Using aesthetics in design: Display or print and hand out Activity sheet A, which shows different products. Ask students if they remember what ‘form follows function’ means. Explain that the products shown follow this principle; in other words, aesthetics was not considered as important as function when these products were designed. Ask students to redesign these products using the moodboard they produced in the previous activity.

Tip: *Students could use the viewfinder from Activity sheet B from Unit 1.8.3 to help with this activity.*

Skills activity (page 93): Students work individually, in pairs or in small groups. They have to choose two designers from the list or two of their own, and critically compare their work. They should use the internet to research each designer. Indicate to students how their research should be presented. A presentation board, a slideshow, a poster for classroom display or a research page in sketchbooks would all be good methods for recording and presenting research.

Knowledge check (page 93): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Presenting research: Students can present their comparison of two designers from the Skills activity on page 93.

Creative homework 1.8.7: This is a good interdisciplinary research task that looks at the golden ratio and the Fibonacci sequence. Ask students to do the research for the creative homework.

Answers to Student Book activities

Skills activity (page 93)

Look for reference to the aesthetic elements (shape, form, proportion, balance, symmetry, pattern, colour and texture) outlined on pages 92–93 of the Student Book.

Knowledge check (page 93)

1. In your own words, define 'style'. (2)

Style is a personal preference towards a certain aesthetic. It is the interaction of aesthetic elements such as shape, form, pattern, texture, colour and proportion, and is constantly changing.

Award 2 marks for a good explanation.

Award 1 mark for a poor or confused explanation.

2. Explain why balance and symmetry are important in design. (2)

Balance is important so that parts, images and components look correct against other aspects of the design. (1) Symmetry is also important and both symmetry and asymmetry make things more interesting. (1)

3. In what ways can colour be used in design to change products? (2)

It can be used for functional reasons, for gender or cultural reasons, and to enhance styling using tints / contrasting colours / warm and cool colours.

Award 2 marks for a good explanation that refers to two or more of the points above.

Award 1 mark for an explanation that refers to only one of the points above.

Total: 6 marks

1.8 Product design application

1.8.8 Style and design movements

Learning objectives

By the end of this unit students should:

- understand the basics of style
- understand the principal design movements.

Resources

Student Book pages 94–96
A range of modern, classical, functional and hi-tech products
Access to ICT and design software and printer for printing work
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 1.8.8.

One lesson should be sufficient for delivering this unit. Encourage students to allow their own design work to be influenced by their study of design history and associated styles.

Lesson starter suggestions

Styles: Put students in groups and assign a different style – classical, modern, functional and hi-tech – to each group. (Refer to page 94 of the Student Book.) Ask students to look around the room for products that fit these styles and place them on the table in front of them. Then ask them why they have categorised the products in a particular way and encourage further discussion on products that may fit into more than one category.

Tip: *This activity is dependent on the availability of resources. You could use photos of products instead.*

Main lesson activities

Design history: This is a good research task that students complete on their own. You may want to teach pages 95–96 of the Student Book or ask students to read them before they begin. Ask students to choose a design movement from the ones in the Student Book, or assign them a design movement. Using the library or the internet, students should research their design movement and then create a poster as a resource for the classroom wall. The poster should include the style of the movement, the main designers involved, dates, example products and any other useful information. The poster should also be in the visual style of the movement researched.

Tip: *Assigning design movements will ensure an even spread. Letting students choose may result in a skew towards one particular style.*

Tip: *Ask students to create a poster using Adobe Photoshop, Adobe Illustrator or other design software to help them practise their ICT, CAD and layout skills.*

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.

Skills activity (page 96): Students work individually, in pairs or in small groups to do the activity.

Tip: *This activity could be given as homework.*

Knowledge check (page 96): Students can complete this at the end of the topic or for homework.

Plenary suggestions

In the style of …: Hold up a product and ask students to sketch a quick redesign of it in the style of one of the design movements in this unit.

Now and next: Considering some recent products, students discuss what design movement we are in now. It could be fun for them to coin a name for this movement. You may even want to encourage them to consider what will come next.

Answers to Student Book activities

Skills activity (page 96)

There is a wide range of possible answers. This is a difficult task, so do not penalise students for not identifying a product for each category.

Knowledge check (page 96)

1. Explain why it is important to look at the work of past designers in your own creative work. (4)

It is important for inspiration; by looking at what has been done already, new and innovative ideas may emerge.

Award 3–4 marks for a good answer that includes most of the points above.

Award 2 marks for an answer that outlines one of the points above.

Award 1 mark for a one-word answer.

2. When we talk about style, what are we considering when it comes to products? (2)

effective and innovative use of materials; careful consideration and use of colour; texture; how the product feels; the product's aesthetic value; its shape and form

Award 2 marks for an answer that includes two of the points above.

Award 1 mark for an answer that includes one of the points above.

3. Look at the style and design movements again and choose one of the products photographed. From the information given, explain why you think it fits into that design movement. (4)

Award 4 marks for a good description of the product in relation to the design movement, e.g. for the Art Nouveau lamp, the student could comment on the organic leaf pattern, the green colour (symbolising nature) and the curved lines of the base.

Award 3 marks for an answer showing some understanding of the product in relation to the design movement.

Award 2 marks for an answer showing limited understanding of the product in relation to the main elements of the design movement.

Award only 1 mark if the explanation does not relate to the design movement.

Total: 10 marks

1.8 Product design application

1.8.9 Using models to test proposals

Learning objectives

By the end of this unit students should:

- understand the importance of anthropometrics and ergonomics in design
- be able to use models to test proposals.

Resources

Student Book pages 97–98
Activity sheet A (available online on Collins Connect)
Product testing videos on YouTube; projector or interactive display
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 1.8.9.

This unit overlaps with Unit 1.4.1; therefore you may wish to combine these two units when you deliver the content for testing models. Unit 1.8.9 is best delivered when students are creating models so as to give them an overview of how the models can be tested successfully. Additionally, students can use these concepts to design a test for their final product. One lesson is required to deliver this unit.

Lesson starter suggestions

Evaluation techniques: In pairs, students discuss what evaluation techniques they have conducted or heard of so far that involve feedback. Feed back as a class and in particular focus on user trials, focus groups, questionnaires and field testing.

Product testing videos: There is a series of videos called Product Testing Institute by Sony Ericsson on YouTube, which are light-hearted but informative. You could select one of these to introduce the concept of testing and to engage students in a discussion on how and where products are tested.

Main lesson activities

Designing tests: Print and hand out Activity sheet A to pairs of students. Ask them to identify the user group or target market for the product and then to design a test or series of tests to enable the designer to get feedback for improvements. They should consider who to involve, where the test should be conducted and any equipment required. They should also think of questions they could ask the user. There are example answers in the Activity sheet A notes.

From design to models to testing: Ask students to look at a model they have made for their project, choose one idea and design a test involving feedback. Then ask them to consider who should test it, where to test it and what questions to ask.

Tip: *Students could undertake this test on a model or final product and use the data to inform the evaluation against specification.*

Interactive activity: This activity will help to reinforce students' understanding of the differences between inclusive and exclusive design. They can read about inclusive and exclusive design on page 98 of the Student Book before doing this activity.

a home telephone for the visually impaired, with large buttons and digits that are easy to identify (inclusive)

Record scores. You could give a prize to the winning team.

Answers to Student Book activities

Skills activity (page 98)

A possible answer should include the application of the data gathered to the product being designed. For example, the mobile phone should be a suitable width to fit in the palm of the hand; the main button should be in a position where it is accessible to the thumb; and the volume buttons should be accessible to the fingers.

Knowledge check (page 98)

1. How does modelling a design help its development? (2)

The designer gets a sense of scale (1) and a 3D view of an object (1).
The product can be held and felt (1), and it can be tested by a range of users (1).

Award 2 marks for an answer that includes two of the points above.

2. What is an ergonome and how can it help you when designing? (2)

It is a scaled model of a human (1) and it can be used to test models for ergonomics (1).

Total: 4 marks

1.8 Product design application

1.8.10 Modelling

Learning objectives

By the end of this unit students should:

- understand the need to model and test proposals.

Resources

Student Book pages 99–100
Student Book, Unit 1.2.1 (pages 20–25) and Unit 1.2.2 (pages 26–29)
Activity sheet A (available online on Collins Connect)
Samples of models and prototypes, including resources used in the process of testing
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 1.8.10.

Modelling has already been covered in detail in Units 1.2.1 and 1.2.2, so Unit 1.8.10 is best delivered in conjunction with them. Students should be exposed to a range of modelling materials, processes and joining methods, and if possible given time to play or experiment with them before conducting their own modelling. Some ideas for such activities are in the lesson plans for Units 1.2.1 and 1.2.2.

Lesson starter suggestions

The importance of modelling an idea: Source a range of models and prototypes that have been made by students. Ask students to list the construction materials and the processes that were used to create each model. Then ask them what could be tested with each model and get them to apply some of the theory from previous units.

Main lesson activities

Advantages and disadvantages of types of modelling: Ask students to read pages 99–100 of the Student Book and look at the photos. Print and hand out Activity sheet A and ask students to discuss the advantages and disadvantages of hand modelling and CAD modelling. Refer to the Activity sheet A notes for possible answers and feed back as a class.

Practical tasks: Students should be given time to develop both hand modelling and CAD modelling skills. You can refer to the teaching notes for Units 1.2.1 and 1.2.2 for ideas for practical activities for modelling.

Skills activity (page 100): Students work individually, in pairs or in small groups to do the activity.

Tip: *This activity could be given for homework.*

Knowledge check (page 100): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Team building game: Put students in groups of five. Give each group five sheets of A4 paper and scissors. Students work together to build the tallest tower. Set a time limit for this; 5–10 minutes would be a reasonable time to complete the task.

Tip: *If there is time, you could discuss which skills were needed to build the tower and how could students could have done better.*

Interactive activity: Students drag and drop the different forms of modelling and sketching to their likely place on the design cycle.

Answers to Student Book activities

Skills activity (page 100)

Possible answers: footwear, electronic devices, car bodies, building designs and architecture

Knowledge check (page 100)

1. Give five benefits of modelling designs. (5)

Possible answers: You can see the design in 3D. Some people cannot 'read' drawings. You get a sense of scale. You can show the designs to clients. They are useful for marketing purposes. They can be used for testing.

Award 1 mark for each answer (to a maximum of 5).

2. Name five materials that can be used for modelling designs. (5)

Possible answers: clay; Styrofoam; MDF; modelling foam; polymorph; card or paper; corrugated card; tubes; wire; string; masking tape; polypropylene; foam board; acrylic; balsa wood

Award 1 mark for each answer (to a maximum of 5).

Total: 10 marks

1.9 Environment and sustainability

1.9.1 Forms of energy

Learning objectives

By the end of this unit students should:

- know about a range of conventional energy forms
- know about a range of alternative energy forms
- understand the difference between finite and infinite sources of energy.

Resources

Student Book pages 101–107
Activity sheets A–C (available online on Collins Connect)
Samples of natural and manufactured materials; samples of different products made of materials that can and cannot be recycled
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 1.9.1.

This is a significant unit and a minimum of three lessons should be devoted to it. A suggested lesson progression would cover types of energy, strategies for designers, and a lesson for students to apply this knowledge to their own design projects.

Lesson starter suggestions

Energy types: Students work as a group to brainstorm as many energy sources as they can. As an extension, ask them to categorise the sources as renewable or non-renewable.

Tip: *Make sure students understand that electricity is not an energy source; it is a type of power that can be generated from an energy source such as wind, the Sun or coal.*

Main lesson activities

Energy research task: Put students in four groups. Ask two of the groups to research renewable energy and its advantages and disadvantages. The other two groups research non-renewable energy and its advantages and disadvantages. The groups then report back their findings to the class.

Tip: *Possible outcomes for this activity could be a presentation board, poster or slideshow.*

Conventional and renewable energy sources: Using their sketchbooks, work journals or Activity sheet A, students consider each energy source, determine its origin, state if it is finite or renewable, and list the advantages and disadvantages of each.

Infographic: An infographic is a way of presenting information or data using easily comprehensible graphics or symbols and only a limited amount of text. Ask students to read about efficient and effective use of energy on page 103 of the Student Book and then produce an infographic to help consumers to make the right choices on how to conserve energy.

Tip: *Students could create the infographic by hand or by using graphic design software.*

Efficient and effective use of energy sources: In pairs or in small groups, students discuss and compile a list of their own energy use throughout the day. They then consider and explore ways in which they could reduce their energy consumption. Discuss the outcomes as a class.

Skills activity (page 103): Students look at the countries and discuss which energy sources are used there and why.

Materials recycling: Ask students to find out how different materials are recycled. You could assign different materials to different groups of students, e.g. paper, metal, plastics and wood. The best resource for this is the internet and if students find any good websites or videos, they can share them with the rest of the class or upload them to the school virtual learning environment for revision.

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.

Skills activity (page 105): Students discuss the environmental impact of throwing away batteries and potential solutions to the problem. Share ideas as a class.

Disassembly: Disassembly is an excellent practical task that will help students to understand some of the concepts in this unit. Provide students with a small handling sample of commercially available products and/or a variety of packaging that utilise a range of materials in their construction. Students work individually or in pairs to disassemble the products and list the materials and joining methods used in each. They should also consider if the design of the product allows it to be recycled and repaired easily, and they should justify their conclusions. You may need to provide tools to help students to disassemble. You could print and hand out Activity sheet B, which has prompts on what to consider. In the Activity sheet B notes there is a visual example that you can share with students or discuss beforehand.

Tip: *Small electronic products are good for disassembly tasks.*

Tip: *Disassembly can get messy. Provide gloves and goggles to protect students from harm.*

Skills activity (page 107): This is a good activity for students to consider which materials can be recycled or which cannot.

Planned obsolescence: Ask students to read about disassembly, planned obsolescence and materials recycling on page 106 of the Student Book. Print and hand out Activity sheet C. Ask students to discuss the advantages and disadvantages of planned obsolescence and to complete the table on the activity sheet. There are possible answers in the Activity sheet C notes.

Designing for or against planned obsolescence: This design task could follow on from the disassembly activity. Students work as a group to redesign the product they have disassembled. They should decide whether to embrace or reject planned obsolescence – this is a moral decision. They should also consider the durability of the materials and the joining methods (non-permanent methods make it easier for the product to be repaired or recycled).

Tip: *Encourage students to use some of the communication techniques they learnt in Unit 1.2.4. In particular, exploded drawings would be good for this task.*

Design in action: Practical Action (practicalaction.org) is a charity that supports poor people all over the world and uses sustainability as the foundation for their charity work. Ask students to work in pairs or small groups to research the work of this group. They should then present their findings to the class for discussion.

Knowledge check (page 107): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Considering sustainability in the specification: A good plenary would be for students to update the design specifications for their project by modifying or adding a sustainability point. Applying the theory to their own design situation will help them to consolidate what they have learnt.

Tip: *Encourage students to consider joining methods, removable batteries, design for disassembly and materials.*

1. Name four sources of renewable energy. (2)

*w*ind, solar, tidal, geothermal, hydro, biomass

Award half a mark for each source named.

2. Name ways in which we can make more efficient use of energy to reduce our consumption. (4)

Possible answers: switch off appliances when they are not in use; buy low power products; do not buy products if you do not need them; turn down the heating or use natural ventilation instead of air conditioning

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

3. What three of the six R's are the most recent? (3)

rethink (1), reuse (1), repair (1)

4. What are the advantages of making products that can be disassembled? (6)

Possible answers: take-back policy forced on manufacturers; more facilities to provide consumers with recycling options; more education about the environmental impact of throwing away batteries; a complete rethink of batteries so that toxic chemicals are no longer used in their production

Skills activity (page 107)

Possible answers:

Materials that *can* be recycled	**Materials that *cannot* be recycled**
paper	thermosetting plastics
card	film plastic such as plastic bags
metal: aluminium and steel	aerosol cans
thermoplastics	composite materials
glass	
electronic items	
clothing	

Knowledge check (page 107)

1. Name four sources of renewable energy. (2)

*w*ind, solar, tidal, geothermal, hydro, biomass

Award half a mark for each source named.

2. Name ways in which we can make more efficient use of energy to reduce our consumption. (4)

Possible answers: switch off appliances when they are not in use; buy low power products; do not buy products if you do not need them; turn down the heating or use natural ventilation instead of air conditioning

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

3. What three of the six R's are the most recent? (3)

rethink (1), reuse (1), repair (1)

4. What are the advantages of making products that can be disassembled? (6)

The materials can be easily separated for recycling. The battery can be replaced when it fails. The appliance can be repaired easily if it fails. It encourages consumers to repair products instead of throwing them away. It extends the life of the product. Less raw materials and energy are wasted. It minimises the amount of toxic chemicals and other pollution released into the ground and air. The manufacturer can reuse components instead of remanufacturing them.

Award 1 mark for each point (to a maximum of 6).

5. What is meant by 'planned obsolescence'? (2)

It is the practice of designing a product with a limited life. / It is the practice of designing a product to fail or be replaced after a set time.

Award 1 mark for mentioning a product with 'a limited life' or 'designed to fail'. Award 1 mark for an example.

Award 1 mark for mentioning a product with 'a limited life' or 'designed to fail', but no example.

Total: 17 marks

2.1 Formal drawing techniques

Orthographic, isometric, planometric and perspective

Learning objectives

By the end of this unit students should:

- be familiar with a range of formal drawing techniques, including first- and third-angle orthographic projection, isometric, planometric and estimated two-point perspective
- understand how to use British Standards correctly.

Key terms

British Standards, crating, dimensions, first-angle projection, hidden detail, isometric, orthographic drawing, orthographic projection, planometric, scale, third-angle projection, estimated two-point perspective

Resources

Student Book pages 110–114
Activity sheets A–H (available on Collins Connect)
Compass, drawing board and clips (if available), 45° and 30/60° set squares, pencil, eraser
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 2.1.

As with all technical drawing, mastery comes with practice. Give students plenty of time to practise formal drawing methods using the activity sheets as scaffolding to build skills. A minimum of four one-hour lessons should be devoted to this unit: two lessons for orthographic drawing and one each for isometric/planometric and estimated two-point perspective.

***Tip:** When printing A3 activity sheets, do not fit to page as this will reduce the scale.*

Lesson starter suggestions

Class discussion: Display or print and hand out Activity sheet A. Ask students to discuss in pairs where they may have seen these types of drawings before. Feed back as a class and ask students if they know the correct names of any of the drawings. Answers may include: a floor plan produced by an estate agent, an exploded drawing in assembly instructions for furniture, an isometric drawing in a sketchbook, etc.

Skills activity (page 111): This activity should give students a good idea of what an object looks like in 2D from different views. Do not be strict about accuracy; freehand sketching is fine. As an extension, ask students to guess what the object is from one of the drawn views.

Practising using equipment: You can use this activity to get students used to setting up a drawing board and using clips to hold A3 paper. Follow up with a short demonstration on how to use the parallel motion bar along with 45° and 30/60° set squares. Ask students to draw cubes and cuboids in a variety of sizes using 45° and 30/60° set squares on a sheet of paper. You may need to demonstrate this first.

Main lesson activities

Orthographic drawing

Discussion and note-taking (whole class): Use page 110 of the Student Book to introduce the key concepts of orthographic drawing. Make sure students are familiar with the key terms and understand the difference between first- and third-angle projection.

Student activity (1): Print and hand out Activity sheet B (A3 landscape). Students fill in the details as shown in the Activity sheet B notes. Ask students: a) if the drawing is first- or third-angle projection and then to complete the symbol in the top right-hand corner; b) to label the views; c) which parts of the drawing are missing. Show them how to project lines from the front view to the plan to complete the plan. Emphasise that projection lines should be light. Also show them how to draw a 45° line and project lines from the plan to the end elevation to complete the end elevation. Refer to the Activity sheet B notes.

Student activity (2): Print and hand out Activity sheet C (A3 landscape). Students fill in the details as shown in the Activity sheet C notes (leave the scale). Ask students: a) if the drawing is first- or third-angle projection and to complete the symbol in the top right-hand corner; b) to label the views; c) which parts of the drawing are missing; d) to complete the drawing. Refer to the Activity sheet C notes. This activity gives students an opportunity to practise first-angle orthographic.

Interactive activity: Use the Interactive activity to help students to understand British Standards.

Student activity (3): Use page 113 of the Student Book to explain scale and dimensions. Ask students to add the scale and important dimensions in British Standards to Activity sheets B and C. Make sure they practise using the diameter symbol as well as regular dimension lines.

Skills activity (page 112): This activity gives students practice in constructing an orthographic third-angle projection. Ask students to do the activity on a sheet of A3 paper. Alternatively, print and hand out Activity sheet D (A3 landscape). For additional practice in British Standards, students can add relevant dimensions. Dimensions can be added using British Standards.

Isometric and planometric drawing

Discussion and note-taking (whole class): Use pages 112–3 of the Student Book to introduce the key concepts of isometric and planometric drawing. Make sure students are familiar with the key terms and understand the difference between the two types of drawing.

Student activity: Print and hand out Activity sheet E. Students use 30/60° set squares to draw each shape in isometric. Before they draw the last two shapes, they can practise drawing isometric circles referring to page 113 of the Student Book. Repeat with 45° set squares for planometric.

Tip: *Have students lightly draw a crate the full width, length and height of each shape first.*

Estimated two-point perspective drawing

Discussion and note-taking: Use page 113 of the Student Book to introduce the key concepts of estimated two-point perspective drawing. Make sure students understand the terms ‘horizon line’ and ‘vanishing point’.

Student activity (1): Print and hand out Activity sheet F (A3 landscape). Use the Activity sheet F notes to teach students how to build up an estimated two-point perspective drawing in stages.

Student activity (2): Students can try to draw each shape in Activity sheet E using estimated two-point perspective. Note that it is not necessary for students to use correct dimensions; all sizes should be estimated.

Tip: *Have students lightly draw a crate the full width, length and height of each shape first.*

Knowledge check (page 155): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Define it: Print and cut 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.

Exit tickets: Print two copies of Activity sheet H. Cut one copy into cards and keep the other copy for reference. Give one card to each student and tell them you have given them an isometric, a plan, a front elevation or an end elevation. Each set of four students who group together successfully can leave at the end of the lesson. Some students may not have a match; these students have the 'jokers'.

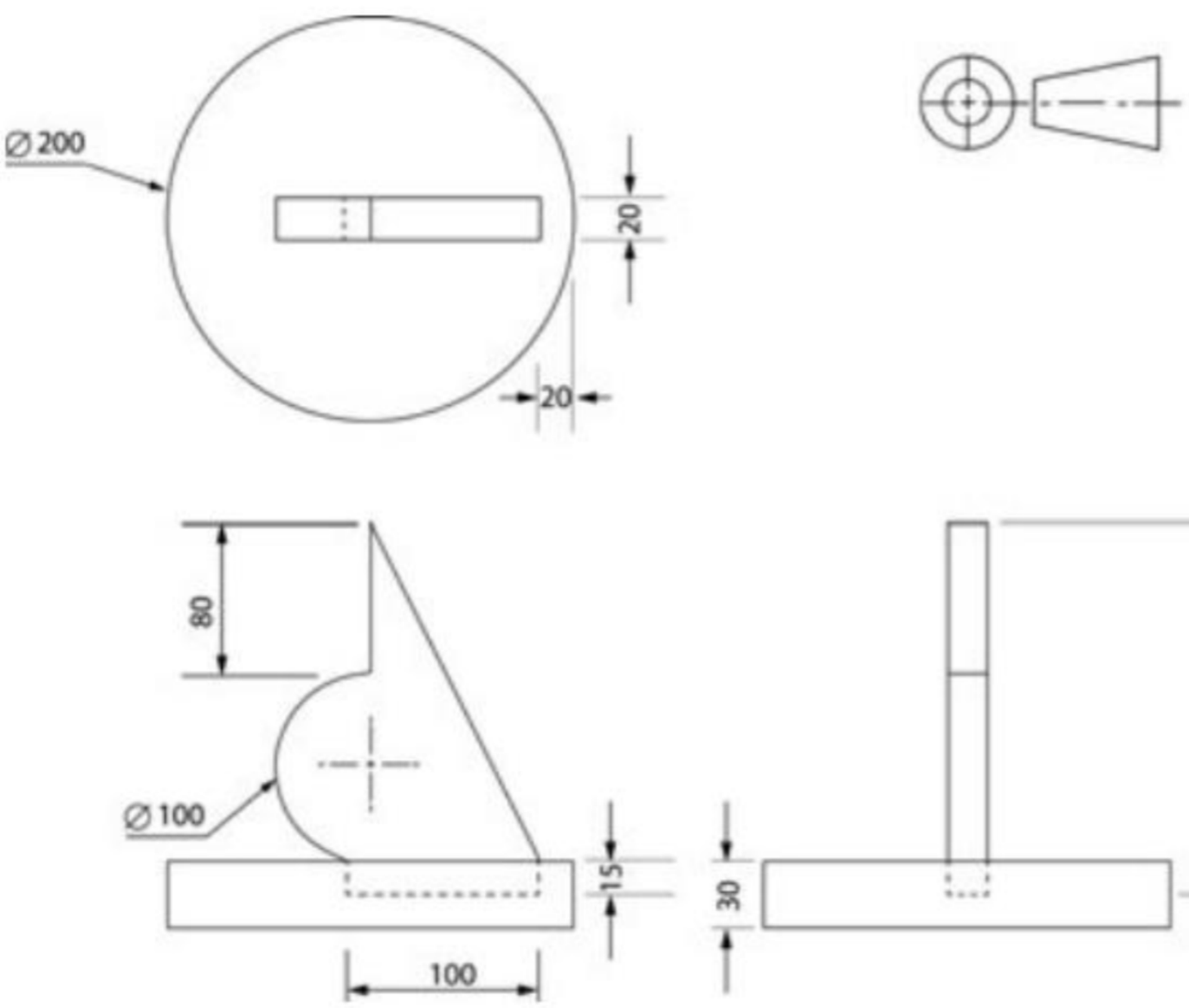
Answers to Student Book activities

Skills activity (page 111)

Look out for common mistakes such as drawing in 3D; emphasise to students that closing one eye when they draw can help to avoid this.

Skills activity (page 112)

Hidden detail should be shown with dotted lines. Dimensions do not need to be drawn exactly as in the example, but care should be taken in applying British Standards. The correct symbol for third-angle projection should be added.



Knowledge check (page 114)

1. What tools can be used to draw isometric and planometric? (1)

set squares: 60° and 30° for isometric; 45° for planometric

2. Draw the symbols for first- and third-angle orthographic projection. (2)

Award 1 mark for each.



3. Explain what is meant by 'hidden detail'. (4)

Hidden detail shows the parts of an object that cannot be seen if you look at the object from a given view because other solid parts of the object obscure them. (2) Examples could be holes or slots in an object. (1) Hidden detail is shown as a dotted line. (1)

Total: 7 marks

2.2 Sectional views, exploded drawings and assembly drawings

Learning objectives

By the end of this unit, students should:

- be able to construct different types of sectional views
- be able to construct exploded and assembly drawings.

Key terms

assembly drawing, cutting plane, exploded drawing, sectional view

Resources

Student Book pages 115–119
Activity sheets A–J (available on Collins Connect)
Compass, drawing board and clips (if available), 45° and 30/60° set squares, pencil, eraser
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 2.2.

A minimum of three one-hour lessons should be devoted to this unit: two lessons for practising sectional views and one for exploded/assembly drawing.

Lesson starter suggestions

Class discussion (sectional drawing): Display or print and hand out Activity sheet A. Ask students to imagine or sketch what they would see if the fruit were cut down the middle. The answers are in the Activity sheet A notes. Explain to students that a sectional view is often used to show the interior of an object, as if a part has been cut away.

Class discussion (exploded and assembly drawing): Display or print and hand out Activity sheet F. Ask students where they might see an exploded drawing like this and how it helps people. Then ask them what additional information may be helpful, e.g. parts list, numbering.

ICT: If students have access to SketchUp Make, they can practise drawing shapes and use the section cut tool to see what the shapes look like as a section.

Main lesson activities

Sectional views

Discussion and note-taking (whole class): Use pages 115–116 of the Student Book to introduce the concepts of sectional views. Make sure students are familiar with the key terms and different types of sectional views.

Student activity (1): Print and hand out Activity sheet B (A3 landscape). Ask students: a) to identify the front and plan views on the pictorial drawing; b) to add hidden detail to the plan view; c) to visualise what

the display stand would look like if cut down the middle. Students complete the sectional view to the right of the front view. They then add dimensions. See the Activity sheet B notes for answers.

Tip: *When drawing sectional views, hidden detail is not required.*

Student activity (2): Print and hand out Activity sheet C (A3 landscape). Ask students: a) to fill in the details at the bottom of the activity sheet; b) to identify the front and plan views on the pictorial drawing; c) to visualise what the display stand would look like if cut down the middle. Students complete the sectional view to the right of the front view. See the Activity sheet C notes for answers.

Tip: *When drawing sectional views, hidden detail is not required.*

Student activity (3): Print and hand out Activity sheet D (A3 landscape). Ask students: a) to fill in the details at the bottom of the sheet; b) to identify the front and plan views on the pictorial drawing; c) to visualise what the display stand would look like if a quarter was cut away as shown on the plan view. Students complete the part sectional view to the right of the front view. See the Activity sheet D notes for answers.

Skills activity (page 117): Students can further practise sectional drawing by using an A3 page landscape to draw a sectional view of the object. If you feel scaffolding is necessary, use Activity sheet E, which will help students to start the drawing. You can ask students to add dimensions to give them further practice in British Standards.

Tip: *This activity could be given for homework.*

Exploded and assembly drawing

Discussion and note-taking (whole class): Use pages 117–118 of the Student Book to help students to understand the key concepts of exploded and assembly drawings.

Student activity (1): Print and hand out Activity sheet G. Students complete the exploded drawings using the views given. See the Activity sheet G notes for the answers.

Tip: *Crating should be used when constructing exploded drawings.*

Student activity (2): Print and hand out Activity H. Students complete the exploded drawings using the views given. This is more demanding as it requires construction of circles in isometric. See the Activity sheet H notes for answers.

Student activity (3): Print and hand out Activity sheet I. Students complete the assembly drawings using the views given. This is more demanding as it requires construction of circles in isometric. See the Activity sheet I notes for answers.

Skills activity (page 119)) Students can further practise exploded drawing by using an A4 page landscape to draw an exploded view of the object.

Tip: *This activity could be given for homework.*

Interactive activity: This activity will help students to reinforce their understanding of the drawings in this unit.

Knowledge check (page 119): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Define it: Print and cut out Activity sheet J, 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.

Top tip: *List some top tips for drawing sectional/exploded/assembly.*

Test the teacher: Students take turns to hold up an object while you try to sketch a sectional drawing of the object in 10 seconds.

where the section is. This is often done for clarity in the drawing. (2) A **revolved sectional** view is used when a part of an object does not fall into line with the cutting plane. Part of the cutting plane is rotated so that the desired part is shown cut away in the sectional drawing. (2)

2. What is meant by a cutting plane? (1)

A cutting plane is the imaginary plane that slices through an object to give a sectional view.

3. Explain a context in which an exploded drawing may be used. (2)

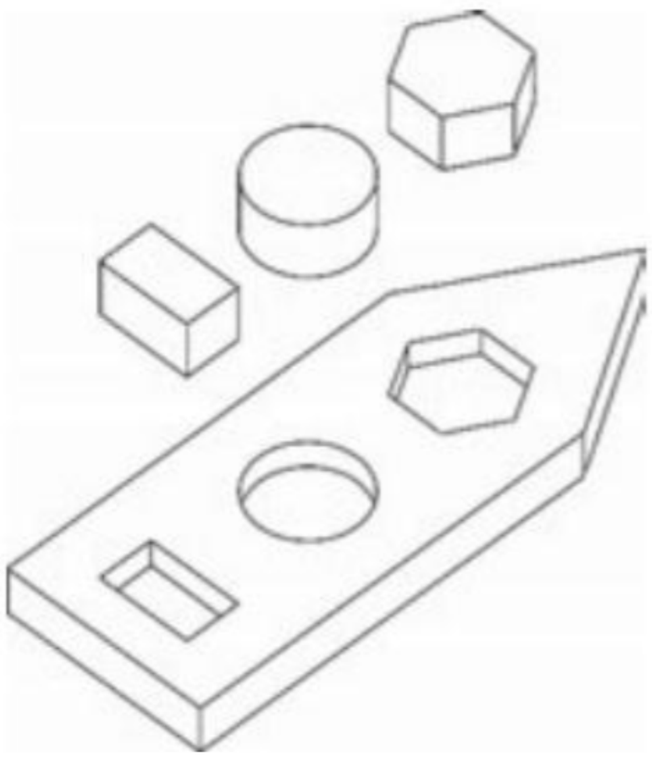
Possible answers:

- instructions for flat-packed furniture to show how and in what order parts fit together
- a technical drawing for a manufacturer to show how a product should be assembled
- instructions for a model in a modelling kit to show the stages of assembly

Award 1 mark for each example and 1 mark for a suitable explanation.

Total: 11 marks

Shapes should be shown removed and aligned correctly above the holes in the base. Drawing should be in isometric. Scale and dimensions are not important.



Knowledge check (page 119)

1. Explain the difference between sectional, part sectional, revolved sectional and removed sectional drawings. (8)

A **sectional** view shows the interior of an object as if it has been cut away to show components or parts of an interior that are hidden from view. (2) A **part sectional** view shows a part of an object cut away. This is often used when it is important to show the interior of half an object but not the remaining half. (2) A **removed sectional** view shows a sectioned part drawn off the main drawing where the section is. This is often done for clarity in the drawing. (2) A **revolved sectional** view is used when a part of an object does not fall into line with the cutting plane. Part of the cutting plane is rotated so that the desired part is shown cut away in the sectional drawing. (2)

2. What is meant by a cutting plane? (1)

A cutting plane is the imaginary plane that slices through an object to give a sectional view.

3. Explain a context in which an exploded drawing may be used. (2)

Possible answers:

- instructions for flat-packed furniture to show how and in what order parts fit together
- a technical drawing for a manufacturer to show how a product should be assembled
- instructions for a model in a modelling kit to show the stages of assembly

Award 1 mark for each example and 1 mark for a suitable explanation.

Total: 11 marks

2.3 Freehand drawing

Learning objectives

By the end of this unit students should:

- be able to sketch in a variety of ways using freehand drawing.

Resources

Student Book pages 120–121
Activity sheets A–C (available on Collins Connect)
Blank A4 paper, pencils
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 2.3.

One one-hour lesson should be enough to cover all the types of drawing in this unit, which will give students an opportunity to practise the different types of drawing they have learnt in freehand, using no tools.

Lesson starter suggestions

Equipment check: Discuss with students the different grades of pencils, H, B and HB, and what type of drawing they are suitable for. Students can look at their equipment and identify what grades of pencils they have.

Class discussion: Print and hand out Activity sheet A. Use it as a prompt for discussion. What is freehand drawing? What advantages are there in drawing freehand? Why is it important to choose the correct type of freehand drawing?

Drawing practice: Ask students to find a product in their bag or something they have brought in for homework from the last lesson, preferably something that has different parts. Then ask them to look at it and sketch an isometric / estimated two-point perspective / orthographic / sectional or exploded drawing of the product.

Main lesson activities

Discussion and note-taking (whole class): Use pages 120–121 of the Student Book to help students to understand the key concepts of drawing in freehand.

Student activity (1): Display or print and hand out Activity sheet B. Also hand out blank A4 paper. This activity will give students the opportunity to practise drawing each toy using orthographic, isometric, perspective, sectional and exploded freehand drawing techniques. Accuracy is not important; however, common mistakes include wrong angle of lines, too heavy construction lines, poorly drawn circles or ellipses and drawing that is too big. You may want to check and guide students on these aspects.

Tip: *Depending on time constraints, you may want to limit one type of drawing for each toy and set strict time limits for each drawing.*

Student activity (2): Print and hand out Activity sheet C. This activity will give students the opportunity to practise freehand drawing to represent information. They should be able to choose the best method of freehand drawing to represent the information.

Skills activity (page 121): Students draw the clock in freehand in each of the three views.

Tip: *This activity could be given for homework.*

Knowledge check (page 121): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Peer evaluation: Ask students to look at a partner's work and write one thing they have done well and one thing they can improve for each type of sketch. Suggest success criteria such as line quality, line thickness, angles of lines, use of crating, accuracy, quality of annotation and proportion of drawing to original.

Interactive activity: Students can complete the questions in class or for homework.

Answers to Student Book activities

Skills activity (page 121)

The key learning outcome here is the correct choice of drawing method for each of the tasks, not the quality or accuracy of the drawing. Students should have selected the following types of freehand drawing:

- instructions on how to assemble the hands to the clock – exploded drawing
- a redesign of the clock in a different style – isometric
- a drawing showing three sides of the clock – orthographic

Notes and annotation should accompany each sketch.

Knowledge check (page 121)

Which type of drawing would be used to produce the following? (5)

- a drawing of a torch showing interior detail?
  either orthographic *or* sectional
- design ideas of a shop sign in three dimensions?
  either isometric *or* perspective
- a sketch of chocolate packaging showing how a plastic tray is inserted?
  exploded
- a sketch of a children's playground?
  perspective
- a sketch of a living room showing the placement of furniture in the room?
  either orthographic (plan view only) *or* estimated one-point perspective

Total: 5 marks

2.4 Drawing basic shapes

Learning objectives

By the end of this unit students should:

- be able to construct a variety of regular and irregular polygons accurately
- be able to construct circles accurately
- be able to construct ellipses accurately
- be able to construct tangents and tangential arcs accurately.

Key terms

ellipse, irregular polygon, regular polygon, tangent

Resources

Student Book pages 122–126
Activity sheets A–B (available on Collins Connect)
Compass, ruler, protractor, pencil, blank paper
Access to Collins Connect for Interactive activity
Access to ICT: Adobe Illustrator or other vector graphics software

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 2.4.

A minimum of two one-hour lessons should be devoted to this unit.

Lesson starter suggestions

Class discussion: The topic of basic shapes has cross-curricular overlaps with mathematics. A good discussion would be on what students have already done or already know about shapes from studying other subjects.

Shapes dominoes: Print Activity sheet A and cut out dominoes (enough for one class). Students play dominoes in groups, matching the shapes to the names of the shapes. The rules are in the Activity sheet A notes.

Main lesson activities

Skills activity (page 122): Ask students to read page 122 in the Student Book and complete the table in the Skills activity.

Student activity (1): Ask students to follow the instructions on page 123 of the Student Book to construct a hexagon. They can also try to draw different polygons following your instructions, depending on time.

Student activity (2): Students follow the instructions on pages 124–125 of the Student Book to construct a circle and ellipses without using compasses.

Student activity (3): Students follow the instructions on page 126 of the Student Book to construct a tangent and tangential arc.

Knowledge check (page 126): Students can complete this at the end of the topic or for homework.

Possible answers: use the trammel method; use a stencil; draw two circles of major and minor axis and using intersecting lines

Award 1 mark for each correct way and 1 mark for a suitable explanation/example.

3. Explain the difference between a regular and irregular polygon. (3)

A regular polygon has equal sides (1) and equal internal angles (1).
An irregular polygon has sides and internal angles that are unequal. (1)

Total: 11 marks

Skills activity (page 122)

Answers in bold below:

Number of sides	Name	Central angle (°)
3	triangle	120
4	quadrilateral (square)	90
5	pentagon	**72**
6	**hexagon**	60
7	heptagon	**51.5**
8	**octagon**	45
9	**nonagon**	**40**

Knowledge check (page 126)

1. Explain two different ways of drawing a circle. (4)

Possible answers: use a stencil; use a compass, draw a centre point with lines intersecting

Award 1 mark for each correct way and 1 mark for a suitable explanation/example.

2. Explain two different ways of drawing an ellipse. (4)

Possible answers: use the trammel method; use a stencil; draw two circles of major and minor axis and using intersecting lines

Award 1 mark for each correct way and 1 mark for a suitable explanation/example.

3. Explain the difference between a regular and irregular polygon. (3)

A regular polygon has equal sides (1) and equal internal angles (1).
An irregular polygon has sides and internal angles that are unequal. (1)

Total: 11 marks

2.5 Developments

Learning objectives

By the end of this unit students should:

- understand what a development is and how to construct it
- be aware of a range of different developments
- be able to add constructional details such as tabs and flaps.

Key terms

development/net, flaps, tabs, truncation

Resources

Student Book pages 127–129
Activity sheets A–E (available on Collins Connect)
Drawing board and clips, pencil, ruler, protractor, blank paper; packaging examples
Access to Collins Connect for Interactive activity
Access to ICT: SketchUp
Creative homework 2.5 (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 2.5.

Understanding how developments work requires being able to visualise and think in three dimensions; this is something many people find difficult. Students should be offered opportunities for kinaesthetic learning to allow them to develop this skill. A minimum of two one-hour lessons should be devoted to this unit.

Lesson starter suggestions

Class discussion: This topic has cross-curricular overlaps with mathematics. A good discussion would be on what the students have already done or already know about three-dimensional shapes from studying other subjects.

Shape charades: This activity is a review of Unit 2.4. Students nominate each other to stand up and draw a shape learnt from that lesson in the air with their finger. The others have to guess the shape.

Practical activity: Print Activity sheet A and cut out the developments (or get students to do it) so that each student has a development. Explain that the flattened shapes are called developments. Ask students if they can tell what shapes these will be when assembled in three dimensions. Also explain that a dashed line is a fold line. Students cut out and assemble their developments.

Tip: *More able students could draw glue flaps/tabs before cutting out the developments.*

Tip: *As an extension, you could ask students to sketch the development of their assembled shape.*

Main lesson activities

Skills activity (page 127): Ask students to read page 127 of the Student Book and do the Skills activity.

Interactive activity: Students do the Interactive activity showing the different parts of packaging.

Practical activity: Provide students with a range of packaging and ask them to disassemble it and identify glue tabs/flaps, tuck flaps and dust flaps.

Design in action (page 128): Ask students to read about how packaging is made and assembled in quantity. A supporting video of packaging die cutting / gluing / assembly would help students to understand this process.

Student activity (1): Print and hand out Activity sheet B. Ask students to complete the questions. See the Activity sheet B notes for the answers.

Student activity (2): Print and hand out Activity sheet C. Ask students to complete the questions. This will allow them to practise some of the skills they learnt in Unit 2.4. See the Activity sheet C notes for the answers.

Skills activity (page 129): Students complete the activity. This will help them to visualise developments with tabs and flaps. Accuracy is not important.

Knowledge check (page 129): Students can complete this at the end of the topic or for homework.

ICT: If students have access to SketchUp Make, a plugin called Flattery is available. It allows students to create 3D shapes, flatten the sides and add tabs and flaps. This is a good exercise in creating developments.

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.

Paired activity: One student draws a 3D shape and the other draws the development.

Research task: Students conduct research on the internet into interesting packaging shapes and present their findings to the class.

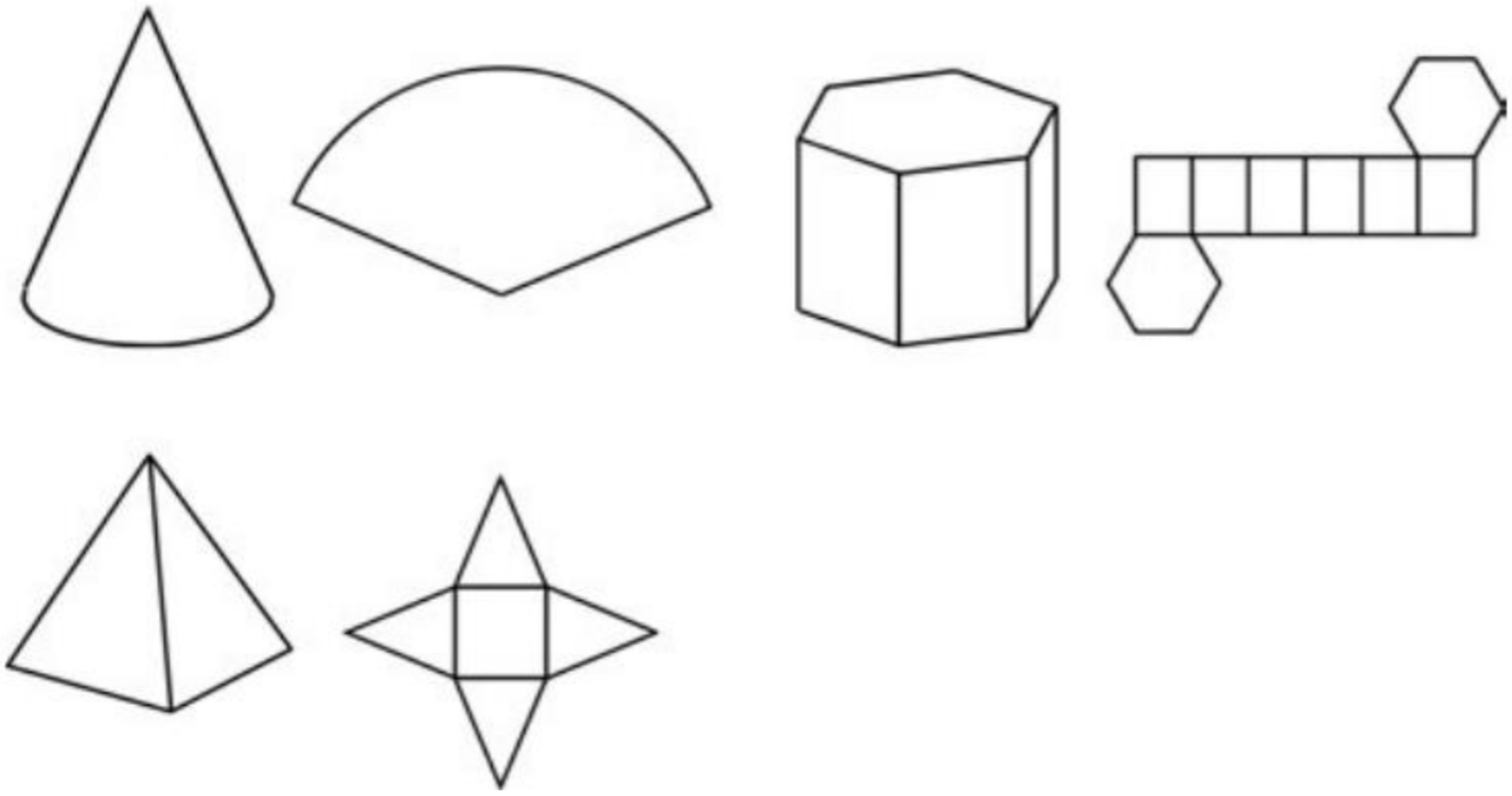
Odd one out: Print and hand out Activity sheet E. Students try to identify which development is the odd one out. See the Activity sheet E notes for the answers.

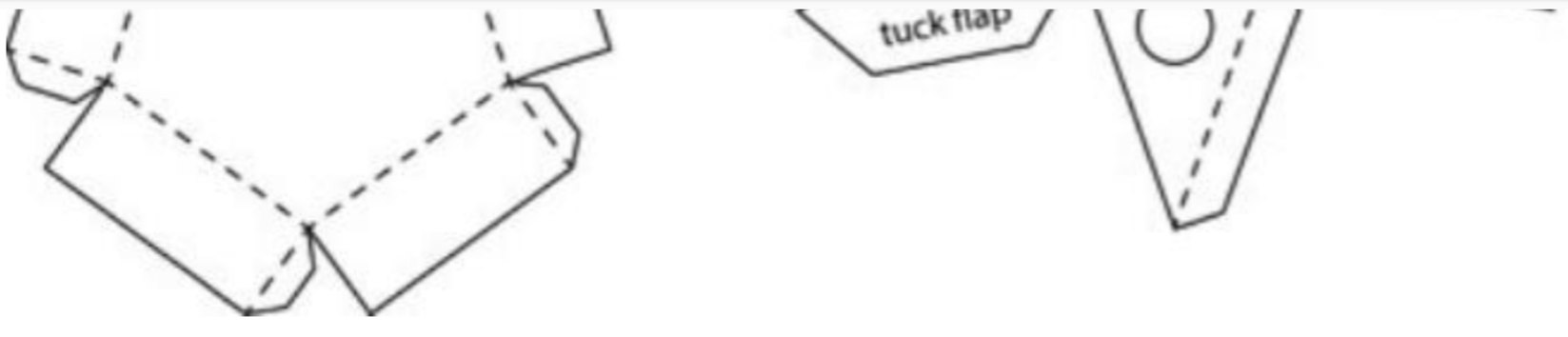
Tip: *This could be done in pairs or presented on the board as a class quiz.*

Creative homework: Students complete the task on truncations.

Answers to Student Book activities

Skills activity (page 127)





Knowledge check (page 129)

What is the purpose of adding the following to a development?

1. dashed lines (1)

to indicate an edge that should be folded

2. glue tabs (1)

to allow two sides to be adhered together

3. dust flaps (1)

to prevent any openings in the package where dust or other particles can enter

4. tuck flaps (1)

to allow the lid or a side to stay secure when closed

Total: 4 marks

2.6 Enlarging and reducing

Learning objectives

By the end of this unit students should:

- be able to enlarge and reduce circles
- be able to enlarge and reduce irregular and regular polygons
- be able to enlarge text
- be able to enlarge and reduce using estimated one-point perspective.

Resources

Student Book pages 130–133
Activity sheet A (available on Collins Connect)
Drawing board and clips, pencil, ruler, protractor, compasses, blank paper
Access to Collins Connect for Interactive activity
Access to ICT for vector graphics software

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 2.6.

A minimum of one one-hour lesson should be devoted to this unit and students should be given the opportunity to practise both enlarging and reducing shapes and text.

Lesson starter suggestions

Interactive activity: Students do the quiz, which tests relevant mental arithmetic skills in preparation for the lesson.

Review of basic shapes: You could review how to draw basic shapes (see Unit 2.4) if you feel this is necessary. Ask students to list the steps and equipment required to draw circles, ellipses and regular and irregular polygons.

Main lesson activities

Student activity (1): Print and hand out Activity sheet A. Ask students to read pages 130–131 of the Student Book about how to enlarge and reduce circles and regular polygons. They then complete questions 1–2 in Activity sheet A.

Student activity (2): Ask students to read page 131 of the Student Book about how to enlarge and reduce text and irregular polygons. They then complete question 3 in Activity sheet A.

Student activity (3): Ask students to read pages 132–133 of the Student Book about how to enlarge and reduce shapes using estimated one-point perspective. They then follow the steps on blank paper.

Skills activity (page 135): Students complete the Skills activity. This will provide further practice in enlarging.

Knowledge check (page 135): Students can complete this at the end of the topic or for homework.

ICT: Using vector graphics software, students can draw a variety of shapes and investigate how to accurately enlarge and reduce them using the scale tool.

Plenary suggestions

Design in practice: Ask students to think about logo design and discuss why it is necessary to enlarge or reduce logos. Feed back to the class and elicit that logos need to be seen in different contexts, e.g. on a business card, poster or website.

Paired task: Using grid paper one student sketches a shape and the other enlarges or reduces it to a scale specified by the first student.

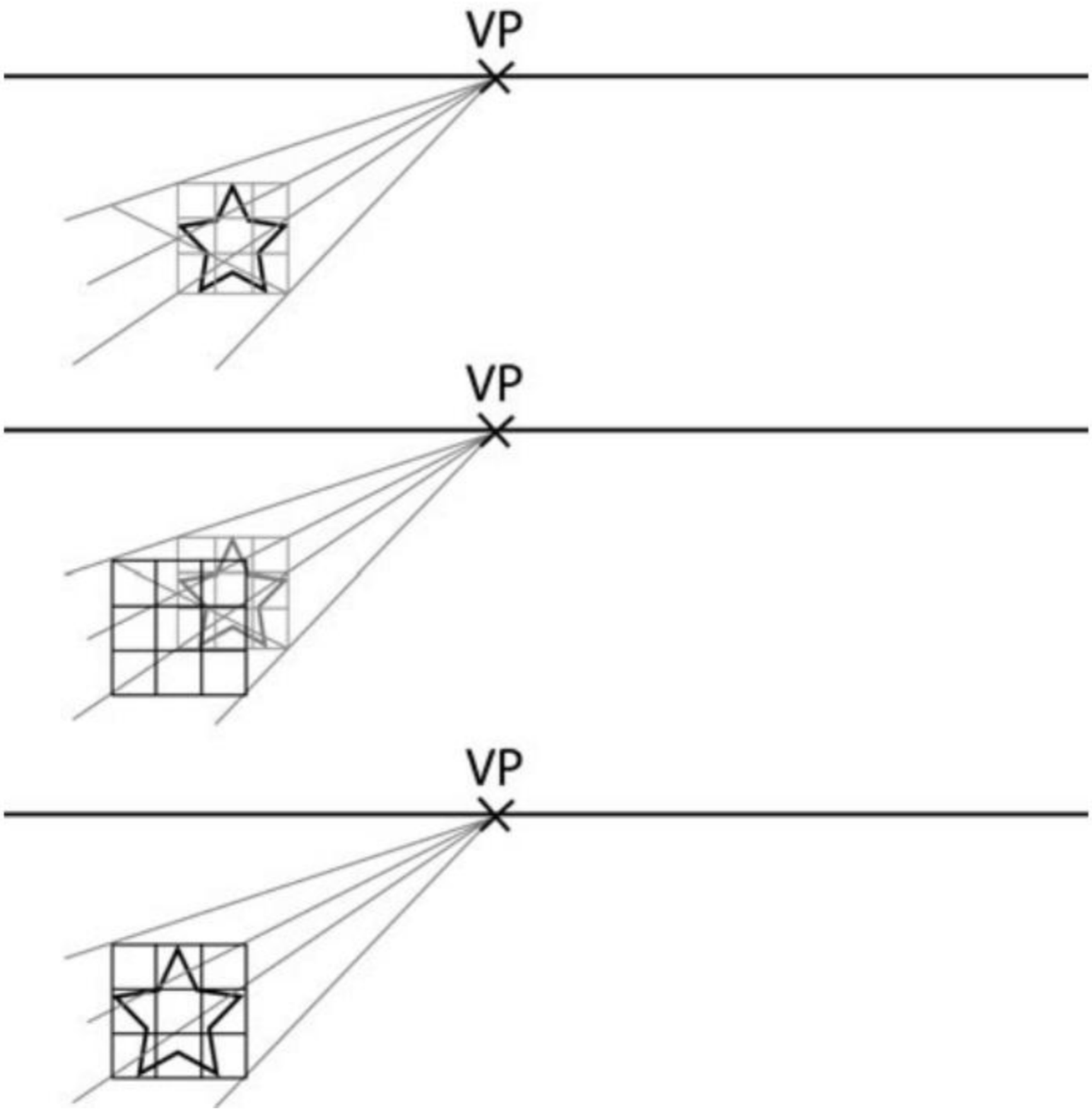
Answers to Student Book activities

Skills activity (page 133)

1. Look for evidence of a grid drawn total size 100 mm × 100 mm. Grid lines ideally should be 25 mm apart.



2. Look for evidence of construction lines as in the example.



Knowledge check (page 133)

A sign maker would like you to enlarge a sign with the word ‘FORTUNE’.

Outline the steps needed to enlarge the sign accurately. (5)

1. Draw a box around the word. (1)
2. Split the box into quarters. (1)
3. Split the quarters into a grid. (1)
4. Enlarge the grid. (1)
5. Draw the letters into the grid accurately. (1)

Award 1 mark for each stage outlined. Accept sequential drawings, flowchart or list.

Total: 5 marks

2.7 Instruments and drafting aids

Learning objectives

By the end of this unit students should:

- be able to recognise and use a range of different instruments and drawing aids to create accurate drawings with a good standard of graphical representation.

Resources

Student Book pages 134–135
Activity sheet A (available on Collins Connect)
A variety of drafting aids, blank A3 paper
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 2.7.

At this point students should already be aware of many of the instruments and drafting aids covered in this topic so it may be useful to focus on the ones they are unfamiliar with. Alternatively, this topic could be covered at the beginning of the course; it should take no longer than one lesson.

Lesson starter suggestions

Skills activity (page 135): Students follow the instructions in the first Skills activity on page 135 and list all the shapes they have learnt and the instruments and drafting aids required to draw them.

Class discussion: Source all the instruments and drafting aids on page 134 of the Student Book and lay them on a table. If there are any other instruments you feel would be useful for students to know about, include these too. Discuss what each is called and what it is used for.

Main lesson activities

Skills activity (page 135): Ask students to read the second Skills activity on page 135 of the Student Book and think about what equipment they will need to complete both drawings. It is important that they are given the opportunity to source their own equipment to complete the task. If necessary, print and hand out Activity sheet A to help students begin the drawing.

Knowledge check (page 135): Students can complete this at the end of the topic or for homework.

Plenary suggestions

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.

Key terms: Ask students to write down as many key terms as they can from the Graphic Products units they have studied so far.

Answers to Student Book activities

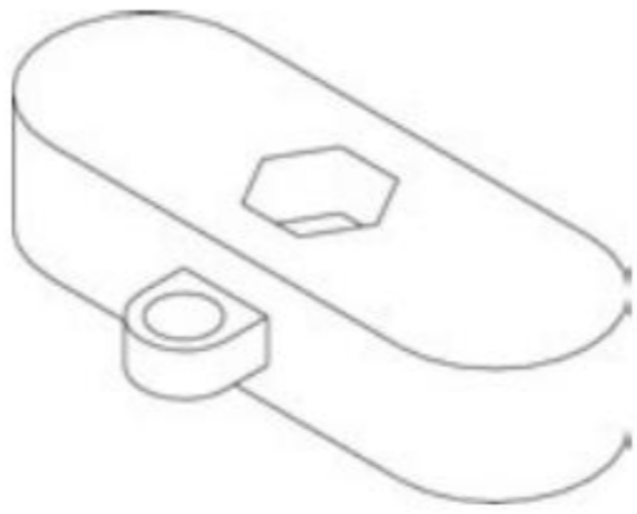
Skills activity (page 135)

Shape	Instrument / Drawing aid
circle	pencil/pen, compass or stencil
square	pencil/pen, ruler, set square
regular polygon	pencil/pen, compass, protractor, ruler
irregular polygon	pencil/pen, ruler
ellipse	pencil/pen, compass, ruler *or* stencil *or* trammel

Skills activity (page 135)

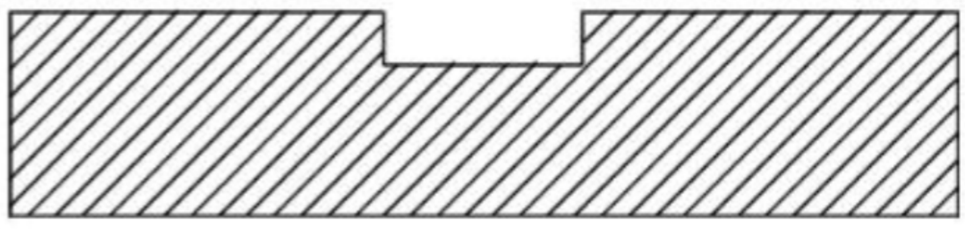
1. Ensure that the following instruments have been used in the construction of the drawing:

30/60° set square for straight edges;
30/60° set square, compass and ruler
for isometric circles and hexagon.



2. Ensure that the following instruments have been used in the construction of the drawing:

ruler, 45° set square.



SECTION A - A

Knowledge check (page 135)

Which drawing aids and instruments would you select to draw the following?

1. a planometric drawing of the interior of a room (1)

drawing board, 45° set square, pen/pencil (ruler optional)

2. an isometric drawing of a mobile phone (1)

drawing board, 30/60° set square, pen/pencil (ruler optional)

3. an orthographic drawing of packaging in the shape of an octagonal prism (1)

drawing board, compass, protractor, ruler, pen/pencil

4. a sectional drawing of a torch (1)

drawing board, 45° set square, pen/pencil, (ruler optional)

5. a freehand estimated two-point perspective drawing (1)

pen/pencil

Total: 5 marks

2.8 Layout and planning

Learning objectives

By the end of this unit students should:

- be able to set up an A3 sheet for drawing in orthographic, isometric and perspective
- be able to plan a drawing.

Resources

Student Book pages 136–138
Drawing board and clips, pencil, ruler, compasses, blank A3 paper
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 2.8.

A minimum of one one-hour lesson should be devoted to this unit. So far students have used activity sheets with lines already drawn on and guides to start the drawing. In future lessons they should be expected to lay out and plan their own drawings on blank sheets of paper.

Lesson starter suggestions

Class discussion: Ask students to take out their drawings from previous lessons. Then ask them why they are laid out well (lines and description at the bottom of the paper, equal space around the drawings, drawings not too close to the edges). Explain that from now on they will be laying out and planning their own drawings.

Main lesson activities

Student activity: Hand out A3 paper. Ask students to read how to lay out a sheet for drawing on page 136 of the Student Book. They then follow the instructions outlined in the Student Book. They should set up three A3 pages ready for the Skills activity.

Skills activity (page 138): Students read the task, fill in the details at the bottom of the first sheet of A3 paper and follow the instructions on pages 137 of the Student Book for planning an orthographic drawing. They then add details to the sheet they have laid out and do question 1 of the Skills activity.

Skills activity (page 138): Students fill in the details at the bottom of the second sheet of A3 paper and follow the instructions on page 137 of the Student Book for planning an isometric drawing. They then add details to the sheet they have laid out and do question 2 of the Skills activity.

Skills activity (page 138): Students fill in the details at the bottom of the third sheet of A3 paper and follow the instructions on page 137 of the Student Book for planning an estimated two-point perspective drawing. They then add details to the sheet they have laid out and do question 3 of the Skills activity.

Knowledge check (page 138): Students can complete this at the end of the topic or for homework.

Plenary suggestions

Peer evaluation: Ask students to suggest some success criteria for laying out, planning and drawing. Write their suggestions on the board, e.g. even space around the drawing, having the drawing centred on the page, good quality presentation, correct title and scale, even line work, and good use of

construction lines. Students can swap work with a partner and write one thing that has been done well and one thing that could be improved in each other's work.

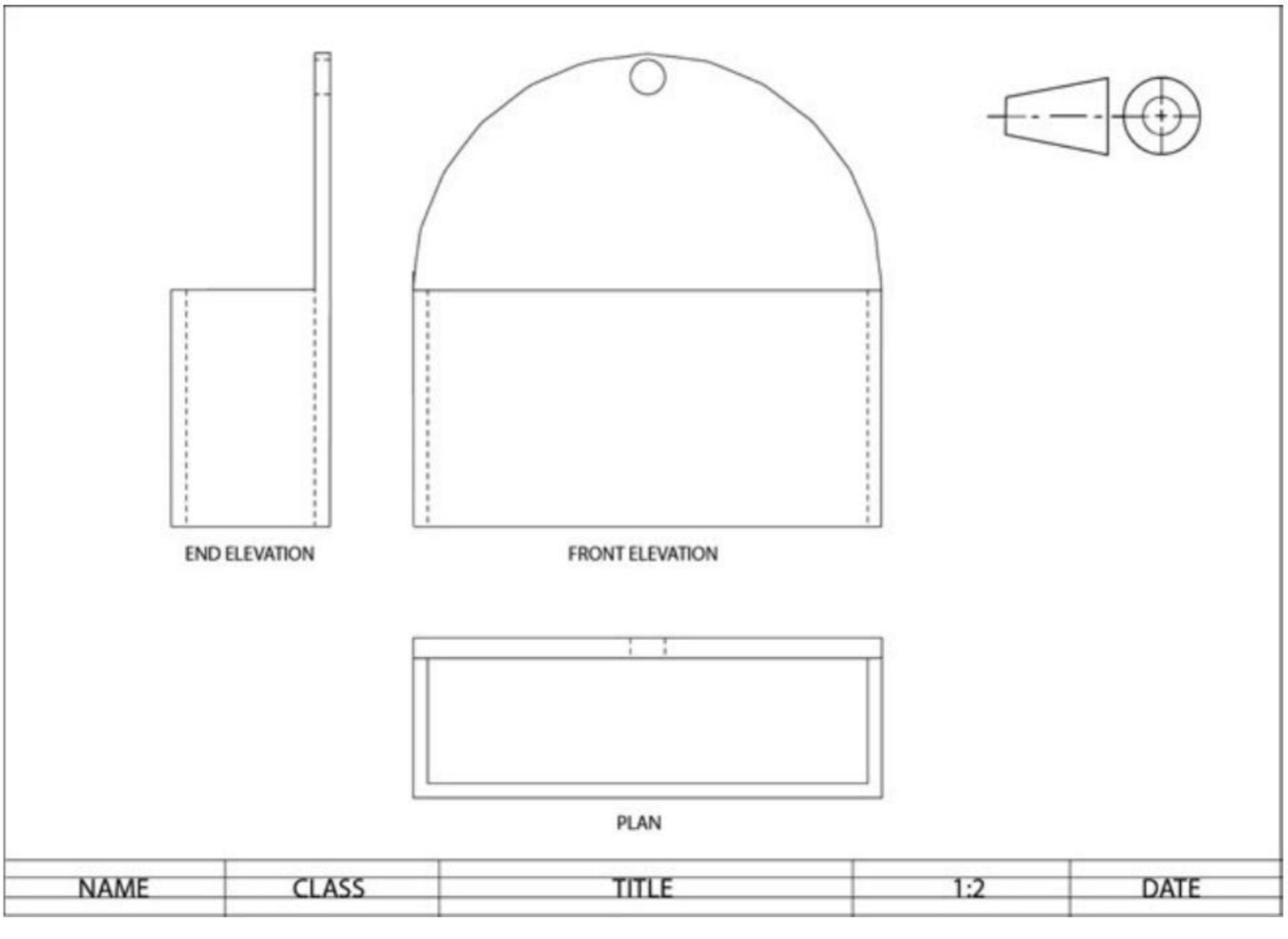
Interactive activity: Students complete the Interactive activity. Alternatively, this can be done as a class quiz.

Answers to Student Book activities

Skills activity (page 138)

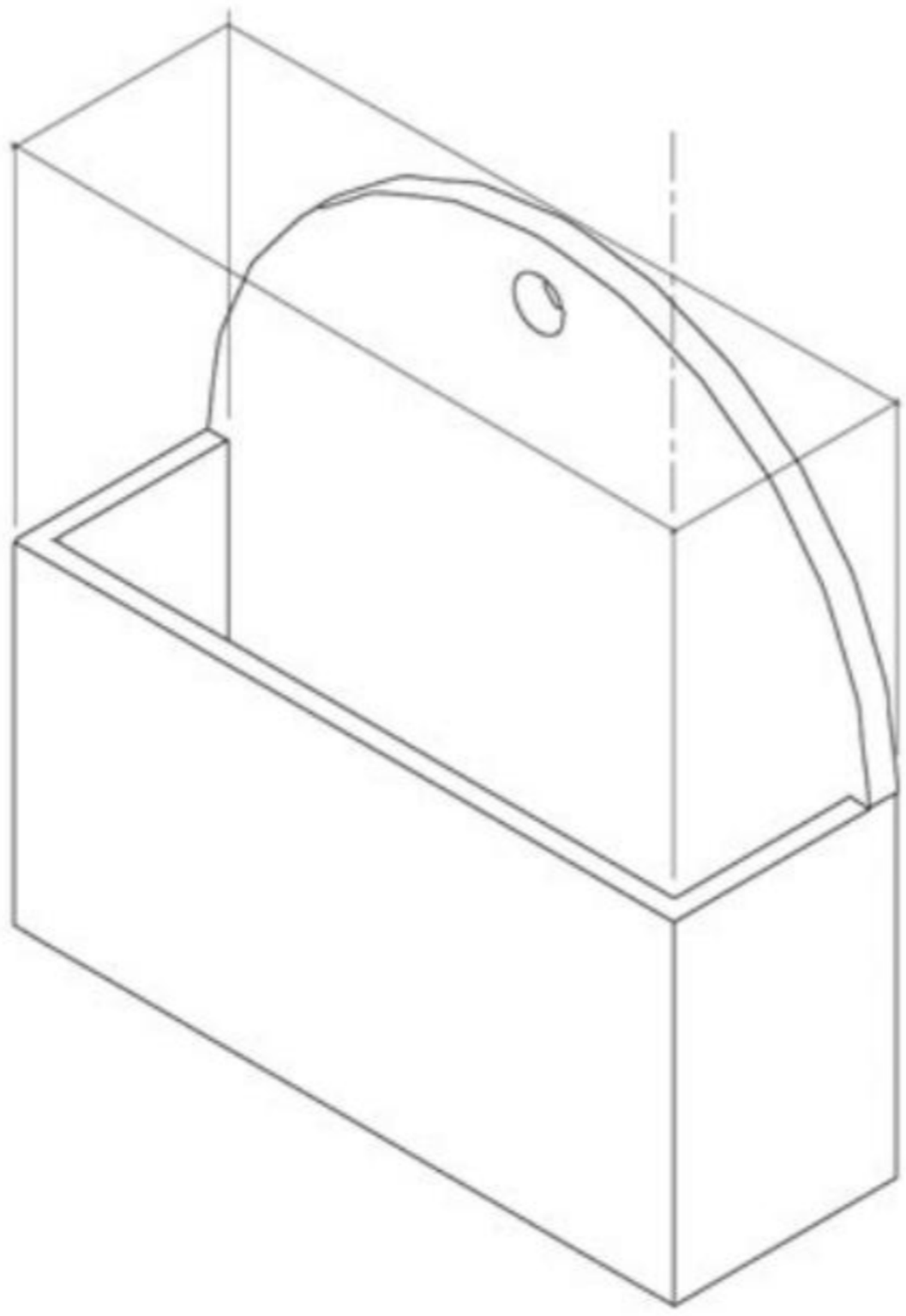
1. an orthographic first-angle projection using the scale 1:2

Look for a good layout with lines 4 mm apart at the bottom of the page and the relevant information in the boxes. The plan and front elevation should be centred on the page and the correct projection symbol should be in the top right. Dimensions are not necessary but can be added by the student for practice.



2. an isometric drawing using the scale 1:2

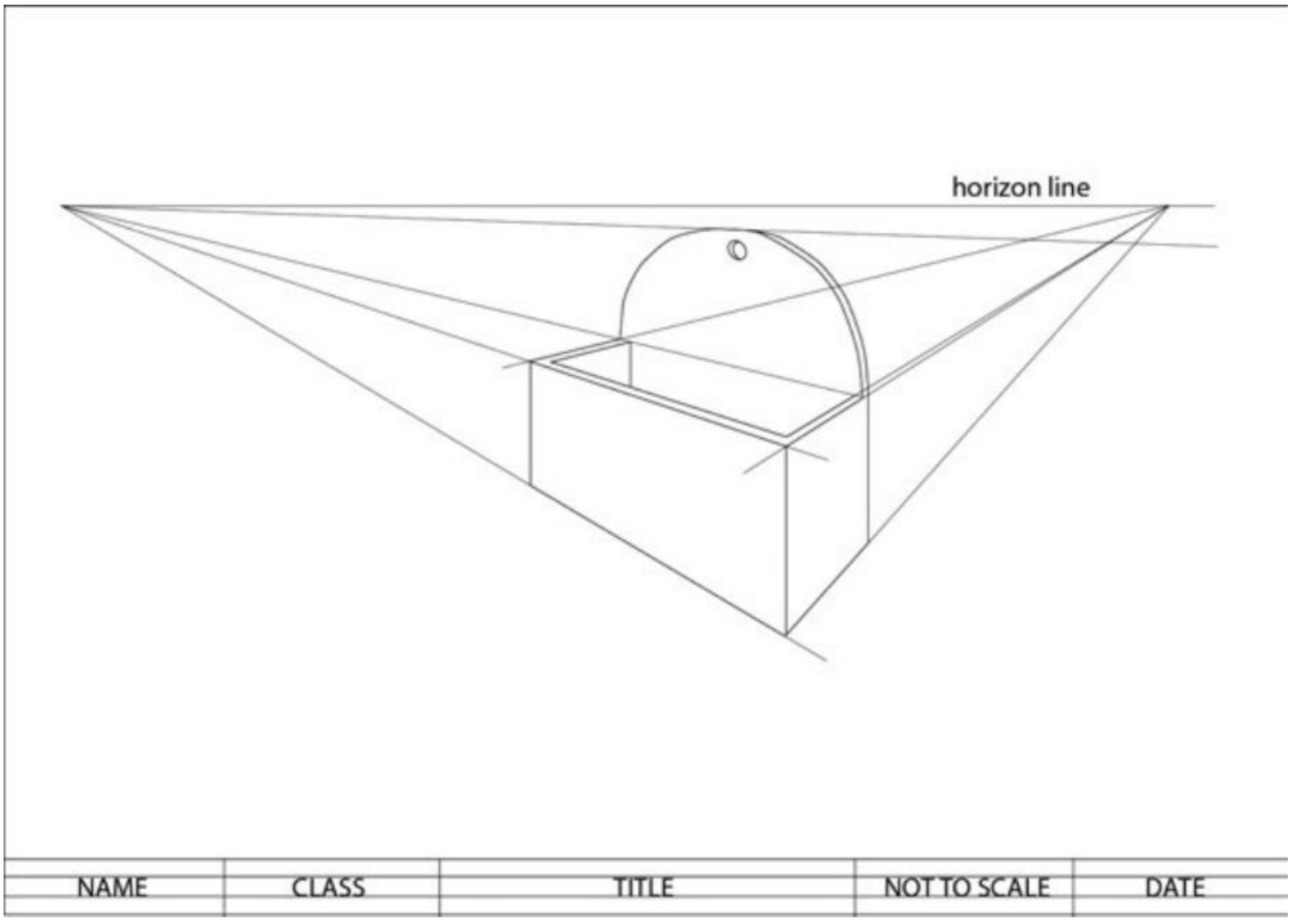
Look for a good layout with lines 4 mm apart at the bottom of the page and the relevant information in the boxes. The bottom right corner of the isometric should line up with the centre of the page and there should be evidence of a centre line and crating.



NAME	CLASS	TITLE	1:2	DATE

3. an estimated two-point perspective drawing (estimate all sizes)

Look for a good layout with lines 4 mm apart at the bottom of the page and the relevant information in the boxes. Drawings for this may differ greatly due to estimated sizes and positioning. Look for a horizon line that has been drawn near the top of the page and vanishing points to each side. There should be some attempt to draw this in proportion to the original drawing and position the drawing well on the page.



Knowledge check (page 138)

When setting up an A3 page for drawing:

1. Where on the page should the projection symbol be? (1)

top right

2. What distance apart should the lines at the bottom of the page be? (1)

4 mm

3. What two things do you draw before you begin drawing an isometric drawing? (2)

a centre line and a crate

4. How can you ensure you fit a two-point perspective drawing on your page? (1)

Draw the horizon line towards the top of the page and make sure the angles of the first vanishing point lines are not too acute.

Total: 5 marks

2.9 Presentation

Learning objectives

By the end of this unit students should:

- be able to use the thick- and thin-line technique to enhance a drawing
- understand light source and its effect on light and shade
- use rendering to emphasise three dimensions and textures and materials.

Key terms

kerning, light source, rendering, tracking, typography

Resources

Student Book pages 139–143
Activity sheets A–D (available on Collins Connect)
A variety of blocks; pencils 2B or above, coloured pencils
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 2.9.

A minimum of two one-hour lessons should be devoted to this unit: one hour for rendering and one for typography.

Lesson starter suggestions

Class discussion (1): Hand out blocks (cylinders, cubes, cuboids, spheres). Ask students to identify the light source(s) in the room. Then ask them to squint and identify the light and dark tones on the blocks. This works better with a limited light source from one direction.

Equipment check: Ask students to check which grade their pencils are. Discuss which grades of pencil are best for rendering and why (softer pencils give a smoother finish).

Class discussion (2): Ask students to read the first paragraph on page 139 of the Student Book. Discuss why presentation is important in design.

Typography starter: Laser cut a variety of letters in different styles (serif, sans-serif, block serif, decorative). Put a letter in each of six bags. Then put students in small groups and ask them to pass the bags round the class. Students have to feel the letter and identify the character and style of lettering.

Main lesson activities

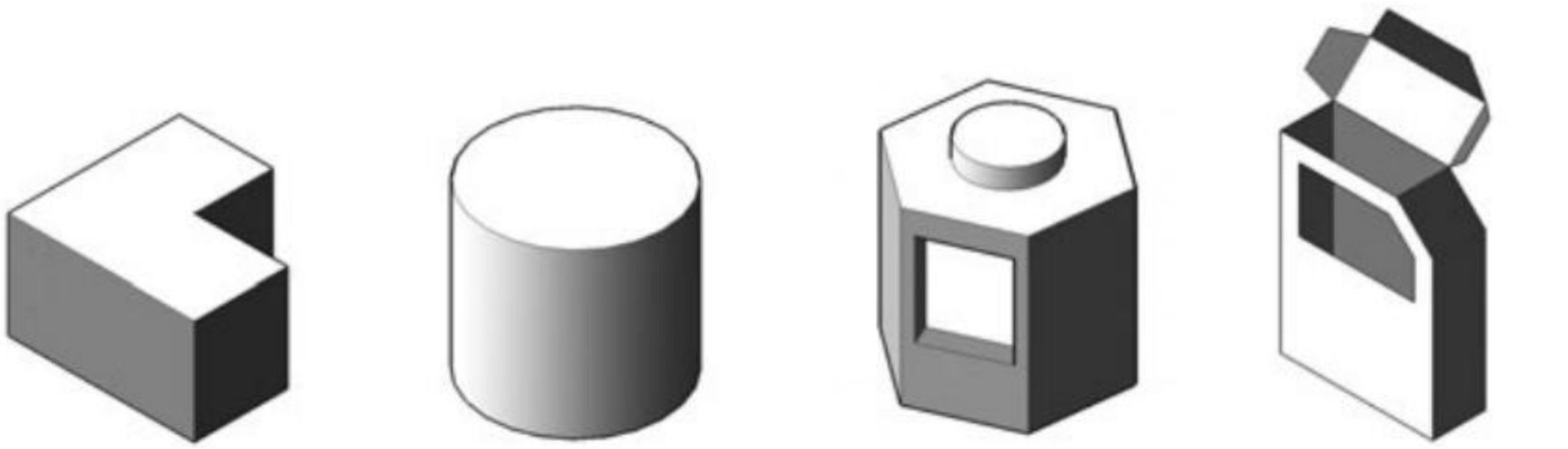
Skills activity (page 140): Ask students to read about the thick- and thin-line technique for enhancing drawings on page 139 of the Student Book. They then try the first Skills activity on page 140. This is a good opportunity for them to practise their freehand isometric drawing. However, if time is short, print and hand out Activity sheet A, which has a template of these shapes.

Interactive activity: Students identify the lines with the incorrect thickness.

Tip: *This activity could be given for homework.*



Skills activity (page 140)



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.

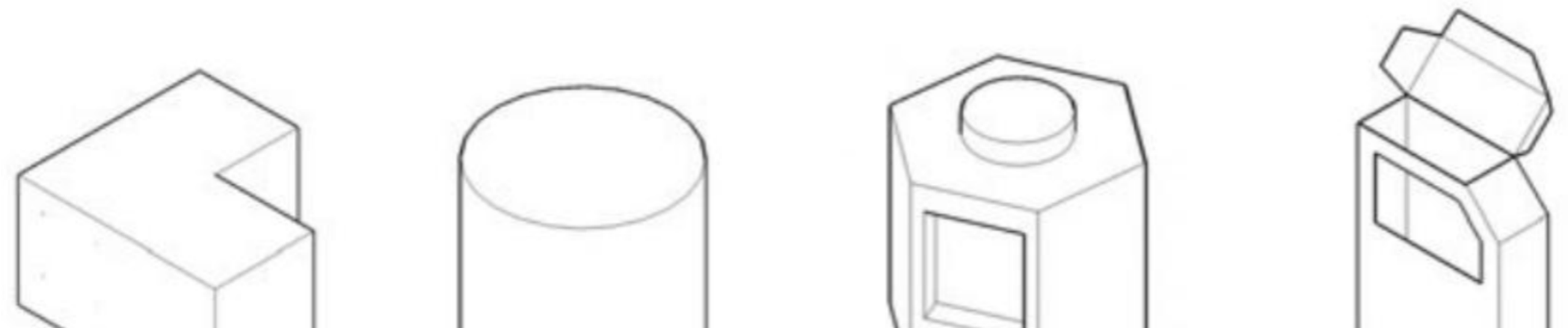
Beat the teacher: Draw a three-dimensional shape or object and show it to the class, who then draw the same shape. Both you and the students render the shape as neatly as possible within a time limit. The class then vote for the best drawing.

Blocks: In groups students compete to build the most interesting or the strangest object or tower out of the blocks. They then try to draw and render the object or tower.

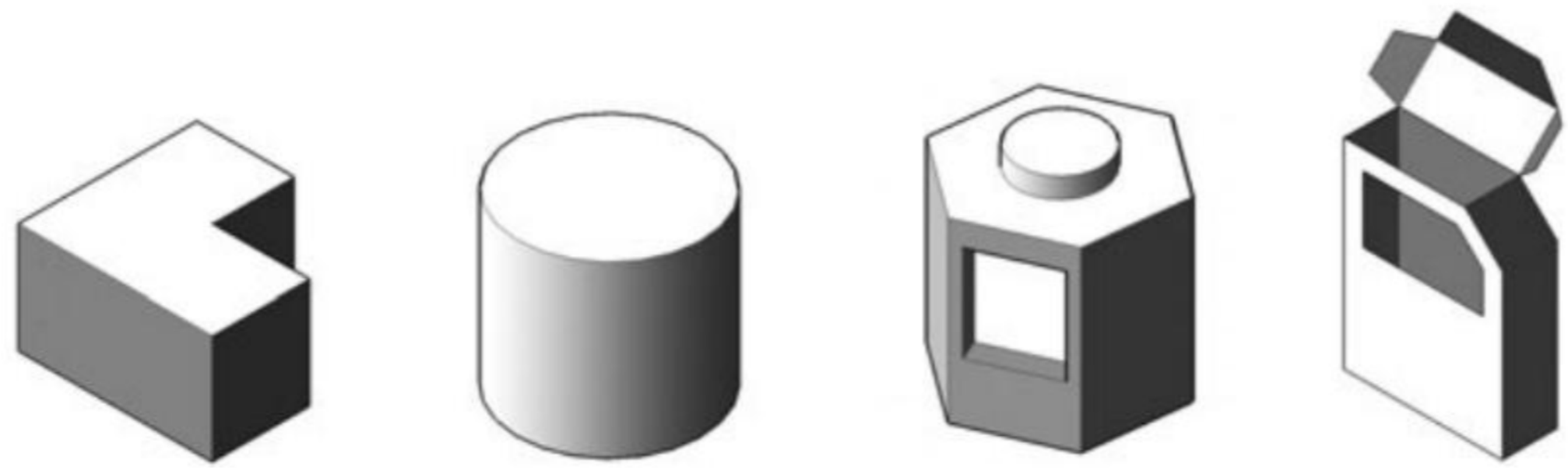
Design your own typeface: Using three guidelines drawn on paper, students design their own serif or sans-serif font.

Answers to Student Book activities

Skills activity (page 140)



Skills activity (page 140)



Skills activity (page 142)

Rendering:

- smooth gradient on the cylindrical parts
- light medium and dark faces on the wooden body
- slight blue tone added to the metal wheels
- highlights removed on the plastic and metal parts to give a shiny finish

Thick- and thin-line: as shown below. See the colour version in the Activity sheet C notes.



Skills activity (page 143)

There is no right or wrong for this task. Encourage students to use the internet to research how to adjust kerning in their preferred CAD program and allow some time for experimentation.

Knowledge check (page 143)

1. Explain why presentation is important in design. (3)

It enables designers to communicate their ideas to other people,
e.g. clients or colleagues. (1)
It can help to improve the visual appearance and realism of design ideas, (1)
e.g. by showing different tones, textures or materials. (1)

2. Outline three ways you can improve the presentation of your design ideas. (3)

Using thick- and thin-line technique can improve visual impact. (1)

Considering a light source, highlights and rendering in different tones can help to improve the three-dimensional look. (1)

Using coloured pencils and an eraser can give the illusion of texture and materials. (1)

3. When rendering, which type of shape would have a gradient applied? (1)

rounded objects such as cylinders or cones

4. What type of pencil should you use for rendering? (1)

softer pencils such as 2B

Total: 8 marks

Skills activity.

ICT: Students try to plot graphs using spreadsheet or vector graphic software. They could use the data in the Skills activity on page 145 of the Student Book.

Skills activity (page 147): Ask students to read pages 145–147 of the Student Book and then do the Skills activity. They can refer back to previous units for help with this and you can print and hand out Activity sheets A and B as scaffolding if further help is needed.

Interactive activity: Students complete the Interactive activity to reinforce flowchart theory. Alternatively, you could give this activity for homework.

Knowledge check (page 147): Students can complete this at the end of the topic 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

Activity sheets A–C (available on Collins Connect)
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 2.10.

A minimum of two one-hour lessons should be devoted to this unit: one lesson for graphs and one for sequence drawings and flowcharts. Students should have experience of drawing charts and graphs from other subjects, so try to draw on their past experience and encourage them to make connections between subjects.

Lesson starter suggestions

Bad graphs: Display or print and hand out Activity sheet A. Tell students there is something wrong with each graph and ask them to discuss in groups what is wrong and feed back. See the Activity sheet A notes for the answers.

Main lesson activities

Skills activity (page 145): Ask students to read pages 144–145 of the Student Book and then do the Skills activity.

ICT: Students try to plot graphs using spreadsheet or vector graphic software. They could use the data in the Skills activity on page 145 of the Student Book.

Skills activity (page 147): Ask students to read pages 145–147 of the Student Book and then do the Skills activity. They can refer back to previous units for help with this and you can print and hand out Activity sheets A and B as scaffolding if further help is needed.

Interactive activity: Students complete the Interactive activity to reinforce flowchart theory. Alternatively, you could give this activity for homework.

Knowledge check (page 147): Students can complete this at the end of the topic 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

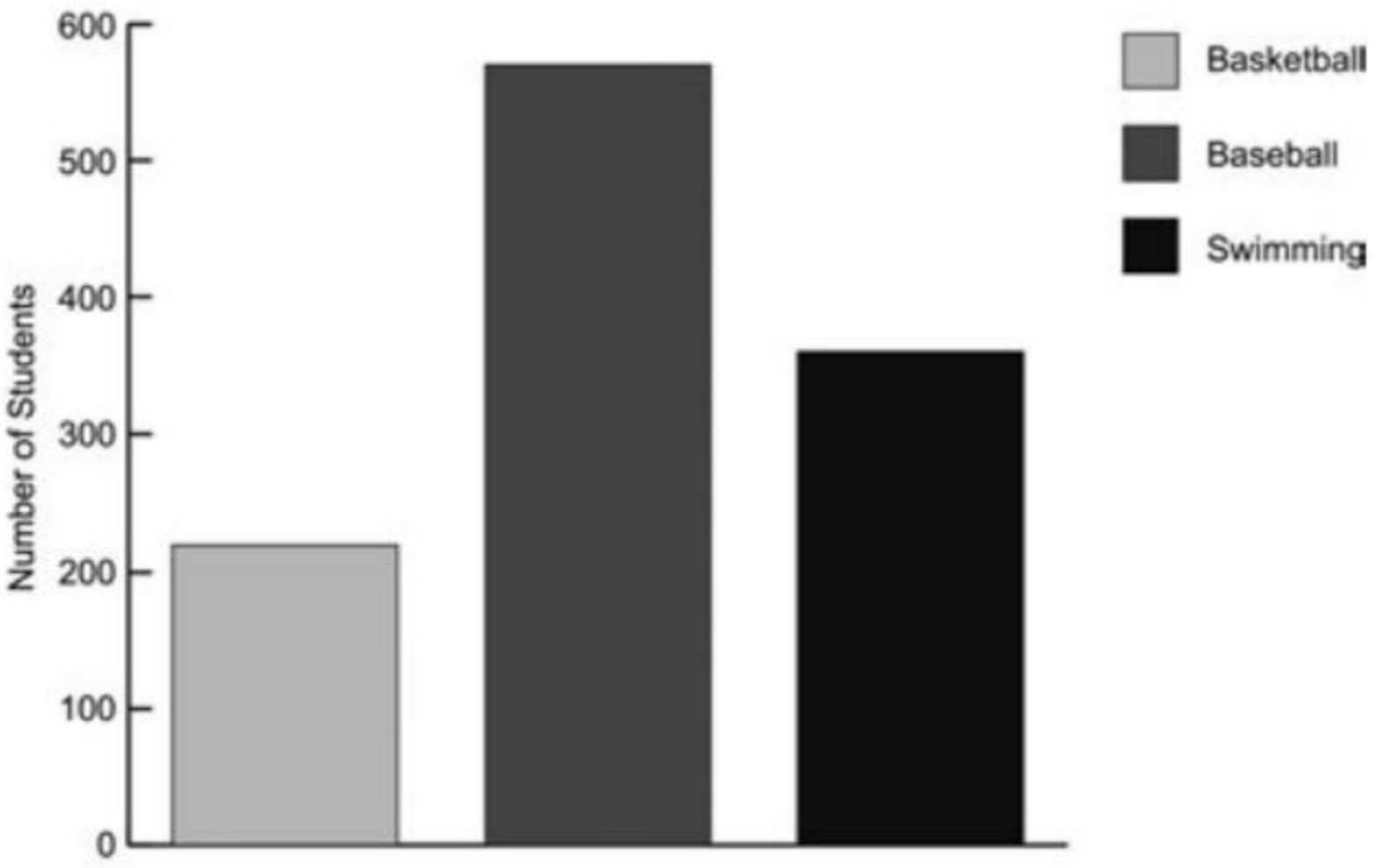
take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Real life graphs: Ask students to consider a situation in their life for which they could plot a graph. Offer examples, such as how many hours they sleep per day of the week, how many hours they exercise a day, the types of sports they play during the week, the percentage of food groups in their diet. Ask them to choose a suitable method of presenting this data and draw a graph.

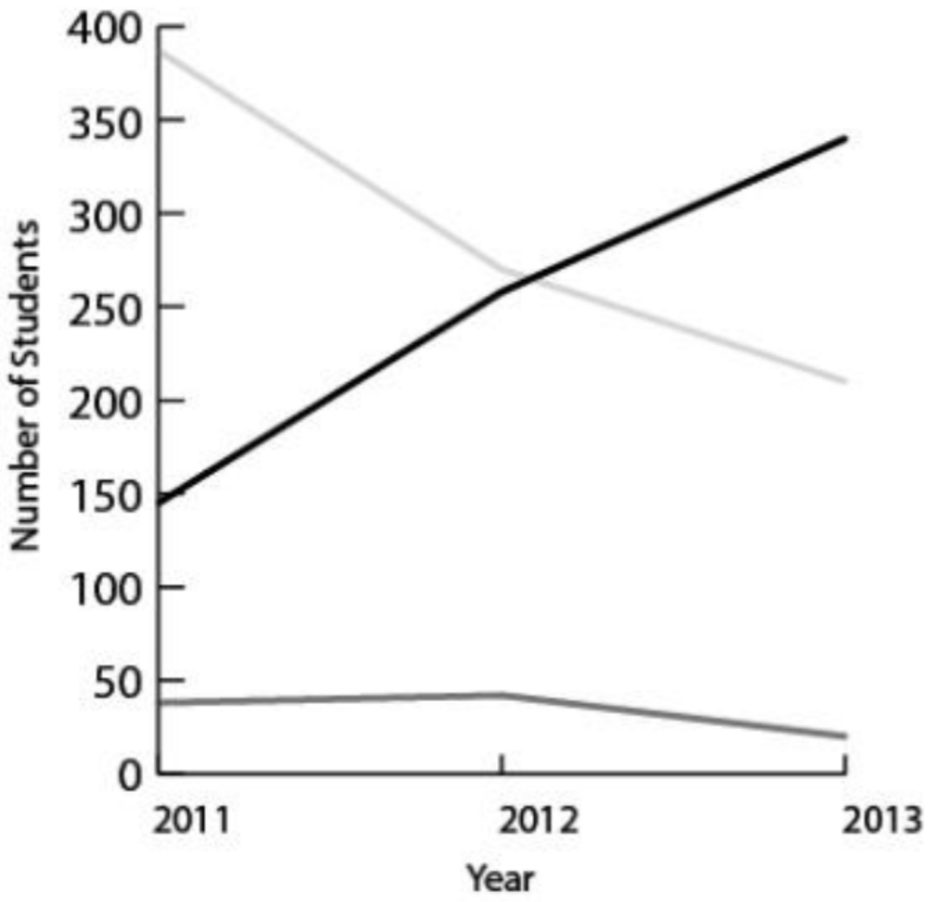
Answers to Student Book activities

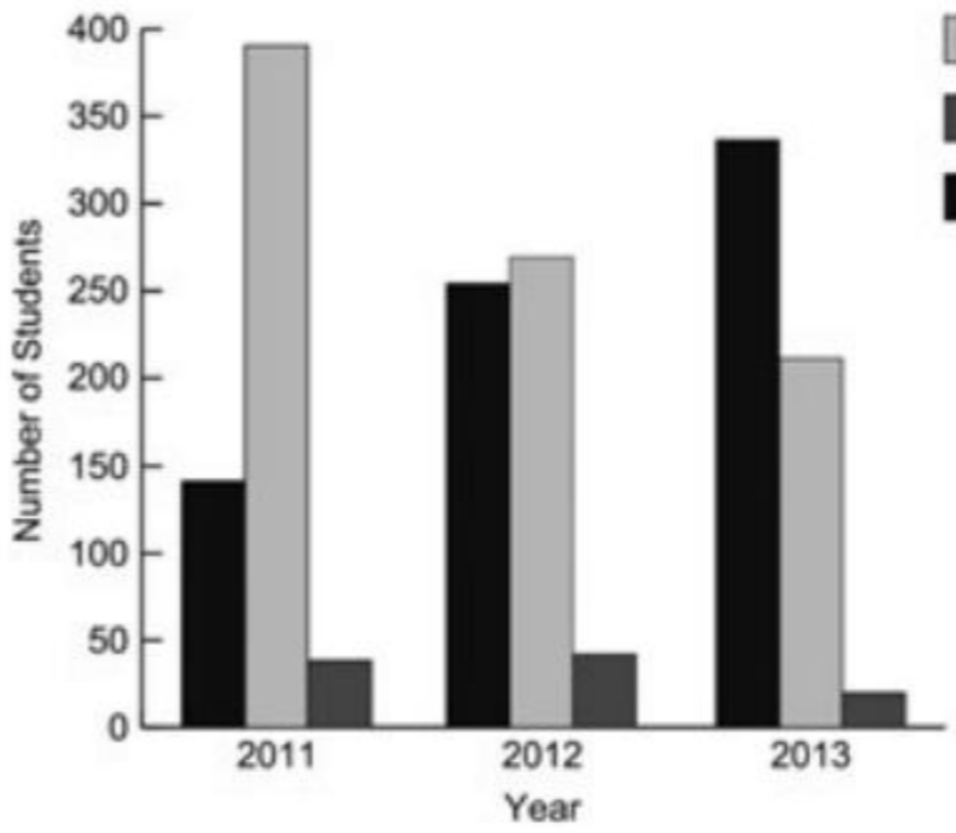
Skills activity (page 145)

1. Look for correct choice of unit increments on the *y*-axis, even spacing between units on the *x*-axis, and use of a ruler and labelling/use of a key.



2. Look for correct choice of unit increments on the *x*-axis, even spacing between units on the *x*-axis and *y*-axis, and use of a ruler and labelling / use of a key.



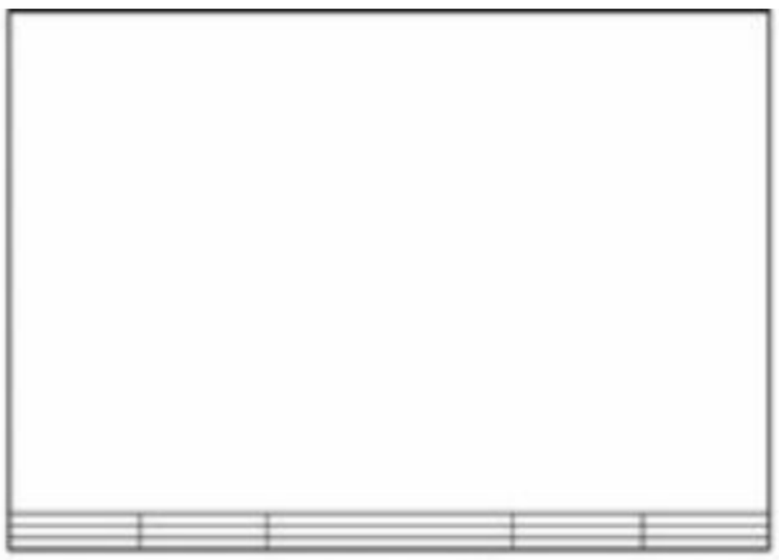


Skills activity (page 147)

1.



1. Draw three lines at the bottom of the page 4mm apart using the parallel motion tool



2. Draw two lines from the left and two from the right 60 mm apart.



3. Write in the details on the sheet.

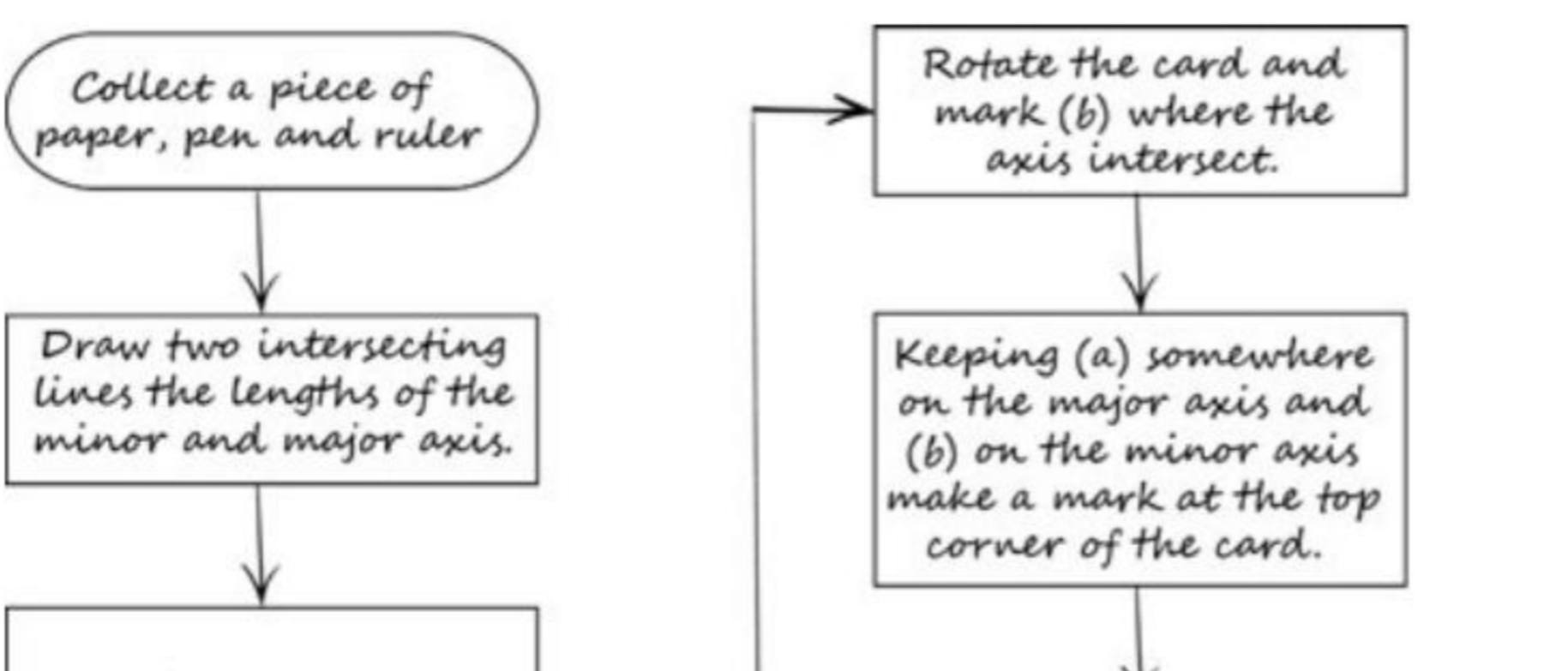


3. Draw the projection symbol in the top right.



3. Draw a line 40mm up from the bottom of the page.

2.



Knowledge check (page 147)

A manufacturer of stationery products requires some data analysis of who buys their products and which products are most popular. Answer the following questions:

1. Which graph or chart should be used to represent the increasing or declining popularity of pencil sharpeners over the period of five years? Justify your answer. (2)

A line graph or bar chart would be suitable as either can be used to represent data changing over time.

Award 1 mark for identifying the correct chart and 1 mark for an explanation.

2. Which graph or chart should be used to represent the proportion of different age groups that purchase protractors? Justify your answer. (2)

A bar chart or a pie chart would be suitable as these would show a proportion of a whole.

Award 1 mark for identifying the correct chart and 1 mark for an explanation.

3. Which graph or chart should be used to compare the sales of five different stationery products? Justify your answer. (2)

A bar chart would be best as it would allow comparison of the sales of each stationery product.

Award 1 mark for identifying the correct chart and 1 mark for an explanation.

4. Give an example of how an input/output box would be used in a flowchart. (2)

An input/output box is used when something is added or taken away from the process, e.g. introducing a new material.

Award 1 mark for identifying the correct chart and 1 mark for an explanation.

5. What is the purpose of a feedback loop? (1)

A feedback loop acts as a ‘no’ route from a question to a different part of the process.

Total: 9 marks

2.11 Reprographics

Learning objectives

By the end of this unit students should:

- understand a range of commercial printing methods.

Key terms

printing plate, process colours, resolution, substrate

Resources

Student Book pages 148–149
Activity Sheets A–B (available on Collins Connect)
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 2.11.

A minimum of one one-hour lesson should be devoted to this unit. Encourage good independent research skills and use the opportunity for students to practise communicating information in a visually pleasing way.

Lesson starter suggestions

Brainstorm: In groups, students brainstorm as many products as they can think of that have been printed on. Encourage them to consider products with printed substrates other than paper or card, e.g. aluminium cans, T-shirts, snack wrappers and plastic bags. Ask them to arrange this information in mindmap form using the branches of the mindmap as material types.

Main lesson activities

Discussion and note-taking (whole class): Ask students to read about commercial printing methods on page 148 of the Student Book. Supporting videos on YouTube can help students to understand these processes.

Research task: Ask students to research each form of printing using the internet or books. They can present their research into each form of printing in a visually pleasing way using notes and sketches.

Skills activity (page 149): This is an inquiry activity. Students identify different types of printed products and consider the printing method. Encourage them to consider aspects of different commercial printing methods, such as probable volume of production, cost, quality of print and material printed on. Alternatively, they could use the mindmap generated in the Lesson starter. The table in Activity sheet A can be used as a template.

Tip: *This would make a good homework task.*

ICT: Students investigate how to set up a page for print in the correct page size, using software such as Adobe Photoshop, CMYK, 300dpi. Students could also experiment with applying printer's marks in the print settings, such as crop marks, registration marks and labels when printing photos or artwork.

Knowledge check (page 149): Students can complete this at the end of the topic 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.

Answers to Student Book activities

Skills activity (page 149)

Outcomes may differ.

- Gravure – high run, high quality, paper and card, more costly than offset lithography
- Offset lithography – high run, medium quality, paper and card, low cost
- Screen printing – short run, block colours, fabrics and other materials that cannot be printed
- Flexography – medium run, medium quality, foiled and plastic materials, medium cost

Knowledge check (page 149)

Which commercial printing method would be used to print the following:

1. a foil bag of snacks? (1)

flexography

2. a newspaper of 200,000 copies? (1)

offset lithography

3. a tea towel? (1)

screen printing

4. a postage stamp? (1)

gravure

Total: 4 marks

2.12 Materials and modelling

Learning objectives

By the end of this unit students should:

- understand the reasons for modelling
- understand how to use modelling to an appropriate scale
- understand why scale drawings enable a visual model to be made
- understand the properties and uses of a range of modelling materials
- recognise a range of modern adhesives and their uses.

Key terms

prototype, scale model

Resources

Student Book pages 150–155
Activity sheets A–C (available on Collins Connect)
Models from previous classes (early stage, mid-stage and late stage); material samples (e.g. paper, card, plastics); a range of adhesives (e.g. spray adhesive, double-sided tape, hot melt glue, tensol cement, glue sticks); packaging samples
Access to Collins Connect for Interactive activity
Creative homework 2.12 (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 2.12.

A minimum of two one-hour lessons should be devoted to this unit. It should involve as much practical activity and inquiry-based learning as possible. Allow students freedom to source, investigate and manipulate the materials, adhesives and packaging available in your classroom or workshop. This unit is best delivered before students start modelling for their project or while they are doing so.

Lesson starter suggestions

Class discussion: It is a good idea to keep some models and prototypes from previous classes to use in a discussion on modelling. Use masking tape to divide a table into three sections. Arrange the models randomly on the table. Explain to students that the development process often goes through three stages of modelling: early-stage (sketch modelling), mid-stage and late-stage modelling. Ask them to sort the models into early-, mid- or late-stage on the sections of the table. Use this as a basis for discussion. What form do early-, mid- and late-stage models take, and what can they be used to test? At which stage is scale modelling important? At which stage are materials more important? If you have no models to hand, then some pictures of models can help generate discussion.

Main lesson activities

Materials inquiry: Source samples of paper, card, plastics and other materials for students. Alternatively, get them to source and cut their own; encouraging them to do so will save you time in the future as they will become used to sourcing their materials independently. Print and hand out Activity

sheet A. Students use it as a template, stick their material samples on it and write about them. Ask students to read pages 151–152 of the Student Book as a guide to which materials they should be looking for.

Adhesives inquiry: Source a range of adhesives, including spray adhesive, double-sided tape, hot-melt glue, tensol cement and glue sticks. Create 'stations' on tables, with one type of adhesive and a range of modelling materials at each station. Students move around, trying the different adhesives on the materials. Allow them to make mistakes. Use the experiments as a basis for a class discussion afterwards and focus on which adhesives are suitable for use on each material, which are not, and why.

Tip: *Hot-melt glue can burn on contact with skin, so warn students of the dangers of this type of adhesive.*

Packaging inquiry: Ask students to read about permanent and temporary joining methods on pages 152–155 of the Student Book. Source some packaging samples for students; it is useful to have a wide range, such as blister packs, cartons, packs and boxes. Students work in groups to disassemble the packaging and identify the different forms of joining. They can take photos or draw round the flaps and tabs and annotate these with the correct names from the Student Book.

Skills activity (page 155): You could give this activity for homework. Students should look at evidence of permanent and non-permanent joining methods and try to identify the materials used and their properties.

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.

ICT: Students can use three-dimensional drawing software SketchUp with the plugin Flattery to experiment with drawing three-dimensional packaging, flattening into nets and adding tabs and flaps to relevant faces.

Knowledge check (page 155): Students can complete this at the end of the topic 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.

Environmental impact: Ask students to think about the adhesives and materials they have studied. They then discuss in groups which types of packaging, materials and adhesives have the greatest environmental impact. Feed back as a class. You could discuss issues such as biodegradability, flat-packed self-assembly packaging, overpackaging, toxic materials, composites and recyclability.

Adding flaps and tabs: Print and hand out Activity sheet C. Students practise adding flaps and tabs to developments.

Creative homework 2.12: Students read the Creative homework and conduct research into packaging symbols.

Answers to Student Book activities

Skills activity (page 155)

As this is an enquiry activity, outcomes may differ.

Knowledge check (page 157)

1. Which modelling material is best for the following?

- modelling a grip for testing the ergonomics of a hairbrush (1)
  Accept block modelling materials such as polymorph or styrofoam.
- a quick sketch model of a pop-up card (1)
  Accept paper or low gsm card.
- modelling a computer mouse (1)
  styrofoam or balsa wood
- a scale model of a display stand (1)
  foam board or corrugated card

2. Which material and joining methods are best for constructing the following?

- a pizza box (1)
  corrugated card with fold over locking flap
- a perfume box (1)
  duplex card / glossy card / foiled card with lock rudder flaps and a glue tab

Total: 6 marks

2.13 ICT

Learning objectives

By the end of this unit students should:

- understand that digital images can be captured and stored on a computer
- understand that different types of image manipulation programmes can be used to alter images
- understand that computers can be used to output to a range of devices
- be aware of the use of computer aided design (CAD) and computer aided manufacture (CAM) in design.

Key terms

bitmap graphic, computer-aided manufacture (CAM), vector graphic

Resources

Student Book pages 156–158
Activity sheets A–B (available on Collins Connect)
Access to Collins Connect for Interactive activity
Access to ICT and vector, bitmap software
Digital photo of teacher

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 2.13.

A minimum of one one-hour lesson should be devoted to this unit. Students should ideally have access to some good bitmap and vector software such as Adobe Illustrator and Photoshop or equivalent.

Lesson starter suggestions

Bitmap or vector: Display or print and hand out Activity sheet A. Ask students what the difference is between a vector and bitmap image. Then ask them to discuss which of the images are vector graphics and which are bitmap. Feed back to the class and discuss the differences between the two images.

Main lesson activities

Class discussion: Ask students to read pages 156–157 of the Student Book and take notes on the advantages and disadvantages of CAD. They should also take notes on the difference between vector and bitmap software. A good way to demonstrate the difference is to zoom into a bitmap image and then a vector image to see the difference in the way the image is created. Then have a class discussion about which software is utilised for certain graphic items and products and why.

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.

Wreck the teacher: This is an activity to get students experimenting with bitmap software. Share a digital photo of yourself with students. Ask them to experiment with changing colour, adding filters, etc. to manipulate the image. Choose some interesting manipulated images and ask students to share what they did.

Tip: *Students could use photos of themselves or friends instead of a photo of you.*

Award 3 marks for a good explanation of vector graphics and 1 mark for an example of vector graphic software.

3. Explain what is meant by *bitmap graphics* and name a piece of bitmap graphic software. (4)

Bitmap graphics software uses pixels (small dots) to create an image. (1) The number of dots per inch (dpi) is called resolution and determines the quality of the image. (1) Bitmap images cannot be scaled without loss of quality and can take up a lot of computer space to store. (1) Bitmap graphics software include Adobe Photoshop, GIMP or Microsoft Paint. (1)

Award 3 marks for a good explanation and 1 mark for an example of bitmap graphic software.

4. Explain the benefits of vector graphics software. (3)

Vector graphics are created using mathematics. (1) When scaled, the computer works out the scaling using mathematics (1) so there is in no loss of quality (1).

Total: 13 marks

later date into their sketchbooks or journals.

Wider issues: Get students to consider the wider issues surrounding the increased use of CAD and CAM. Questions to start conversations could be around the impact on work, automation and jobs, and global communication.

Answers to Student Book activities

Skills activity (page 157)

Outcomes will vary.

Knowledge check (page 158)

1. Explain the advantages of ICT in design. (2)

Speed, accuracy, quality of presentation, more opportunities for communication, collaboration with others, easy to make changes, backing up work

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

2. Explain what is meant by *vector graphics* and name a piece of vector graphic software. (4)

Vector graphics use mathematical information to create images; this could be colour values, co-ordinates of points, dimensions and angles. Examples of vector graphic software include Adobe Illustrator, 2D design, Inkscape, etc.

Award 3 marks for a good explanation of vector graphics and 1 mark for an example of vector graphic software.

3. Explain what is meant by *bitmap graphics* and name a piece of bitmap graphic software. (4)

Bitmap graphics software uses pixels (small dots) to create an image. (1) The number of dots per inch (dpi) is called resolution and determines the quality of the image. (1) Bitmap images cannot be scaled without loss of quality and can take up a lot of computer space to store. (1) Bitmap graphics software include Adobe Photoshop, GIMP or Microsoft Paint. (1)

Award 3 marks for a good explanation and 1 mark for an example of bitmap graphic software.

4. Explain the benefits of vector graphics software. (3)

Vector graphics are created using mathematics. (1) When scaled, the computer works out the scaling using mathematics (1) so there is in no loss of quality (1).

Total: 13 marks

2.14 Manufacture of graphic products

Learning objectives

By the end of this unit students should:

- be able to use hand tools safely and accurately to manufacture graphic products
- understand the use of commercial production techniques for forming plastics
- understand the commercial processes used to cut, crease and shape materials.

Key terms

blister packaging, die cutting / die stamping, vacuum forming

Resources

Student Book pages 159–163
Activity sheets A–B (available on Collins Connect)
Cutting mats, craft knives, a range of materials to cut
Access to Collins Connect for Interactive activity
Creative homework 2.14 (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 2.14.

A minimum of one one-hour lesson should be dedicated to this unit.

Lesson starter suggestions

Sorting activity: In groups, students list as many methods of manufacturing and cutting graphic products as they can think of. They could look round the room or the workshop for inspiration. Feed back as a class and pick up on any mistakes, e.g. a saw would not be classed as a tool in the manufacture of graphic products. Ask students to make a table with two columns with the headings ‘Cutting’ and ‘Shaping’. Then ask them to categorise their tools and equipment into these two columns. If any equipment cannot be categorised (e.g. a safety rule), ask them to invent additional categories for these items.

Main lesson activities

Skills activity (page 162): Students often find using craft knives difficult because of bad technique. Draw attention to the Top tip on page 159 and allow students time to practise using craft knives to cut different materials. They should know how to change the blade as a blunt blade is the primary reason for a poor quality finish. Cutting thicker materials such as foam board may take several passes to cut all the way through. This comes with experience and practice. Pick up on any mistakes and correct them. You could introduce other cutting equipment, e.g. paper trimmers, circle cutters or rotary cutters.

Manufacture inquiry: In groups, students identify a machine or tool they are unfamiliar with. They could conduct research into its safe and proper use and then present to the class.

Student activity: Print and hand out Activity sheet A. Students write the process of vacuum forming below the diagrams. Encourage the use of proper terminology.

Tip: *It would be useful for students to have experience in vacuum forming before completing this task.*

Award 2 marks for a basic explanation, some errors and tools not identified.

Award 1 mark for an attempt at an explanation with errors.

b) scoring and creasing the fold line (2)

Use a creasing tool or the blunt edge of scissors or a craft knife to score the packaging. Fold this over a ruler or safety rule for a straight fold.

Award 1 mark each for the correct explanations of scoring and folding.

c) forming the plastic window (5)

Place the mould on the platen of the vacuum former.

Clamp the clear thermoplastic so it is airtight.

Pull the heater over the plastic to soften it.

Push the heater back and turn on the vacuum to form the plastic over the mould.

Remove the mould from the plastic.

Award 1 mark for each correct stage in the vacuum forming process.

answer related to this unit. Collate all the questions into a test and give it to students for homework or in class.

Creative homework 2.14: Students read the Creative homework and conduct research into die cutting.

Answers to Student Book activities

Skills activity (page 162)

Ensure students hold the craft knife the correct way round and at roughly a 45° angle. They should hold the knife like a pencil when cutting detail; when cutting larger areas they should hold it with the forefinger on top to apply pressure.

Knowledge check (page 162)

Here is a net and assembled packaging. The packaging is made from card with a clear plastic window.

1. Explain the process of:

a) cutting out the net (4)

Use a craft knife or scalpel to cut around the outline, the hole for the plastic and the euro slot. Use a safety rule for the straight edges and cut on a mat. A paper trimmer can be used for the straight edges.

Award 4 marks for a good explanation, correct order and tools and equipment named correctly.

Award 3 marks for a good explanation but some inaccuracies.

Award 2 marks for a basic explanation, some errors and tools not identified.

Award 1 mark for an attempt at an explanation with errors.

b) scoring and creasing the fold line (2)

Use a creasing tool or the blunt edge of scissors or a craft knife to score the packaging. Fold this over a ruler or safety rule for a straight fold.

Award 1 mark each for the correct explanations of scoring and folding.

c) forming the plastic window (5)

Place the mould on the platen of the vacuum former.

Clamp the clear thermoplastic so it is airtight.

Pull the heater over the plastic to soften it.

Push the heater back and turn on the vacuum to form the plastic over the mould.

Remove the mould from the plastic.

Award 1 mark for each correct stage in the vacuum forming process.

d) applying an adhesive and assembling the packaging. (2)

Apply double-sided tape round the outside of the packaging and trim any excess. (1)
Remove the protective layer and fold over to stick. (1)

2. Name all tools and equipment required for this process. (2)

craft knife / scalpel, safety rule, cutting mat, double-sided tape, vacuum former, mould, creasing tool

Award 1 mark for identifying some tools and equipment and an additional mark if all are identified.

Total: 15 marks

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

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

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.

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)

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)

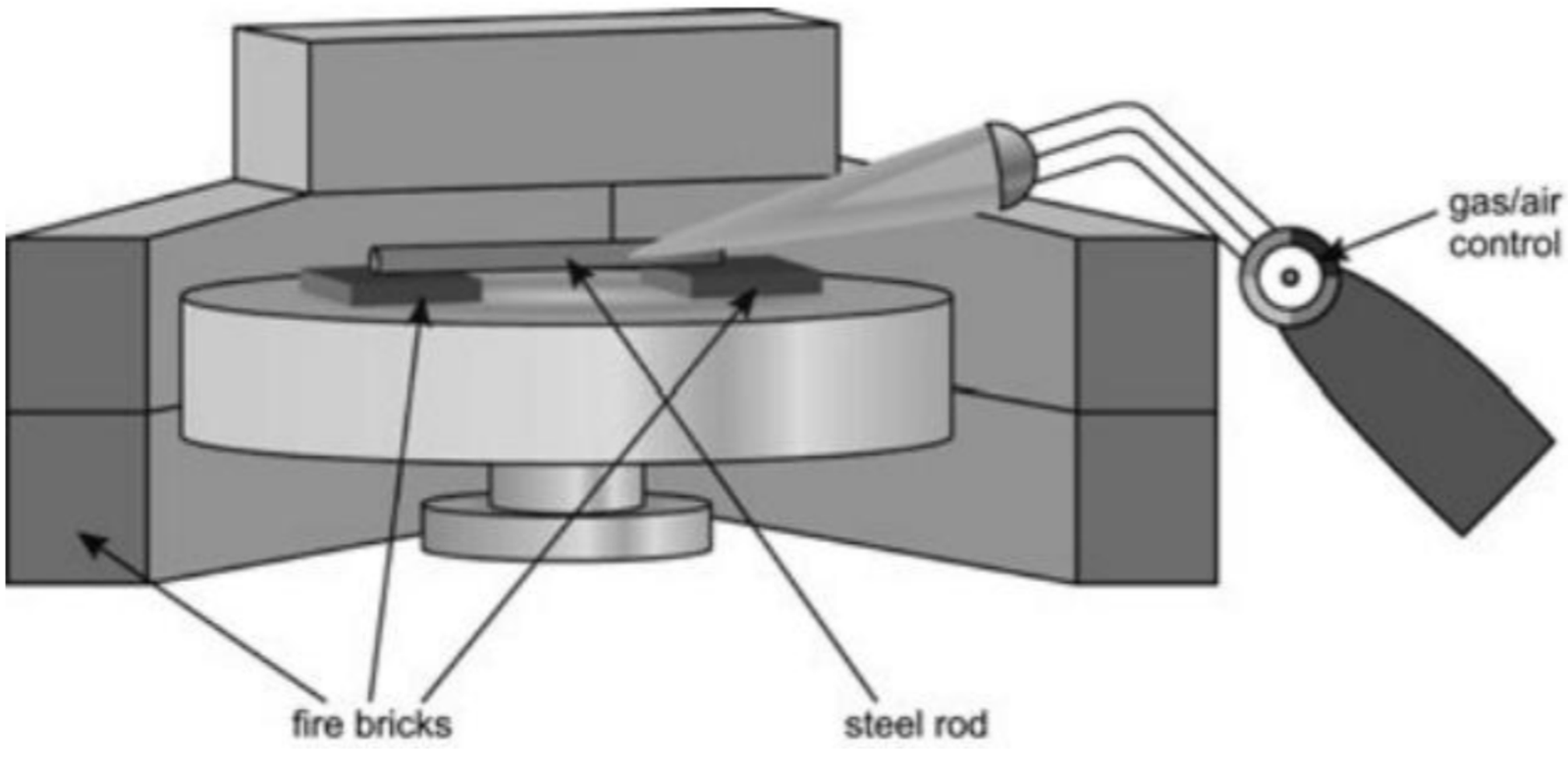
0.05 mm

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:

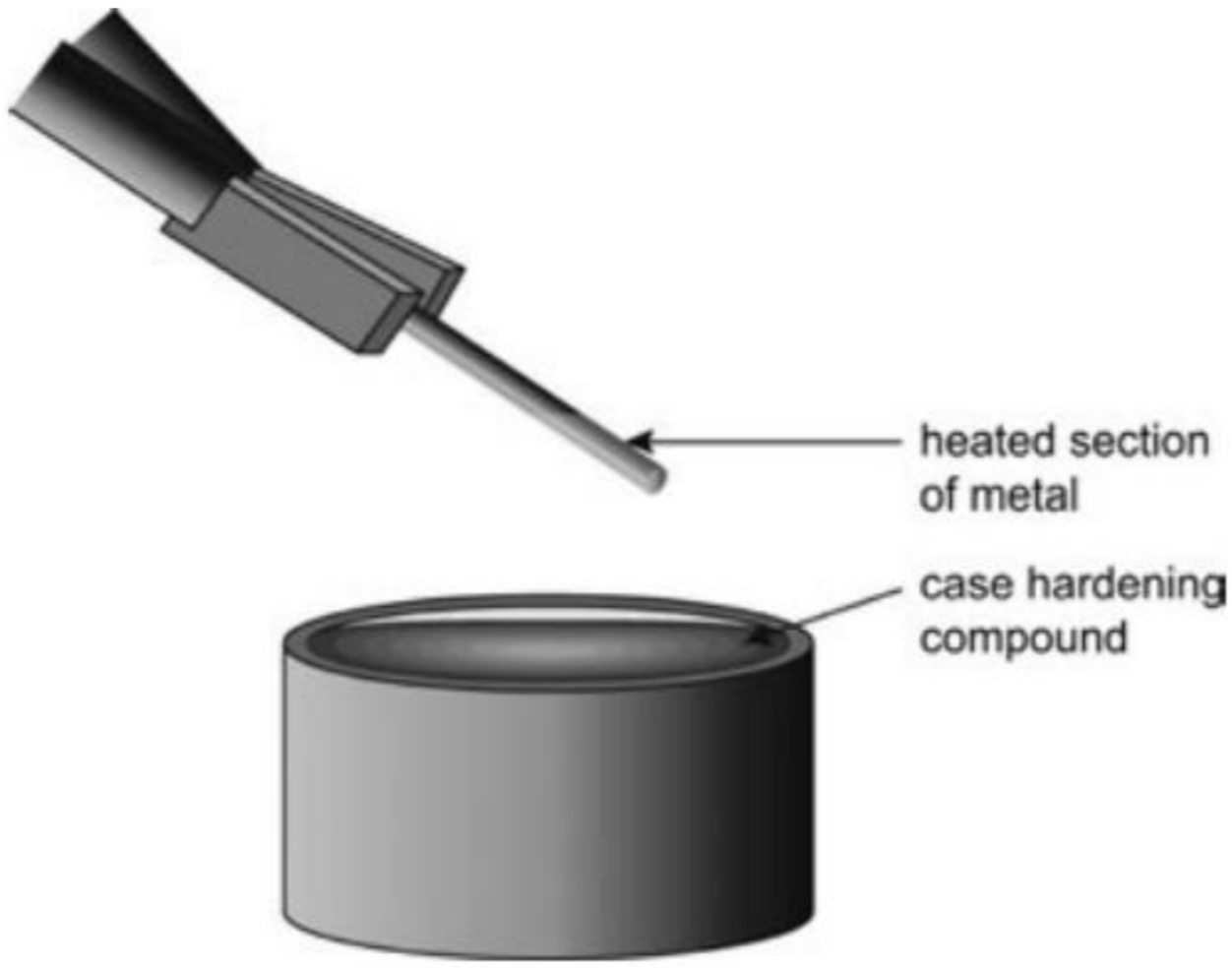
Step 1

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



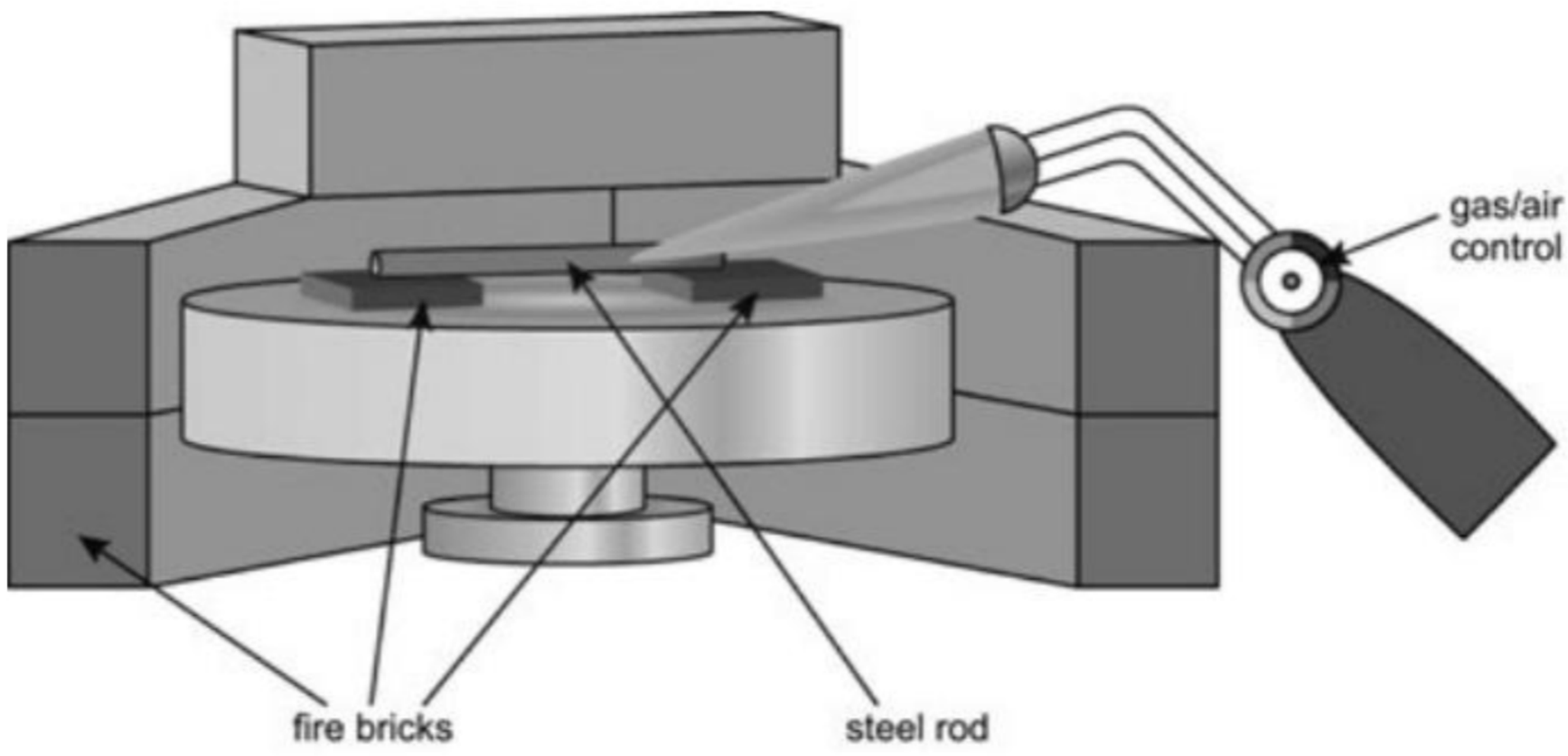
Step 2

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.

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

4.1 Systems

Learning objectives

By the end of this unit students should:

- be able to describe systems using block diagrams
- understand that each system block has an input, an output and describes an operation
- be able to draw a system diagram for a simple system.

Key terms

closed-loop system, feedback, open-loop system, system, systems diagram

Resources

Student Book pages 230–232
Activity sheets A–B (available online on Collins Connect)
A bicycle; a range of electrical products, e.g. torches, hairdryers

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 4.1.

The ideas and activities in this unit are designed to develop students' abilities to consider mechanisms, electronic circuits, structures and other technological products as a system of interrelated parts. This is a useful approach when examining existing products in terms of how they are constructed and operate, as well as being useful in the early stages of systems design, e.g. designing electronic products like alarm systems, sensing circuits and electronic timing systems. The focus should be on learning by doing, so the activities encourage students to consider how system parts link together using input and output quantities. They also encourage students to explore some common products in systems terms and to consider the purpose of each part in relation to the system as a whole.

It is suggested that a minimum of two lessons should be devoted to this unit.

Lesson starter suggestions

Systems ‘ordering’: Put students in groups of four. Print one copy of Activity sheet A for each group and cut out the systems templates, i.e. the systems template for the electric kettle, computer system, baking a cake and the bicycle. Explain how a system diagram can be produced by joining individual process block diagrams together. Each individual process block diagram will have an input and output quantity relating to the purpose of the process in question. Ask students to link the templates for each system in the right order. When they have finished, discuss the outcomes as a class.

How many parts?: Bring a bicycle into the classroom as an example of a mechanical system. Ask students to list as many bicycle parts as they can in two minutes. Then ask individual students to say which parts they identified and write them on the board to create a comprehensive list of parts.

Main lesson activities

Introduction to system block diagrams: Ask students to read ‘What is a system?’ on pages 230–231 of the Student Book, which introduces the concept of using a block diagram to represent part of a system. At this stage, there is no need for students to understand the details of how a part of a system works; they just need to understand the function of the process, and that each system diagram has an

input and an output. Give examples of systems, e.g. bicycles, car systems and kitchen appliances. Make sure students are familiar with the terms *input*, *output* and *process*, and that they understand how systems diagrams can be used in the initial stages of the design process.

Student activity (1): Put students in groups of three or four and provide each group with a simple product, e.g. an electric torch or a hairdryer, to dismantle and examine. Ask students to identify each part of the product, note down the function of each part and establish how the parts are linked together. They should then try to produce a block diagram to describe their product in systems diagram terms. To do this, they will need to identify the input and output quantities for each system part identified and describe how each part of the system relates to another. You could ask each group to give a presentation of their system to the rest of the class, describing the purpose of the product and how each part can be simplified in system terms.

Skills activity (page 231): Students do the activity individually. They can consolidate their knowledge by identifying the input and output parts of each diagram and briefly describing what function each part of the process performs. When they have finished, ask them to feed back their answers to the rest of the class.

Student activity (2): Put students in groups of three or four. Give each student in a group a product (e.g. an electrical toaster, an electronic calculator, a vacuum cleaner, a mobile phone, household weighing scales) to describe as a systems diagram. Tell them to keep their product a secret from the other students in their group. When they have finished, each student passes their system to others in the group so that they can try to identify what product has been described. The members of a group discuss how each system diagram might be improved and how it might be drawn in more detail by refining system parts.

Introduction to open-loop systems: Discuss with students the concept of an open-loop system. Refer them to page 231 of the Student Book. Give examples of an open-loop system so that they can relate the concept to practical examples, e.g. a heating system without a thermostat or sensor to control the temperature.

Introduction to closed-loop systems: Discuss with students the concept of a closed-loop system. Refer them to page 231 of the Student Book. Give examples of an closed-loop system so that they can relate the concept to practical examples, e.g. heating systems with thermostat feedback, driving a car, and outside lights that come on when it is dark.

Skills activity (page 232): Students do the activity individually. Make sure there are plenty of product or appliance examples available for this activity. Encourage students to use systems terminology they have learnt to describe parts of their chosen systems. They should also consider how their chosen products can be conveniently represented in block diagram form similar to those described in the Skills activity on page 231.

Knowledge check (page 232): Students can complete this at the end of the unit or for homework.

Plenary suggestions

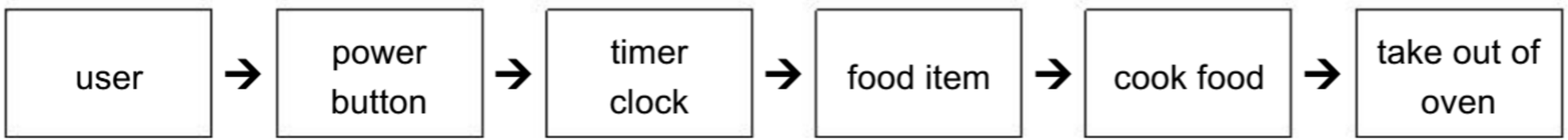
Define it: Print and cut out Activity sheet B, enough for pairs or individual students in the class. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used. Alternatively, do the Define It Quiz at the front of the class, 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.

Answers to Student Book activities

Skills activity (page 231)

Typical answers might be:

Microwave oven



Simple air conditioning system

system 'on' switch → temperature adjustment → cooling pump on → outside air drawn in → air in room cooled

Kettle

water in kettle → switch on kettle → heater on → boiling temperature → switch off

Washing machine

cycle control → water in → heater → washing cycle → water out → spin cycle → finish

Skills activity (page 232)

Possible answers: Design & Technology workshop machines and equipment, kitchen equipment, communication systems

Knowledge check (page 232)

1. What is the difference between an open-loop and closed-loop system? (3)

An open-loop control system is one in which the desired output depends only on the original input setting, e.g. a temperature setting. There are no sensors to adjust the value of the output signal once the system is in operation. A closed-loop system, on the other hand, is one in which the desired output is sensed by a suitable sensor or sensors, e.g. temperature, pressure or flow rate sensors. The sensor or sensors adjust the value of the input signal to keep the output signal at its required value.

Award 1 mark for an appropriate description of an open-loop system, 1 mark for an appropriate description of a closed-loop system, and half a mark for an example of each.

2. How can a framework structure be described as a system? (1)

Because it consists of individual members (parts) that are connected together to form a structure designed to resist the loads acting on it.

3. What is meant by an integrated system? (2)

It is one in which smaller sub-systems, often mechanical, electrical and computer control systems (1), are joined together to form one large system (1).

4. How might sensors be used (i) in a burglar alarm system, and (ii) an automatic door in a supermarket? (2)

(i) Sensors are used in burglar alarm systems to detect if a person has entered a room, broken into a safe, or stolen items from other types of security facilities. A burglar alarm may have a pressure pad sensor or an infrared sensor to start the alarm system if an intruder steps on the pressure pad or breaks the infrared beam. (1)

(ii) Supermarket doors operate when they sense that a person wants to go through them. Some automatic doors are triggered by sensors that sense weight. When a person steps on a mat, the sensor sends a signal to the automatic door that tells them to open. Other sensors make use of infrared beams or light sensors to send a signal to the automatic door. (1)

Total: 8 marks

4.2 Structures

4.2.1 Basic concepts

Learning objectives

By the end of this unit students should:

- understand that structures can be classified as mass, frame or shell structures
- be able to give examples of mass, frame and shell structures
- understand that the principle of levers can be incorporated into a structure
- understand that frame structures are designed to span gaps and support loads
- be able to identify structures which occur in nature.

Key terms

frame structure, mass structure, natural structure, reinforced concrete, shell structure

Resources

Student Book pages 233–236
Activity sheets A–B (available online on Collins Connect)
Images of mass, frame and shell structures; sets of modelling materials: balsa, strips of wood, string, cardboard strips, glue; sheet card

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 4.2.1.

The aim of this unit is to introduce students to ways in which structures can be classified as a) natural and man-made structures, and b) mass, frame and shell structures. It is important to emphasise that the purpose of most structures is to withstand the forces acting on them without excessive deformation.

It is suggested that a minimum of three lessons should be devoted to this unit.

Lesson starter suggestions

Structure quiz: Put students in groups of three or four and provide each group with photos, illustrations or postcards showing examples of mass, frame or shell structures. (There are some examples on pages 233–236 of the Student Book.) Give a brief overview of each type of structure and make sure students understand the basic form of each type. Ask them to examine the structure in each image and to identify the category the structure belongs to.

Nature's wonders: Put students in groups of three or four. Ask them to identify six examples of structures that occur in the natural world, to describe the purpose of each structure, and to say how the structure performs its purpose. You could ask one student from each group to share their group’s ideas with the rest of the class.

Main lesson activities

Mass, frame and shell structures: Keep students in their Lesson starter groups. Ask them to identify three features of each structural type that would classify it as a mass, frame or shell structure, to discuss some of the key points, and to feed back their discussion outcomes to the rest of the class. The

responses from each group can then be gathered and the various factors discussed as a class so that students thoroughly understand the key features of each type.

Teacher-led discussion (1): Ask students to read pages 233–234 of the Student Book and discuss with them how mass and frame structures work. Emphasise that mass structures rely on the mass of material to withstand the various forces acting on them. Typical materials used for mass structures are stone, bricks, soil and reinforced concrete. Also emphasise that frame structures are made by connecting members together with suitable joints to produce a framework skeleton. A key feature of such structures is that parts are connected so that the structure as a whole is designed to withstand the forces acting on it. The individual parts would not be strong enough to withstand the forces on their own.

Skills activity (page 234): Students do the activity individually. They should carry out research using the internet, books or images to identify two different bridge frame structures. They can then make a sketch of each example and note down what they think the purpose of each part is. When they have finished, discuss with them the different bridge structures and outline some of the ways individual structural members provide strength and stability for the structure in question.

Student activity (1): Put students in pairs and provide each pair with a set of modelling materials, e.g. balsa (or similar material) strips of wood, string, cardboard strips and glue. Students use the sketches they made for the Skills activity on page 234 of the Student Book as a stimulus to design a simple bridge that should withstand a load of 10 kg. They should start by making a working diagram of their design and use this as the template for their design. Once they have built the bridge, they can test it to observe if it can withstand the load applied to it. Discuss with students the outcomes of the bridge building and testing activity and take the opportunity to re-cap some of the ways in which the structures withstood the loads and resisted the bending and twisting effects of the load applied. These insights can then be related to some of the principles of frame structures as a whole.

Teacher-led discussion (2): Refer to ‘Shell structures’ on page 234 of the Student Book to introduce students to some of the key principles of strengthening shell structures. You can include examples where shell structures are used in practice and how they can be combined with mechanisms in systems design.

Student activity (2): Put students in pairs. Print and hand out a copy of Activity sheet A to each pair. Ask them to make a model of a flat roof structure using sheet card that can withstand a central load of 5 kg. Encourage them to think about ways in which the card can be formed to give it greater rigidity, and to use other techniques to strengthen the flat roof span.

Skills activity (page 236): You could set this activity for homework. It is designed to introduce students to identifying structures that occur in nature and to recognise the way they perform in their environmental setting.

Knowledge check (page 236): 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.

Answers to Student Book activities

Skills activity (page 234)

Students could mention different types of truss structures that are made from triangulation type frames, and bridges that combine frame and suspension principles for their operation.

Skills activity (page 236)

Possible answers: trees and other types of plants, birds' nests, snail shells, the wings of insects, spiders' webs, sea shells, geological features, the leaves of plants, animal skeletons, the wings of bats

The purposes of such structures include providing natural features with good strength to weight ratios, providing protection, giving form to the feature, and providing space.

Knowledge check (page 236)

1. Give two examples of each of the following: mass structures, frames structures, shell structures. (3)

Possible answers:

Mass structures: buildings, dams, brick walls

Frame structures: bicycles frames, bridges, roof trusses, the human skeleton, chair leg frames, electricity pylons, skyscraper frames

Shell structures: tents, car bodies, crash helmets, the roofs of buildings, birds' eggs, cardboard cartons for holding liquids

Award half a mark for each correct example of a mass structure (to a maximum of 1 mark), half a mark for each correct example of a frame structure (to a maximum of 1 mark), and half a mark for each correct example of a shell structure (to a maximum of 1 mark).

2. Explain in your own words what is meant by a mass structure and a frame structure. (2)

A mass structure is made by piling up or forming materials to produce a structure that is designed to withstand the forces acting on it due to its own weight. (1) A frame structure uses parts joined together to form a 'skeleton' to withstand the loads acting on it and prevent undue deflections when loaded. (1)

Total: 5 marks

4.2 Structures

4.2.2 Types of frame structure members

Learning objectives

By the end of this unit students should:

- understand that frame structures can be constructed using ties, struts, beams and columns
- understand that ties resist pulling (tension) forces
- understand that struts resist compressive (squeezing) forces
- understand that beams are designed to resist bending
- understand that columns resist compressive forces.

Key terms

beam, column, structural member, strut, tie

Resources

Student Book pages 237–239
Activity sheets A–B (available online on Collins Connect)
Images of famous frame structures, e.g. Sydney Harbour Bridge, Golden Gate Bridge; images of frame structures, e.g. a bridge, a crane, a bicycle, a tent; a range of flat materials, e.g. balsa wood, thick card, mild steel sheet, plastic sheet (250 mm × 20 mm) with differing thicknesses; straws, balsa wood strips, card or parts from construction kits, string, glue, scissors, craft knives, tenon saws

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 4.2.2.

This unit introduces the idea that frame structures are constructed using members termed beams, ties, struts and columns. The activities encourage students to analyse the purpose of such structural parts through practical exploration. This approach seeks to develop students' abilities to recognise the types of structural members used in simple frame structures and to understand the purpose of each type in the structure as a whole.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

Frame structure quiz: Show students images of famous frame structures; these may be photos on a handout or shown on a screen in front of the class. Ask students to identify each of the structures and to note down where they are situated. Examples could include Sydney Harbour Bridge, the Golden Gate Bridge (San Francisco), the Brooklyn Bridge (New York), the Eiffel Tower (Paris), the Oresund Bridge (Denmark/Sweden), the Millau Viaduct (France), Tower Bridge (London), the Bird's Nest Stadium (Beijing), the Iron Bridge (UK) and the Empire State Building (New York). When students have finished, give them the answers and discuss why the structures could or could not be described as frame structures.

Main lesson activities

Student activity (1): Provide each student with a photo, diagram or illustration of a type of frame structure, e.g. a bridge, a crane, a bicycle (frame), a tent or a framed building. Ask them to identify the purpose or purposes of the structure and describe what types of loads it might have to carry or stand up to. When they have finished, ask individual students to describe their frame structure and then to briefly outline how it might support the loads acting on it. Emphasise that all structures have two important purposes in common: a) they must be able to withstand the loads they have to support, and b) they should not deflect too much when loaded.

Structural members: Ask students to read about frame structures and the types of members that make them up (i.e. beams, ties, struts and columns) on page 237 of the Student Book. Make sure they understand the concepts of static and dynamic loads that many structures have to withstand during use.

Beam members: Ask students to read about beams on pages 237–238 of the Student Book. Emphasise the principle that beams are designed to support vertical loading without undue bending, and when a beam is bent due to the loads it is carrying, one of its surfaces will be in tension and the other in compression.

Student activity (2): Put students in pairs and provide each pair with a flat material beam with the same dimensions (e.g. 250 mm long and 20 mm wide) and varying thicknesses. Provide each group with different types of materials, e.g. balsa wood, thick card, mild steel sheet, plastic sheet. Ask students: a) to support the beam on blocks so that the beam has an effective span of 200 mm; b) to set up a dial test indicator at the centre of the beam; this will be used to measure the deflection of the beam when it is loaded; c) to explore the deflection characteristics of the beam by loading it at its centre using a range of small masses and measuring its deflection at each ‘mass stage’; d) to draw a graph of mass against deflection; and e) to use the graph to estimate the amount of deflection when the beam is loaded with a particular mass value within the range used. When students have finished, ask each pair to feed back their observations to the rest of the class. This should lead to the common conclusion that the amount of beam deflection depends greatly on the type of material it is made from; for example, balsa wood will deflect more than mild steel given the same load and dimensions.

Student activity (3): Ask students to consider other factors that would contribute to how much a beam might deflect in practice. This could include: a) the depth of the beam, i.e. the deeper the beam, the less it will deflect under the same loading conditions, and b) the length of the beam between its supports.

Student activity (4): To follow on from Student activity (3), ask each pair of students to devise a way to reduce the amount of deflection for their particular beam using the loads given. This might include adding ribs to the beam, corrugating the beam if it is made from a material such as card, and supporting the beam with a framework. Students then re-load with the masses and measure the amount of deflection of the redesigned beam. A second graph of mass against extension deflection can be plotted on the same axes as the previous graph to illustrate how such modifications have helped to increase the stiffness of the beam. Then ask each pair to feed back their observations to the rest of the class.

Tie and strut members: Ask students to read about ties and struts on page 238 of the Student Book. Ensure they understand that ties are designed to withstand tensile (tension) forces, whereas struts are designed to withstand compressive (squeezing) forces. Then ask students to say where they may have come across such force types before.

Student activity (5): Ask students to make two simple three-member frames as shown on page 239 of the Student Book. Provide them with straws, balsa wood strips, card or parts from construction kits. They can then use one hand to hold each frame on a bench top (or similar surface) and use the other hand to apply a downward force to each frame. When loading the frames, they should be able to recognise which members are in tension and which are being compressed, and therefore, which members are ties and which are struts. From this experience students should recognise that members acting as ties can be made from cables, ropes, wire and string parts. However, struts cannot be made using such parts because the material would simply collapse under the load.

Student activity (6): Put students in pairs. Print and hand out a copy of Activity sheet A to each pair. Ask students to decide which member would be a tie or and which would be a strut by considering how the loads acting on the structure would either exert a pulling force on a member or squeeze the member.

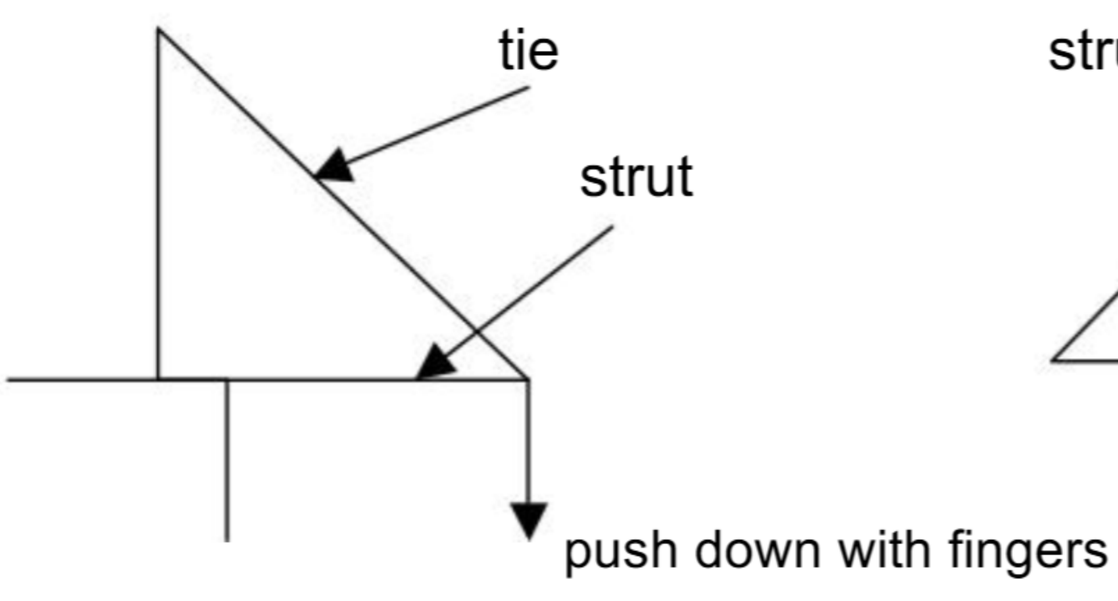
Then ask students to build their structure using string for the members they have identified as ties and ‘solid’ material for the members they have identified as struts.

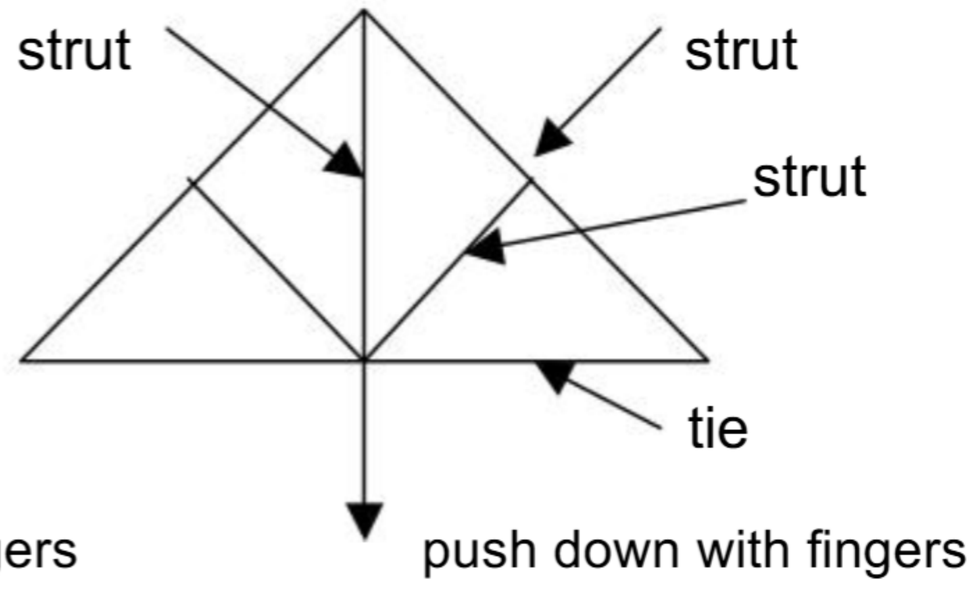
Plenary suggestions

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.

Answers to Student Book activities

Skills activity (page 239)





4.2 Structures

4.2.3 Strengthening frame structures

Learning objectives

By the end of this unit students should:

- understand how triangulation can strengthen a frame structure
- understand how bracing and gusset plates strengthen structures at their corners.

Key terms

space frame, triangulation, truss

Resources

Student Book pages 240–241
Activity sheets A–B (available online on Collins Connect)
Drinking straws or similar materials, tools to cut and shape the straws, glue

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 4.2.3.

The activities in this unit are designed to develop understanding of how frame structures can be strengthened by using the principle of triangulation and strengthening the corners of the frames, e.g. cross-bracing and gusset plates.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

Skills activity (page 240): Ask students to do the first part of the activity. This involves making a rectangular frame out of drinking straws and exploring how the frame deforms under squeezing and pulling loads. Students can strengthen their frame using a triangulation member that connects the corners of the rectangle. They then note the effect of the cross member in strengthening the framework when it is loaded.

Main lesson activities

Teacher-led discussion (1): Ask students to read about triangulation on page 240 of the Student Book. Make sure they understand the principle of triangulation. Emphasise that the concept is widely used in the design of frame structures to add rigidity and strength. You can use photos of common structural examples like bridges, buildings and bicycle frames to show students how triangulation is used in a range of Design & Technology applications.

Skills activity (page 240): Ask students to do the second part of the activity. This involves exploring how cross-bracing and gusset plates are commonly used to strengthen the corners of frame structures.

Teacher-led discussion (2): Discuss with students how cross-bracing and gusset plates are used in practice. Emphasise how the strengthening methods are used in the design of frame structures to add rigidity and strength. You can use photos or material from the internet to show students examples of the use of cross-bracing and gusset plates, e.g. in frame structures such as bridges, gusset plates are often

used to connect beams to the columns supporting the bridge. Gusset plates can be joined to the bridge parts using rivets, bolts or by welding methods.

Student activity: Put students in pairs. Print and hand out Activity sheet A. Students use drinking straws to build a side section of a roof and bridge truss. Refer students to the examples on page 241 of the Student Book. They then consider how the joints may be reinforced using either cross-bracing or gusset plates and build these into their models. Encourage them to explore how each truss behaves under loading and to pay particular attention to how each member bends, twists or stretches under the loading conditions. When they have finished, discuss how each member deforms in such a way as to help carry the overall loads applied to the structure. It would also be useful to explain how some of the members are squeezed together (compressed) under loading while others experience a pulling force.

Skills activity (page 241): Students do the activity individually.

Tip: *This activity could be given for homework.*

Teacher-led discussion (3): Ask students to read about space frames on page 241 of the Student Book. Then discuss with them how space frames are used for buildings such as factory spaces and warehouses.

Knowledge check (page 241): 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.

Answers to Student Book activities

Skills activity (page 240)

Students should understand how attaching cross members to the corners of a rectangular frame strengthens the frame and prevents it from collapsing under loading. They should also recognise that using two cross-bracing members to connect all four corners of the rectangle results in a stronger construction than using only one cross-bracing member.

Skills activity (page 241)

Possible answers: many types of bridges, truss structures associated with buildings and monuments, transport applications

Knowledge check (page 241)

1. Describe two ways to strengthen a rectangular frame when used as part of a structure. (4)

Triangulation uses triangular shapes to give rigidity and stability to structures. The triangle is the most rigid frame structure and so is commonly used in the design of structural parts. Gusset plates are also used to strengthen various structures by connecting the corners of structural members together in such a way that the corners can withstand higher loads than if the gusset plate was not used. Gusset plates are generally connected to structural members by using rivets, bolts or welding.

2. Give two examples of where trusses may be used as part of a building or other construction application. (2)

Possible answers: a roof truss for a building; as a space frame

Total: 6 marks

4.2 Structures

4.2.4 Nature of structural members

Learning objectives

By the end of this unit students should:

- understand that deflection of a structural member depends on the material it is made from
- understand that deflection of a structural member depends on its cross-sectional shape
- understand that struts can fail by buckling
- understand that deflection of a beam is related to the depth of the beam.

Key terms

buckling, composite sandwich beam, cross-sectional shape, I-beam

Resources

Student Book pages 242–244
Activity sheets A–B (available online on Collins Connect)
30-cm rules; balsa wood

Lesson ideas

This unit gives students the opportunity to explore how beams bend under loading and how struts can fail by buckling. They will also examine how cross-sectional shapes used for structural members relate to frame structure design in terms of weight, cost and maintenance considerations. It is suggested that two lessons should be devoted to this unit.

Lesson starter suggestions

Ease of bending: Put students in pairs. Ask them to examine the bending performance of a 30-cm rule by gripping it at both ends and applying a force to bend it. They then discuss with their partner why a rule can be bent easily in the direction of its thinner section whereas it is much more difficult to bend it in the direction of the thicker section. When they have finished, ask them to share their ideas with the rest of the class.

Main lesson activities

Skills activity (page 242): Ask students to read about the nature of structural members on page 242 of the Student Book. They then do the activity, which consolidates some of the principles they have read about. They can use a number of approaches to find the information required, including internet research, gathering information from books or by observing buildings in their area.

Teacher-led discussion: Discuss with students the way a beam bends during loading and how one of the surfaces will be in tension and the other surface will be in compression. Relate this concept to the design of the I-beam and the composite beam and how this principle leads to the design of strong beams that have a relatively low mass for the distance they can span. Ask students where they may have seen I-beams or composite beams and why the beams may have been used.

Constructing and loading an I-beam and a composite beam: Put students in pairs. Print and hand out one copy of Activity sheet A to each pair. Students have to build an I-beam and a composite beam using balsa wood (or other suitable material) and then explore how they behave when loaded. Two points should emphasised: a) for a composite beam, a relatively strong structure can be made by combining two relatively weak materials in a sandwich construction; b) the I-beam principle relies on the

fact that the two outer flanges of the beam carry most of the bending loads. Consequently, I-beams are an effective way of spanning large gaps with minimal mass.

Skills activity (page 244): Put students in pairs or in small groups and ask them to do the activity. When they have finished, the outcomes can be gathered together and discussed.

Student activity: Ask students to discuss other criteria for selecting materials for structural purposes and then share their ideas with the rest of the class.

Knowledge check (page 244): 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, referring to the Student Book and giving examples of how the terms are used.

Answers to Student Book activities

Skills activity (page 242)

Possible buildings: houses, sports halls, religious buildings, shops, office buildings, skyscrapers, garages, train stations, airport buildings, school buildings

Possible materials to make frames: types of wood, steel, stainless steel, aluminium, reinforced concrete. Possible reasons for choosing materials: strength; the ability to withstand the various loads acting on the building; weather and corrosion resistance; appearance; ease of maintenance; ease of joining the materials together

Skills activity (page 244)

1. Possible examples: the girders supporting the roadway of a bridge; the beams supporting the floors of a building

They are used because they are an effective way of spanning large gaps with minimum weight.

2. Possible examples: door panels for trucks; sidewalls for automobile applications; aircraft flooring

They are used because composite structures have good strength to weight ratios, making the material suitable for applications where keeping the mass as low as possible is a priority, e.g. in aircraft applications. Some materials can have good corrosion resistant properties. The composite panels used for many transport applications can be easily repaired.

Knowledge check (page 244)

1. What type of member might fail by buckling? (1)

a strut member or a column

2. What happens at the surfaces of a beam when it is bent? (2)

One of the outer surfaces will be in tension (1) and the other surface will be in compression (1).

3. Give one use of an I-beam and one use of a composite beam, and explain why they are used for these applications. (4)

Possible uses of I-beams: joists to span gaps in buildings; columns to hold up building parts; girders for bridges and other large structures; chassis of lorries and rail carriages

Possible uses of composite beams: door panels for trucks; sidewalls for automobile applications; aircraft flooring

I-beams are used because they are often cheaper than solid beams made from the same material; they have a minimum amount of material around the central axis of the beam so they can span large distances with minimum mass. Composite beams are used because they have good strength to weight ratios and in many cases are corrosion resistant.

Total: 7 marks

tape and a 0.1 kg load. Ask students to quickly construct the supports to hold the 0.1 kg mass using the paper and adhesive tape. Students should consider what factors help to support the mass.

Main lesson activities

Student activity (1): Put students in pairs and provide each pair with a flat beam made from a material such as balsa wood (suggested dimensions: 300 mm long × 20 mm wide) and a pair of spring balances. Tell students: a) to support each end of the beam with a spring balance so that the forces acting on the balances can be measured when the beam is loaded; b) to position a 1 kg load at the centre of the beam (i.e. 150 mm from each end) and record the force value for each spring balance. Ask students to observe how each spring 'reacts' to the load when it is applied; c) to move the load to different positions along the beam, e.g. at 50 mm intervals, and note the spring balance values at the different intervals; d) to produce a table showing the magnitude of the two spring balance at each of the loading points.

Teacher-led discussion: Use pages 245–246 of the Student Book to teach students the concept of reaction forces and how they relate to loads acting on a beam. Relate the information to Student activity (1) and point out that the sum of the reaction forces must be equal to the downward forces for the beam

Resources

Student Book pages 245–247
Activity sheets A–B (available online on Collins Connect)
Quantities of A4 paper, adhesive tape, several 0.1 kg loads; pieces of balsa wood (suggested dimensions: 300 mm long × 20 mm wide), spring balances, several 1 kg loads

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 4.2.5.

This unit introduces students to the way in which reaction forces support a beam under equilibrium conditions. A key learning outcome is for students to realise that the sum of reaction forces acting on a beam are equal to the sum of the loading forces acting in the opposite direction.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

Holding the weight: Put students in pairs and provide each pair with quantities of A4 paper, adhesive tape and a 0.1 kg load. Ask students to quickly construct the supports to hold the 0.1 kg mass using the paper and adhesive tape. Students should consider what factors help to support the mass.

Main lesson activities

Student activity (1): Put students in pairs and provide each pair with a flat beam made from a material such as balsa wood (suggested dimensions: 300 mm long × 20 mm wide) and a pair of spring balances. Tell students: a) to support each end of the beam with a spring balance so that the forces acting on the balances can be measured when the beam is loaded; b) to position a 1 kg load at the centre of the beam (i.e. 150 mm from each end) and record the force value for each spring balance. Ask students to observe how each spring 'reacts' to the load when it is applied; c) to move the load to different positions along the beam, e.g. at 50 mm intervals, and note the spring balance values at the different intervals; d) to produce a table showing the magnitude of the two spring balance at each of the loading points.

Teacher-led discussion: Use pages 245–246 of the Student Book to teach students the concept of reaction forces and how they relate to loads acting on a beam. Relate the information to Student activity (1) and point out that the sum of the reaction forces must be equal to the downward forces for the beam

to be balanced, i.e. where the beam is in equilibrium. Go through Example 1 on page 245 and Example 2 on page 246 with students to show them how to calculate the size of the reactions for simple symmetrically loaded beam applications.

Skills activity (page 246): Students do the activity individually.

Student activity (2): Print and hand out Activity sheet A. This activity is designed to help students to consolidate their understanding of how to determine the reactions of symmetrically loaded beams.

Student activity (3): Ask students to read about uniformly distributed loads on pages 246–247 of the Student Book.

Skills activity (page 247): Students do the activity individually.

Knowledge check (page 247): 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.

Answers to Student Book activities

Skills activity (page 246)

R1 = 2 kN

R2 = 2 kN

Skills activity (page 247)

1. 5000 N / 5 kN

2. R1 = 2500 N / 2.5 kN

R2 = 2500 N / 2.5 kN

Knowledge check (page 247)

1. What is meant by the term *reaction*? (1)

the force applied to a beam at its supporting points

2. A simply supported beam has a load of 400 N acting on it. If one of the reactions is 100 N, what will be the value of the other reaction? (2)

400 N – 100 N = 300 N

Award 1 mark for the method and 1 mark for the answer.

3. A simply supported beam has a length of 8 metres. If the beam supports a force of 2 kN acting at its centre, what will the value of the two reaction forces be? (2)

R1 = R2 = 2000N ÷ 2 = 1000 N (1 kN)

Award 1 mark for the method and 1 mark for the answer.

Total: 5 marks

4.2 Structures

4.2.6 Moments

Learning objectives

By the end of this unit students should:

- understand that a moment is a turning force
- understand the equation M = F × d
- be able to use the principle of moments to determine the reactions of non-symmetrical beams.

Key terms

moment, moment of force

Resources

Student Book pages 248–250
Activity sheets A–C (available online on Collins Connect)
A range of different sizes of nuts, bolts, spanners, socket sets, box spanners

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 4.2.6.

This unit builds on some of the ideas learnt in Unit 4.2.5, and focuses on calculating the size of reactions supporting loads that have non-symmetrical loading conditions.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

Feeling the force: Put students in pairs and provide each pair with a nut, a bolt, a spanner and a tool from a socket set (or similar tool). Each pair can have a different size of nut and bolt. Ask students to investigate the factors, e.g. the size of the nut and bolt, the amount of force applied to the spanner, and the length of the spanner, that contribute to the tightening action of the nut on the bolt. As a class, discuss students' findings and relate the outcomes to the definition and characteristics of a turning moment of force.

Main lesson activities

Introductory discussion: Use page 248 of the Student Book to explain the principle of a turning moment of force. Give examples of where turning moments of force are used in systems and control applications, and show how the magnitude of a moment of force depends on the size of the force and the distance the force acts from its pivot point. Explain the formula M = F × d.

Skills activity (page 248): Students do the activity individually.

Teacher-led discussion (1): Ask students to read 'Using the principle of moments for non-symmetrical beams' on page 249 of the Student Book and make sure they understand how the principle of moments can be used to determine the reaction forces for non-symmetrical beams. Emphasise that reaction and other forces can be regarded in terms of clockwise and anti-clockwise moments. Also emphasise that to determine the reaction forces, the beam is considered to be in static equilibrium, where clockwise moments equal the anti-clockwise moments acting on the beam. Go through Example 1 with students so

that they understand the use of moments to calculate the reaction forces R1 and R2 in the case of a single force acting on a beam.

Student activity: Print and hand out Activity sheet A. This activity is designed to develop students' ability to calculate the reaction forces for an offset point load case.

Teacher-led discussion (2): Go through Example 2 on page 250 of the Student Book with students. This example relates to determining the reaction forces R1 and R2 if more than one point load is acting on the surface of the beam.

Skills activity (page 250): Students do the activity individually.

Student activity: Print and hand out Activity sheet B. This activity is designed to develop students' ability to calculate the reaction forces for two point loads.

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.

Answers to Student Book activities

Skills activity (page 248)

The moment of force values are:

450 N × 0.25 m = 112.5 Nm

1.2 kN × 2.1 m = 1200 N × 2.1 m = 2520 Nm

810 N × 0.75 m = 607.5 Nm

Skills activity (page 250)

Example on the left

Assuming the beam pivots around R1:

clockwise moment = 200 N × 1 m = 200 Nm; anticlockwise moment = R2 × 4 m

clockwise moments = anticlockwise moments

200 Nm = 4 m × R2

R2 = 50 N

R1 + R2 = 200 N; R1 = 200 N – 50 N = 150 N

Example on the right

Assuming the beam pivots around R1:

clockwise moments = (300 N × 0.5 m) + (75 N × 2 m) = 150 Nm + 150 Nm = 300 Nm

anticlockwise moment = R2 × 3 m

clockwise moments = anticlockwise moments

300 Nm = R2 × 3 m

R2 = 100 N

R1 + R2 = 375 N; R1 = 375 N – 100 N = 275 N

4.2 Structures

4.2.7 Materials

Learning objectives

By the end of this unit students should:

- understand that materials properties can be divided into mechanical and physical properties
- be able to define the main mechanical properties such as tensile strength, compressive strength and toughness.

Resources

Student Book pages 251–252
Activity sheets A–B (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 4.2.7.

It is likely that students will have learnt about the types of materials and their uses in other Design & Technology units, so this lesson aims to consolidate what they have learnt and relate their knowledge of materials to structural applications.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

What do I know about material properties?: This activity is designed to find out what students already know about material properties in the broader Design & Technology context. Print and hand out Activity sheet A, which asks students to match mechanical and physical properties of materials with their definitions. When they have finished, ask them to share their answers with the rest of the class so that you can assess what they know.

Main lesson activities

Teacher-led discussion: Discuss with students the information on page 251 of the Student Book, which relates material selection factors to structural design needs. Relate the definitions of mechanical and physical properties to the work students did in Activity sheet A.

Student activity: Put students in pairs. Print and hand out Activity sheet B and ask students to answer the questions. They have to select materials for specific purposes based on the information given in the materials ‘merit’ table on page 252.

4.2 Structures

4.2.8 Testing EXTENDED

Learning objectives

By the end of this unit students should:

- understand how dial gauges and strain gauges are used for testing structural parts
- understand that strain gauges form part of a measuring system
- be able to read a dial gauge to measure structural deflections.

Resources

Student Book pages 253–254
300-mm rules, a range of material sections (e.g. wood, metal, plastic, with different dimensions), a dial gauge; strips of wood (40 cm × 30 cm × 0.5 cm), a range of masses, G-clamps

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 4.2.8.

This unit introduces students to two common ways of measuring deflections in structural members: by using dial gauges and by using strain gauges. Students should know how to set up a dial gauge to reduce measurement error and be able to use it to measure the deflection of a beam. The use of strain gauges is also covered in Unit 4.4.7 of the Student Book. Students should know that strain gauges are positioned on the structural parts being measured with a suitable adhesive, and are normally incorporated into a Wheatstone bridge circuit, where the output signal is amplified so that the response of the strain gauge can be measured.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

How accurately can I measure?: Put students in groups of three or four. Provide each student with a 300-mm rule and each group with a range of material sections, e.g. wood, metal or plastic with different dimensions. Each student in a group measures the dimensions of the material sections as accurately as they can and records their answers. Students in a group then compare their answers to see how close their measurements are. Ask them to estimate how accurately they think they can measure the materials with a 300-mm rule. Then ask individual students to feed back their responses to the class.

Main lesson activities

Student activity: The aim of this activity is to encourage students to consider ways in which they might measure the deflection of a cantilever beam. Put students in pairs and provide each pair with a strip of wood (40 cm × 30 cm × 0.5 cm) that can be used as a beam section, a range of masses and a G-clamp that can be used to clamp the end of the beam to a work bench or table. Ask students: a) to clamp the end of the beam to the work bench or table so that the beam becomes a cantilever; b) to load the beam with the masses in convenient steps and to use a rule to estimate the deflection at each step; c) to consider the effectiveness and accuracy of their measuring approach in the light of the outcomes of the ‘How accurately can I measure?’ activity; and d) to report their findings to the rest of the class.

Teacher-led activity (1): Discuss with students the importance of being able to measure the deflection of structural parts with a high degree of accuracy, and also of being able to test the deformation of structural parts such as aircraft wing sections, rail lines and car engine parts. Use the section on dial gauges on page 253 of the Student Book to describe how a dial gauge can be used to measure the deflection of a beam. Ensure that students understand how set up the gauge on the surface of the beam to be measured and how to set the dial gauge to zero before the amount of deflection is measured. Students should be able to read off the amount of deflection using the dial gauge pointer.

Teacher-led activity (2): This activity is designed to show students how to set up a dial gauge and read it off in practice. Clamp one end of a beam section (40 cm × 30 cm × 0.5 cm) to a work bench or table so that it acts as a cantilever beam. Set up a dial gauge so that it can measure the deflection of the free end of the beam when loaded with masses. Describe how the dial gauge is zeroed before it is used to measure the deflection of the beam when the end of the beam is loaded. Load the beam with a range of masses and ask students to read off the deflection that corresponds to each mass stage. Students should record the deflection values they observe for each loading situation and draw a graph of deflection against mass. Then ask students to discuss their results as a class.

Teacher-led activity (3): This activity follows on from 'Teacher-led activity (2)'. Set up the beam as a simply supported case clamped at each end. Then set up the dial gauge at the centre of the beam to measure its deflection at this position when it is loaded. As before, load the beam with a range of masses and ask students to read off the deflection that corresponds to each mass stage. Students should record the deflection values they observe for each loading situation and plot their observed deflection against mass values on the same graph. Once again, students discuss their results as a class.

Teacher-led activity (4): Use the information on strain gauges on pages 253–254 of the Student Book to describe strain gauges and how they are used in practice. Discuss how they can be used to measure the deformation characteristics of structural parts and components, and relate such information to practical examples, e.g. testing the deflection of aircraft wings. Show students an example of a typical strain gauge so that they get an idea of its size and explain how it would be adhered to the part of the structure to be measured.

Skills activity (page 254): Students do the activity individually.

Answers to Student Book activities

Skills activity (page 254)

A number of strain gauges can be adhered to the column. Some might be adhered to the top section of the column and others to the bottom of the column. It would be useful if the gauges were used in such a way to measure whether the column is twisting or bending when in use, so the strain gauges could be placed at 90˚ intervals around the top and bottom sections of the column. If this is done, eight strain gauges could be used. The other equipment needed would be a Wheatstone bridge circuit or circuits, an amplifier to amplify the signals from the Wheatstone bridge and a meter to record the strain outputs.

4.2 Structures

4.2.9 Joints in structures

Learning objectives

By the end of this unit students should:

- understand that joints can be rigid or moveable
- be able to select suitable jointing methods for wood, steel and concrete
- be able to recognise how cross-bracing and the use of lugs and ribs make joints stronger.

Resources

Student Book pages 255–257
A range of screws, adhesives, rivets, nuts, bolts (and other jointing hardware); a range of workshop equipment

Lesson ideas

The aim of this unit is to get students to design and make a simple frame structure, which will help them to put into practice some of the jointing principles learnt in this unit. The design should allow students to work with some moveable and fixed forms of jointing and to consider some of the factors that affect the effectiveness of each type.

It is suggested that two lessons should be devoted to this unit.

Lesson starter suggestions

Which type of joint?: Use photos or illustrations of different structures that have fixed or moveable joints. Ask students whether the joints might be classified as moveable or fixed, and to try to identify the types of joint used, e.g. welded, riveted or bolted.

Main lesson activities

Introduction to joints in structures: Ask students to read about joints in structures on page 255 of the Student Book. Make sure they understand the reason for using joints and the typical jointing methods used for different classes of materials, i.e. wood, steel, plastic and concrete. Emphasise that some joints are permanent while others allow the joint to move under a load. Discuss typical uses of each type of joint for systems and design purposes.

Teacher-led discussion: Ask students to read pages 256–257 of the Student Book. Make sure they understand the construction of some common forms of jointing and where they may be used in practice.

Skills activity (page 257): Students do the activity individually.

Design and make: This activity encourages students to design and make a simple crane structure using suitable modelling materials. Ask students to design their crane and when doing so, to think about how the parts can be joined together, e.g. by using small nuts, bolts or rivets, or by using brazing or soldering methods. Students should also consider using some principles learnt in previous lessons, e.g. using triangulation for structural rigidity and using gusset plates to strengthen the corners of the structure. Students should consider making use of fixed and moveable joints where necessary.

Answers to Student Book activities

Skills activity (page 257)

Responses will vary. Possible reasons for choosing joints: whether a structure needs to be fixed or moveable; the required strength of the joint; the size of the joint; the materials available; the materials the structure is made from; the fabrication methods available for making the joints

4.2 Structures

4.2.10 Forces

Learning objectives

By the end of this unit students should:

- know the meaning of the terms stress, strain, bending, torsion and shear
- be able to calculate simple stress values
- be able to calculate simple strain values
- be able to recognise shear and torsional forces acting on structural parts and members
- be able to identify the key features of a stress–strain graph
- understand the use of safety factors in the design of structural members
- be able to use the triangulation of force method to determine unknown forces in a simple framework
- be able to use the parallelogram of force method to determine the resultant of two forces acting on a part.

Key terms

factor of safety, resultant, strain, stress, stress–strain graph

Resources

Student Book pages 258–264
Activity sheets A–C (available online on Collins Connect)
A range of elastic bands

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 4.2.10.

It is suggested that two lessons should be devoted to this unit.

Lesson starter suggestions

‘Feeling the force’: Put students in pairs and provide them with a range of elastic bands. Ask them to extend the bands by pulling them and to describe the way in which the bands respond to this force. Students then feed back their responses to the rest of the class. Consolidate some of the ideas that emerge from the feedback. Emphasise the concept of a tensile (pulling) force being applied to the material, which acts to stretch the band. This force, in turn, creates an internal force within the band that acts in the opposite way to the pulling force and seeks to restore the band to its original state and dimensions. Once students have understood this, you can introduce the concepts of stress and strain, which form part of the main lesson activities.

Main lesson activities

Teacher-led discussion (1): Refer to the ‘Forces’ section on page 258 of the Student Book to introduce the concepts of tensile and compressive forces acting on a material. Also introduce the SI unit of force, the newton (N), and discuss why it is often more convenient to use kilonewtons (kN) and meganewtons (MN). Then refer to the ‘Strain’ section on pages 258–259 of the Student Book to describe the key

features of strain and how to calculate the magnitude of strain in simple axial cases. Go through the example on page 259 with students to make sure they understand how to do a simple strain calculation.

Skills activity (page 259): Students do the activity individually.

Teacher-led discussion (2): Ask students to read the 'Stress' section on pages 259–260 of the Student Book. Then go over the key aspects of stress with students and make sure they understand how to calculate the magnitude of stress in simple axial cases. Go through the example on page 260 to show students a simple stress calculation.

Skills activity (page 260): Students do the activity individually.

Teacher-led discussion (3): Ask students to read the 'Shear and torsional forces' section on pages 260–261 of the Student Book and discuss with them the way in which torsional and shear forces may affect structural parts. Link the modes of failure to practical examples, e.g. the failure of axles or the shear failure of bolts if they are tightened too much.

Teacher-led discussion (4): Ask students to read the 'Stress–strain graphs' section on page 261 of the Student Book and make sure they recognise the key terminology and key features of a stress–strain graph, including the elastic and plastic regions of the graph, and the yield stress and ultimate stress points.

Student activity (1): Print and hand out Activity sheet A and ask students to plot a stress–strain graph using the data. This will help them to consolidate their knowledge of stress and strain calculations and to apply this knowledge to drawing a stress–strain graph.

Teacher-led discussion (5): Introduce students to the concept and use of factor of safety as outlined on page 262 of the Student Book.

Teacher-led discussion (6): Explain to students how to use the triangulation of force method to determine unknown forces in a simple framework. Then describe the parallelogram of force method to determine the resultant of two forces acting on a part. Emphasise that the diagrams have to be drawn accurately to scale and that the completed diagrams give a diagrammatic representation of the force vectors involved.

Student activity (2): Print and hand out Activity sheet B and ask students to complete the tasks. This will give students practice in the triangulation of force and parallelogram of force methods.

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.

Answers to Student Book activities

Skills activity (page 259)

a climbing rope: value of strain = 30 ÷ 60000 = 0.0005 (tensile)

a chair leg: value of strain = 0.5 ÷ 1200 = 0.000416 (compressive)

a lift cable: value of strain = 4 ÷ 30000 = 0.00013 (tensile)

Skills activity (page 260)

1. stress = force ÷ area

stress = 2000 ÷ 12 mm^2 = 166.7 N/mm^2

2. stress = 800 ÷ 0.03 m^2 = 26667 N/m^2 / 26.667 kN/m^2

4.3 Mechanisms

4.3.1 Basic concepts

Learning objectives

By the end of this unit students should:

- understand that mechanisms are made up of parts like gears, levers, springs, cranks and pulley and belt drives
- understand mechanical advantage
- understand that mechanisms are not 100 per cent efficient.

Key terms

efficiency, effort, fulcrum, lever, linkage, load, mechanical advantage, mechanism, velocity ratio

Resources

Student Book pages 265–272
Activity sheets A–B (available online on Collins Connect)
Photos, illustrations or diagrams of products with levers, e.g. bicycles, doors, scissors, hole punches

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 4.3.1.

This unit introduces students to the operation of mechanisms in terms of their input and output characteristics. They should be able to calculate mechanical advantage, velocity ratio and efficiency and apply these to simple mechanism applications.

It is suggested that three lessons should be devoted to this unit.

Lesson starter suggestions

Identifying the lever: Put students in pairs and provide each pair with photos, illustrations or diagrams of a range of products that incorporate levers, e.g. bicycles, doors, scissors and hole punches. Ask them to identify the lever as part of the product and describe what it is used for. They can then feed back their observations to the rest of the class.

Main lesson activities

Mechanical advantage, velocity ratio and efficiency: Use common mechanisms or machines, e.g. levers, bicycle brake levers, simple pulley systems, belt drives on sewing machines and vacuum cleaner belt drives, to introduce students to the concepts of mechanical advantage, velocity ratio and efficiency. Emphasise that mechanical advantage (MA) = output force or load ÷ input force or load. Introduce students to the concept of velocity ratio. Relate velocity ratio to belt or gear drive mechanisms in order to show where the concept is often used in mechanism design. Show that velocity ratio (VR) = distance moved by effort ÷ distance moved by load. Explain that mechanisms are not a hundred per cent efficient, where efficiency = (output work or power ÷ input work or power) × 100%. Discuss with students why machines and mechanisms are not a hundred per cent efficient, e.g. because there is heat loss, frictional force loss and machine part slippage.

Student activity: Print and hand out Activity sheet A and ask students to do the calculations, which will help to consolidate their competence in calculating the mechanical advantage, velocity ratio and efficiency of mechanism parts.

Mechanical advantage of levers: Use page 266 of the Student Book to explain the terms *fulcrum*, *load* and *effort* in relation to a lever. Make sure students can recognise examples of the three classes of lever, i.e. Class 1, Class 2 and Class 3. Give examples of the three classes of lever. Emphasise how the mechanical advantage of a Class 1 or Class 2 lever is related to the relative distances between the effort, fulcrum and load. It is also important for students to understand that Class 3 levers do not provide any mechanical advantage in a way the other two do. Go through the example on page 268 of the Student Book (and other examples if necessary) to show how to calculate the mechanical advantage of a lever where the mechanical advantage = distance *a* ÷ distance *b*.

Skills activity (page 268): Students do the activity individually. When they have finished, ask them to feed back their answers to the rest of the class.

Linkages: Use a range of examples from diagrams, illustrations or photographs of mechanisms with linkages, e.g. mole grips, toggle clamps and car windscreen wiper mechanisms, to illustrate how linkages are used as mechanism parts. Emphasise that linkages often make use of the leverage principle for their operation. Discuss how linkages are often used to join the moving parts of mechanisms together.

Belt and pulley systems: Use pages 269–270 of the Student Book to explain the principle of pulley systems and belt drive systems. Show students how to calculate the velocity ratio of belt and pulley systems using the example on page 270.

Skills activity (page 270): Students do calculation (i) individually. This will help to consolidate their understanding of how to determine the velocity ratio of pulley systems. When they have finished, ask them to feed back their answers to the rest of the class. Discuss how the velocity ratio of pulleys is a useful calculation because it helps in the selection of pulley sizes for particular speed control applications.

Teacher-led discussion: Use page 270 of the Student Book to show students how to determine the velocity ratio of two meshing gears. The input and output characteristics of the gears can be related to the pulley system.

Skills activity (page 270): Students do the calculation (ii) individually.

Efficiency: Use page 271 of the Student Book to introduce the concept of efficiency and how to calculate it for specific mechanism applications.

Knowledge check (page 271): 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.

Answers to Student Book activities

Skills activity (page 268)

(i) MA = (distance *a*) ÷ (distance *b*) = 1.5 ÷ 0.5 = 3

(ii) Effort to raise 300 N = 100 N

Effort to raise 480 N = 160 N

Skills activity (page 270)

(i) VR = diameter of driven ÷ diameter of driver = 800 mm ÷ 200 mm = 4

Speed of the driven gear = 50 rpm ÷ 4 = 12.5 rpm

(ii) For the 500 rpm motor speed, the driven speed = 166.6 rpm

For the 300 rpm motor speed, the driven speed = 150 rpm

For the 50 rpm motor speed, the driven speed = 200 rpm

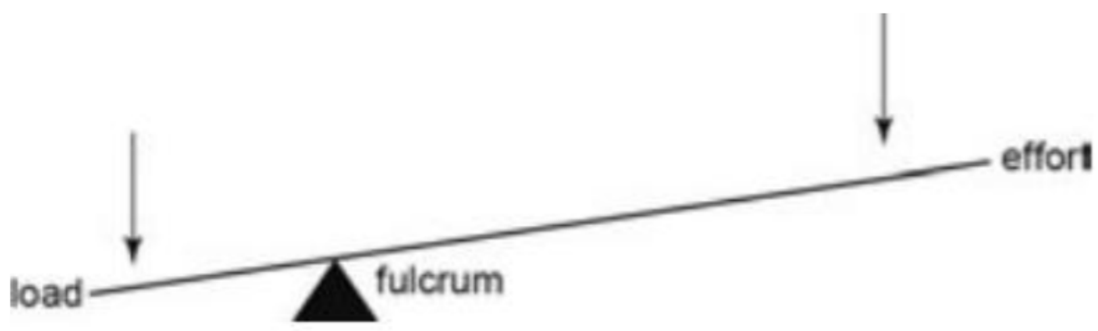
Skills activity (page 270)

(i) VR = ×3; output speed = 1800 rpm

(ii) 60 teeth

Knowledge check (page 271)

1. Draw a lever and label the fulcrum, load and effort. (1)



2. Explain what is meant by the term *mechanical advantage.* (2)

It is the advantage gained (1) by using a tool, mechanism or machine (1).

3. A simple gear train has a driving gear with 100 teeth and a driven gear with 20 teeth. If the output gear needs to have a speed of 300 rpm, what input speed is required? (4)

$$VR = \frac{\text{no of teeth on the driver gear}}{\text{no of teeth on the driven gear}} = \frac{20\ T}{100\ T} = \frac{1}{5}$$ (2)

input speed = 300 × 1/5 = 60 rpm (2)

4. A machine is rated as 75% efficient. If the input power to the machine is 2.5 kW, what will be the output power delivered by the machine in watts? (4)

2.5 kW (or 2500 W) × 0.75 = 1.875 kW (or 1875 W)

Total: 11 marks

Types of motion: Ask students to read page 273 of the Student Book and make sure they understand the basic types of motion, i.e. rotary, linear, reciprocating and oscillating motion. Relate the types of motion to common mechanism examples so that students can see where they are used in practice. Then refer them to page 274 of the Student Book and introduce them to slider and crank mechanisms and where they are used in practice. Emphasise that slider and cranks are used to convert rotary to linear motion or, if the slider is powered, linear to rotary motion. Students should know that the length of the slider stroke is equal to twice the length of the crank. Use the example on page 274 to explain how the rotational speed of the crank is related to distance covered by the slider in one second.

Skills activity (page 275): Students do the activity individually. This helps them to gain an insight into the relationship between the speed of the crank and the motion of the slider in a crank and slider mechanism application.

Transmitting motion using cams: Use pages 275–276 of the Student Book to introduce students to cams. Discuss the way in which cams transmit rotary motion to linear motion through the motion of the cam follower. Students should recognise the output motion of eccentric, pear-shaped, elliptical, snail and hexagonal cams, and understand the terms *rise*, *dwell* and *fall*.

Resources

Student Book pages 273–280
Activity sheet A (available online on Collins Connect)
Card, paper, paper clips, masking tape

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 4.3.2.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

Guess the motion: Put students in groups of three and provide each group with a diagram, illustration or photo of a mechanism such as a bicycle. Ask them to identify as many parts of the mechanism as they can and to try to describe the type of motion each part makes, e.g. a back and forth motion. Ask individual students to share their observations with the rest of the class.

Main lesson activities

Types of motion: Ask students to read page 273 of the Student Book and make sure they understand the basic types of motion, i.e. rotary, linear, reciprocating and oscillating motion. Relate the types of motion to common mechanism examples so that students can see where they are used in practice. Then refer them to page 274 of the Student Book and introduce them to slider and crank mechanisms and where they are used in practice. Emphasise that slider and cranks are used to convert rotary to linear motion or, if the slider is powered, linear to rotary motion. Students should know that the length of the slider stroke is equal to twice the length of the crank. Use the example on page 274 to explain how the rotational speed of the crank is related to distance covered by the slider in one second.

Skills activity (page 275): Students do the activity individually. This helps them to gain an insight into the relationship between the speed of the crank and the motion of the slider in a crank and slider mechanism application.

Transmitting motion using cams: Use pages 275–276 of the Student Book to introduce students to cams. Discuss the way in which cams transmit rotary motion to linear motion through the motion of the cam follower. Students should recognise the output motion of eccentric, pear-shaped, elliptical, snail and hexagonal cams, and understand the terms *rise*, *dwell* and *fall*.

cam position

Skills activity (page 278)

$$VR = \frac{\text{distance moved by effort}}{\text{distance moved by load}}$$

$$VR = \frac{2\pi L}{p}$$

$$VR = \frac{2\pi \times 300}{3} = 628.32$$

$$MA = \frac{\text{load}}{\text{effort}}$$

1 kg = 9.81 N

MA = (80 × 9.81) ÷ 50 = 15.7

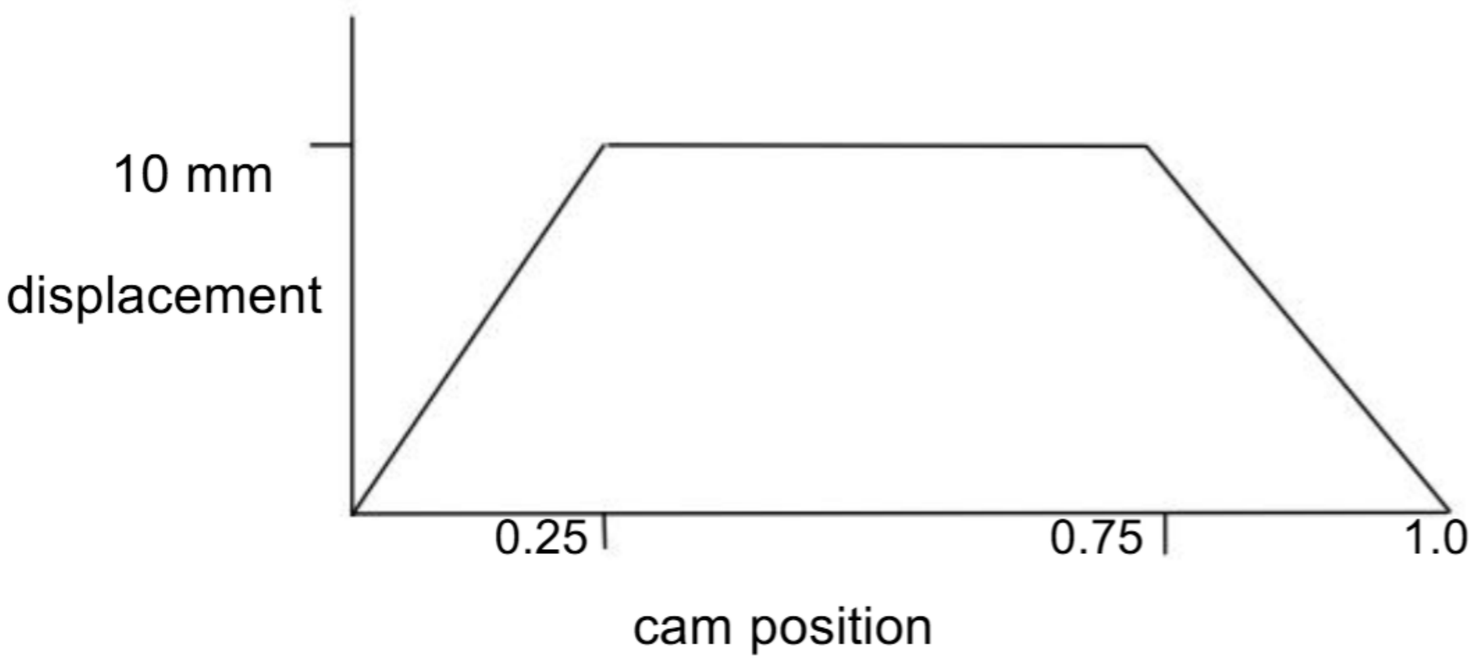
of how the terms are used. Alternatively, do the Define it Quiz at the front of the class, asking students to take turns to answer. Students could stick any terms and definitions they feel they need to review at a later date into their sketchbooks or journals.

Answers to Student Book activities

Skills activity (page 275)

There will be a range of models describing the slider and crank motion. Students' models should show either a) how the slider moves with a linear motion when the crank is rotated, or b) the rotation of the crank when the slider is pushed backwards and forwards in a linear fashion.

Skills activity (page 277)



Skills activity (page 278)

$$VR = \frac{\text{distance moved by effort}}{\text{distance moved by load}}$$

$$VR = \frac{2\pi L}{p}$$

$$VR = \frac{2\pi \times 300}{3} = 628.32$$

$$MA = \frac{\text{load}}{\text{effort}}$$

1 kg = 9.81 N

MA = (80 × 9.81) ÷ 50 = 15.7

Skills activity (page 279)

(i) MA = $\frac{\text{diameter of the wheel}}{\text{diameter of the axle}} = \frac{600\text{ mm}}{25\text{ mm}} = 24$

(ii) MA = $\frac{\text{diameter of the wheel}}{\text{diameter of the axle}} = \frac{700\text{ mm}}{9\text{ mm}} = 77.8$

Knowledge check (page 279)

1. Describe the following types of motion: rotary, linear, reciprocating and oscillating. (4)

rotary motion: motion in a circular path

linear motion: motion that follows a straight line

reciprocating motion: a repetitive motion backwards and forwards or up and down

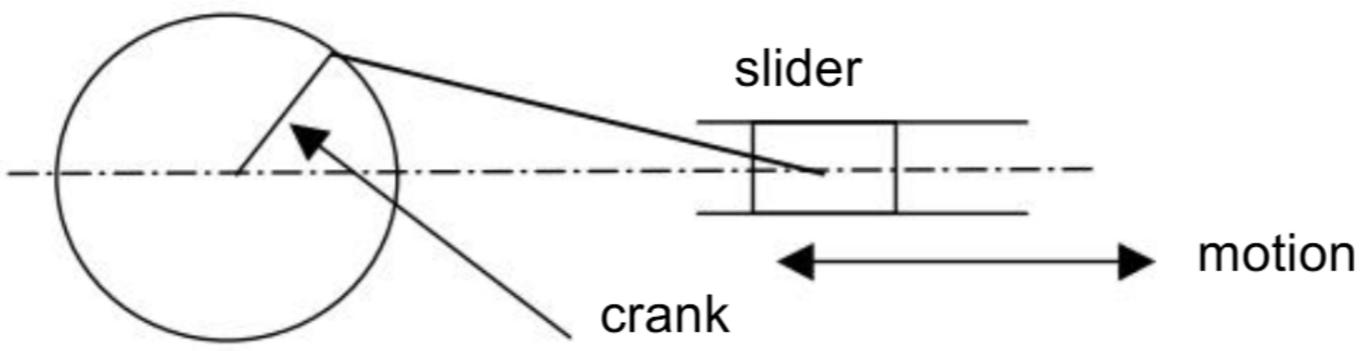
oscillating motion: motion backwards and forwards or from side to side

Award 1 mark for each correct definition.

2. What are the main parts of a cam system? (2)

the cam (1) and the cam follower (1)

3. Draw a crank and slider mechanism and explain how the linear motion of the slider is achieved. (4)



A slider and crank is made from two parts termed the crank and the slider, which slides in a guide. As the crank rotates, it pushes the slider backwards and forwards to produce a reciprocating linear motion.

Award 2 marks for an accurate drawing and 2 marks for a good explanation.

Total: 10 marks

4.3 Mechanisms

4.3.3 Transmission of motion

Learning objectives

By the end of this unit students should:

- understand how gears are used to transmit motion between shafts which are close together
- understand how belt drives are used to transmit motion between shafts which are relatively far apart
- be able to describe different types of gears; for example, spur gears, helical gears, bevel gears, worm and worm wheels, and rack and pinions
- understand the difference between simple gear trains and compound gear trains
- be able to describe different types of belt systems
- be able to calculate the speed ratios for gear train and belt drives systems.

Key terms

driven gear or pulley, driver gear or pulley, gear system, hydraulic system, pulley

Resources

Student Book pages 281–291
Activity sheet A (available online on Collins Connect)
Mechanism kits that include gears, axles, belt and pulley parts, couplings, axle support parts, bases for assembling simple mechanisms, direct current motors, batteries or power supplies, connecting wires, wire strippers, pliers, electrical screw drivers

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 4.3.3.

This unit is designed to allow students to explore gear and belt drive systems and introduce them to some pneumatic equipment. It also introduces students to calculations associated with transmission of motion, which they can apply to any practical projects they may do. It is suggested that students' development should include learning through practical exploration using kits or other construction methods, and through project work designed to ‘pull together’ many of the principles learnt in the unit.

It is suggested that three lessons should be devoted to this unit.

Lesson starter suggestions

A speedy speed exercise: Put students in pairs. Provide each pair with mechanism kit parts including gears, axles, belt and pulley parts, couplings, axle support parts, bases for assembling simple mechanisms, direct current motors, batteries or power supplies, connecting wires, wire strippers, pliers and electrical screw drivers. Each pair should have a selection of gears that will give a known gear ratio, e.g. 2:1 and 3:1, and axles and other parts that they can use to construct a system with two gears meshing. Ask students to build two-gear systems to produce particular velocity ratios, e.g. 2:1 or 3:1, and then record how they selected the gears for each system. When they have finished, they should feed back their insights to rest of the class.

Main lesson activities

Introduction to gears and gear systems: Refer students to pages 281–282 of the Student Book and discuss gears and gear systems with them. Make sure they understand the difference between the driver and driven gears in a gear system, and the use of an idler gear in simple systems. Go through the velocity ratio example on page 282 with students.

Skills activity (page 282): Students do the activity individually.

Compound gear systems: Explain the difference between simple and compound gear systems. With students, go through the compound gear velocity ratio example on page 283 of the Student Book.

Skills activity (page 283): Students do the activity, which aims to consolidate their understanding of the velocity ratio of compound gear trains.

Student activity (1): A kit of parts or other construction method can be used for this activity, which builds on the Lesson starter activity. Put students in pairs and ask them to construct a compound gear system consisting of four meshing gears that will give a particular gear ratio, e.g. 10:1. They then calculate what output speed would be produced for a particular set of input speeds, e.g. 10 rpm, 50 rpm and 100 rpm.

Introduction to torque: Discuss the concept of torque and how this relates to gear train transmission. Refer students to page 283 of the Student Book and relate torque to velocity ratio. Go through the calculation example on page 283 with students.

Skills activity (page 284): Students do the activity individually.

Student activity (2): Ask students to read about the various types of gears on page 284 of the Student Book and make notes. They can then use the internet to research the uses of each type of gear for practical applications.

Worm gear systems: Discuss with students the principle and application of worm gear systems shown on pages 284–285 of the Student Book. Explain how the gear ratio of a worm and worm-wheel is related to a system's output speed.

Skills activity (page 285): Students do the activity, which consolidates their understanding of worm-gear systems.

Rack and pinion systems and ratchet and pawl: Refer students to pages 285–286 of the Student Book and discuss the principle and application of rack and pinion systems and ratchet and pawls.

Student activity (3): Ask students to read about belt drives on page 286 of the Student Book and make notes. They can use the internet to research the uses of belt drives for practical applications.

Teacher-led discussion: With students, go through the velocity ratio and torque calculation example on pages 286–287 of the Student Book.

Skills activity (page 286): Students do the activity individually.

Student activity (4): Ask students to read about types of belt systems, i.e. flat, round, vee and toothed, and ways of tensioning belts on pages 287–288 of the Student Book.

Student project: This can be a design and make construction project that makes use of mechanism parts such as gears and/or belt drives to produce a practical output. Projects can include building a vehicle to achieve a purpose, building a lifting device, or building a fair ground ride. Students can work in small groups and use kits. Encourage them to think about how mechanism parts fit together and how they can make use of concepts such as velocity ratio or mechanical advantage to inform their design and make thinking.

EXTENDED **Pneumatic and hydraulic systems:** Discuss pneumatic and hydraulic systems with students and refer them to pages 289–290 of the Student Book. Emphasise the differences between pneumatic and hydraulic systems. Describe the purpose of cylinders and valves in pneumatic systems. Students should be able to draw and understand the operation of 3/2 and 5/2 valve types. Discuss the use of electronically operated valves.

Student activity (5): Ask students to read about selecting mechanisms for design applications on page 291 of the Student Book and make notes.

Knowledge check (page 291): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Answers to Student Book activities

Skills activity (page 282)

Input speed = 500 rpm; Number of teeth on the driver gear = 20; Number of teeth on the driven gear = 60

Output speed = 166.7 rpm

Input speed = 1500 rpm; Number of teeth on the driver gear = 35; Number of teeth on the driven gear = 105

Output speed = 500 rpm

Input speed = 700 rpm; Number of teeth on the driver gear = 90; Number of teeth on the driven gear = 30

Output speed = 2100 rpm

Skills activity (page 283)

(i) (30/90) × (50/20) = 0.83

(ii) Output speed = 0.83 × 130 rpm = 107.9 rpm

When the gears are changed, the output speed will be 97.5 rpm.

Skills activity (page 284)

(i) output torque = VR × input torque

output torque = 4 × 4 Nm = 160 Nm

(ii) VR = output torque ÷ input torque = 210 Nm ÷ 70 Nm = 3

number of teeth on driven gear = number of teeth on driver gear × VR = 30T × 3 = 90 teeth

Skills activity (page 285)

(i) gear ratio = 60:1 (i) 800 rpm ÷ 60 = 13.3 rpm; (ii) 120 rpm ÷ 60 = 2 rpm.

(ii) any suitable sketch

Skills activity (page 287)

(i) driven pulley speed = 54.6 rpm. If running efficiency is 90% then the speed is 54.6 rpm × 0.9 = 49 rpm.

(ii) Input torque 40 Nm; output torque 8 Nm.

Input torque 60 Nm; output torque 12 Nm

Input torque 100 Nm; output torque 8 Nm

Knowledge check (page 291)

1. Give two advantages of using gears rather than belt drives. (2)

They can generally transmit a higher torque/load. (1) They do not slip under high load conditions. (1)

2. Explain the difference between a simple gear train and a compound gear train. (2)

A simple gear train uses two gears (three if an idler gear is used) attached to different shafts. (1) A compound gear train has a driven and driver gear locked together on a single axle. (1)

3. What is meant by a positive belt drive? (2)

It is one that has been designed to produce movement without slippage, e.g. by using a toothed belt.

Award 1 mark for a correct description and 1 mark for an example.

3. What advantages does pneumatics have over hydraulics when used for food applications? (2)

Possible answers: It is reliable. If leaks occur, there is minimal risk of contamination. The systems are relatively easy to maintain if a fault occurs. The systems are easy to clean down with water.

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

Total: 8 marks

Lesson starter suggestions

What's the cost?: Provide students with photos, diagrams or actual examples of electrical products such as television sets, electrical drills, microwave ovens and electrical cookers. Ask them to estimate how much they think each one would cost to run for an hour. Once they have finished, read out the costs (based on the current cost per unit) and ask students to compare their results with the ones given.

Main lesson activities

Student activity: Ask students to read about mains supplies, batteries, solar cells and generators on pages 292–293 of the Student Book and make notes. They can also use the internet to research the ways each energy source might be used for practical systems and design applications.

Electrical safety: Outline the main safety precautions that need to be taken when working with mains electricity. Relate the factors to the considerations one should take when designing products that include a mains supply.

battery, generator, kilowatt-hour, mains supply, solar cell (photovoltaic cell)

Resources

Student Book pages 292–294
Activity sheet A (available online on Collins Connect)
Photos, diagrams or actual examples of electrical products, e.g. television sets, electrical drills, microwave ovens, electrical cookers

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 4.3.4.

The focus of this unit is to introduce students to switches and switching operations, including relays. Encourage students to explore the operation of different types of switches and switching states through practical experimentation. This includes building a relay operated circuit so that they can explore the use of relays in practical operations. Switches form part of most circuits, so students need a competent understanding of the terms used and how different types operate.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

What's the cost?: Provide students with photos, diagrams or actual examples of electrical products such as television sets, electrical drills, microwave ovens and electrical cookers. Ask them to estimate how much they think each one would cost to run for an hour. Once they have finished, read out the costs (based on the current cost per unit) and ask students to compare their results with the ones given.

Main lesson activities

Student activity: Ask students to read about mains supplies, batteries, solar cells and generators on pages 292–293 of the Student Book and make notes. They can also use the internet to research the ways each energy source might be used for practical systems and design applications.

Electrical safety: Outline the main safety precautions that need to be taken when working with mains electricity. Relate the factors to the considerations one should take when designing products that include a mains supply.

Energy costing: Discuss with students the concept of the kilowatt-hour and how to use it to calculate electrical energy costs. Refer them to page 293 of the Student Book and go through the example on how to calculate such energy costs.

Skills activity (page 294): Students do the activity individually.

Selecting energy sources: Use page 294 of the Student Book to discuss with students some of the main factors to consider when selecting energy sources for systems applications.

Plenary suggestions

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.

Answers to Student Book activities

Skills activity (page 294)

electrical kettle = 1.8 × 0.083 × $0.8 = $0.12

television = 0.05 × 2 × $0.5 = $0.05

steam iron = 2 × 1.5 × $1.6 = $4.8

4.3 Mechanisms

4.3.5 Bearings and lubrication

Learning objectives

By the end of this unit students should:

- understand the purpose of lubrication
- be able to describe the use of plain bearings, ball bearings, roller bearings and thrust bearings.

Key terms

bearing, lubrication

Resources

Student Book pages 295–298
Activity sheet A (available online on Collins Connect)

Lesson ideas

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

Frictional factors: Ask students to think of five examples where friction plays a part in some of the activities they do, e.g. ice skating, running, walking, using a screw driver. Ask students to note down how friction plays a part in such activities.

Main lesson activities

Student activity (1): Ask students to read about bearings, plain, ball, roller, thrust, air and magnetic bearings on pages 295–296 of the Student Book and make notes. They can also research online ways in which each type of bearing might be used for practical systems and design applications.

Selecting suitable bearings for specific conditions: Discuss with students the factors that need to be considered when selecting bearings. Points covered should include the type of loading that the bearing needs to take, the type of environment it will be used in, the operating temperature and operating speed.

Student activity (2): Ask students to read about lubrication on page 297 of the Student Book and make notes. Students can also do internet research into ways lubrication might be used for practical systems and design applications.

Skills activity (page 298): Students do the activity individually.

Plenary suggestions

Define it: Print and cut out Activity sheet A. Students define the key terms, working individually or in pairs, referring to the Student Book and giving examples of how the terms are used.

Answers to Student Book activities

Skills activity (page 298)

Possible appliances: vacuum cleaners, washing machines, tumble dryers, dishwashers, fan ovens

Possible reasons why they are necessary: They enable rotary movement of the appliance parts. They reduce friction between parts that slide and rotate, and withstand the loads placed on them.

4.4 Electronics

4.4.1 Basic concepts

Learning objectives

By the end of this unit students should:

- understand the terms and units for electrical current, voltage, resistance and wattage
- be able to recognise a range of circuit symbols.
- understand how to use the power relationship P = V × I
- understand the difference between direct and alternating current
- be able to recognise and draw simple direct current circuits
- understand how to use meters to measure electrical current, voltage and resistance.

Key terms

electrical current, potential difference, resistance, voltage

Resources

Student Book pages 299–304
Activity sheets A–C (available online on Collins Connect)
Electronic components relating to the table of electronic symbols on page 302 of the Student Book; switches, batteries, light bulbs, push to make switches, light bulbs, battery connectors, batteries, wires, wire cutters, wire strippers, electrical pliers, electrical screwdrivers, a range of other electronic construction tools; multimeters

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 4.4.1.

Electronics is a field that is best understood through practical activities, e.g. using measuring and testing equipment such as ammeters, voltmeters and multimeters; recognising and using discrete and integrated circuits for circuit applications; interpreting circuit diagrams and using them to build circuits for particular applications; building circuits using printed circuit boards, strip boards or prototype boards; and using manufacturers' data sheets to seek information about electronic components. Electronics can also be seen as a 'mathematically clean' subject, whereby many electronic-based calculations, e.g. Ohm's Law, have outcomes that closely match actual circuit values in practice. In view of this, encourage students to use calculations when designing, testing and evaluating the circuits they make as part of their Design & Technology studies.

A common barrier to students' understanding of electronic principles is that the flow of electrical current in a circuit cannot be seen directly. It is the effect of electrical current, e.g. the operation of a motor or an LED lighting up, that can be seen. Therefore, it is important that students have a conceptual understanding of the nature of electronic phenomena such as electrical current and voltage, the way current flows through series and parallel circuits, and the relationship between current, voltage, resistance and power. This understanding will help students to design electronic circuits from first principles more confidently and effectively. A good way to facilitate learning is to make use of electronic

resistance.

Ohm's Law (2): Print and hand out Activity sheet B. Students do the calculation involving Ohm's Law. Make sure they have the correct solutions and understand the principles involved.

Electrical power: Discuss the concept of electrical power. Students should know that the SI unit of power is the watt (W), and that higher values may be given as kilowatts (kW) or megawatts (MW). Explain how knowing or calculating the power rating of a component can form part of component selection. Go through the example on page 301 of the Student Book to consolidate students' understanding.

Skills activity (page 301): Students do the activity individually.

Measuring voltage, current and resistance: Ask students to read pages 303–304 of the Student Book and make sure they understand how to use ammeters, voltmeters and multimeters to measure electrical quantities in circuits. Emphasise that ammeters are used in series with the part of the circuit being measured, and voltmeters are used in parallel with the components being measured. Students should be

Main lesson activities

The nature of current flow: Refer students to the 'Current flow' section on page 299 of the Student Book and make sure they understand the characteristics of direct and alternating current. Emphasise that direct current is provided by energy sources such as batteries and solar cells. Students should realise that it is conventional to assume that electrical current flows from a positive potential to a negative potential, and electronic meters are designed to detect this conventional current flow. In reality, the electrons, which are the charge carriers, flow from a negative potential to a positive potential. Emphasise also that: a) the SI unit of electrical current is the amp (A); b) currents flow through conductors, wires and components; and c) an ammeter is used to measure electrical current.

Student activity (1): Put students in pairs. Print and hand out one copy of Activity sheet A to each pair and ask them to build, test and evaluate three circuits, each consisting of a switch, a battery and one or more light bulbs. They should relate the brightness of the bulbs to the current flow through the branches of each circuit and record their observations. Discuss outcomes as a class so that students gain an insight into the way current splits at each junction in proportion to the resistance offered by the bulbs.

Voltage and potential difference: Use the 'Voltage' and 'Potential difference' sections on pages 299–300 of the Student Book to explain the key concepts to students. Emphasise that the SI unit for both is the volt, which is measured using a voltmeter. Also emphasise that the sum of the potential difference drops in a circuit is equal to the supply voltage. It is important that students understand that when a voltmeter is used to measure the potential difference across a component, it needs to be in parallel with the component so that it measures the voltage drop across the component.

Ohm's Law (1): Explain the linear relationship between voltage, current and resistance for certain circuit applications. Relate this relationship to the formula $V = I \times R$, where V = voltage, I = current and R = resistance.

Ohm's Law (2): Print and hand out Activity sheet B. Students do the calculation involving Ohm's Law. Make sure they have the correct solutions and understand the principles involved.

Electrical power: Discuss the concept of electrical power. Students should know that the SI unit of power is the watt (W), and that higher values may be given as kilowatts (kW) or megawatts (MW). Explain how knowing or calculating the power rating of a component can form part of component selection. Go through the example on page 301 of the Student Book to consolidate students' understanding.

Skills activity (page 301): Students do the activity individually.

Measuring voltage, current and resistance: Ask students to read pages 303–304 of the Student Book and make sure they understand how to use ammeters, voltmeters and multimeters to measure electrical quantities in circuits. Emphasise that ammeters are used in series with the part of the circuit being measured, and voltmeters are used in parallel with the components being measured. Students should be

able to use a multimeter to measure current, voltage and resistance values competently, and know how to handle meters with care to prevent damage.

Student activity (2): Students work in pairs and make use of the circuits they made in Student activity (1). Ask them to use a multimeter: a) to measure the values of current in each branch of the circuits, and b) to measure the voltage drops across each bulb and battery making up the circuit. Students can record the values and make a table of their results.

Skills activity (page 304): Students do the activity individually.

Knowledge check (page 304): 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.

Answers to Student Book activities

Skills activity (page 301)

Power = voltage × current = 10 V × 0.01 A = 0.1 W (nearest resistor; 0.25 W)

Power = voltage × current = 12 V × 0.06 A = 0.72 W (nearest resistor; 1 W)

Power = voltage × current = 18 V × 0.1 A = 1.8 W (nearest resistor; 2 W)

Skills activity (page 304)

$V = I \times R$, where $I = 0.1$ A and $R = 50\ \Omega$

$V = 0.1\ A \times 50\ \Omega$

$V = 5$ V

Knowledge check (page 304)

1. State the units of potential difference, electrical power and resistance. (3)

unit of potential difference: the volt; unit of electrical power: the watt; unit of resistance: the ohm
Award 1 mark for each correct unit.

2. Define the term *potential difference*. (2)

the difference in electrical potential, i.e. the voltage between two points in an electrical circuit

3. Use Ohm's Law to determine the voltage required to produce a current of 0.25 A through a component which has a resistance of 120 Ω. (3)

$V = I \times R$

$V = 0.25\ A \times 120\ \Omega$

$V = 30$ V

Total: 8 marks

4.4 Electronics

4.4.2 Circuit building techniques

Learning objectives

By the end of this unit students should:

- be able to recognise good practice when designing printed circuit boards
- understand that strip board can be used to make simple circuits
- be able to recognise how prototype boards are used for building experimental circuits.

Key terms

electrical solder, printed circuit board (PCB), prototype board, strip board

Resources

Student Book pages 305–310
Activity sheets A–B (available online on Collins Connect)
Printed circuit boards (PCBs) from old/discarded electrical products; PCB materials, PCB making equipment, PCB drill and drill bit, computer and PCB software design package / tracks and pad transfers; soldering irons, soldering iron stands, electrical solder; strip board, strip board track breaking tools, components for circuit, wire, wire strippers, wire cutters, prototype boards

Lesson ideas

This unit makes students aware of the range of circuit building techniques used for designing, making, prototyping and testing electronic circuits. They should be able to produce workable circuits using printed circuit board (PCB), strip board and prototype board and know how to organise and mount discrete components, integrated circuits, wires, sockets and other components onto the boards. Where possible, they should make use of computer software to help them to design PCBs so that they understand the advantages of using CAD equipment for electronic circuit design. Encourage them to evaluate the merits of using each type of board for making or testing the circuits they are using.

It is suggested that a minimum of three lessons should be devoted to this unit.

Lesson starter suggestions

Which component?: Put students in groups of three or four and provide each group with an example of a PCB from an old or discarded electrical product, e.g. an old radio, computer or electronic toy. Ask students to inspect the board and identify some of the components on it. They can then match the components with the correct circuit symbol on page 302 of the Student Book. Discuss students' findings as a class and why PCBs are widely used for electronic product applications.

Main lesson activities

Teacher-led activity: Demonstrate how to make a PCB from the circuit diagram stage to drilling and soldering components (and other parts) onto the board. Refer students to pages 305–306 of the Student Book, which outline the stages involved. Then show them how to carry out the ultra-violet and etching stages of the process safely and competently. Students should also be aware of good practices associated with printed circuit board design. This includes knowing the technical terms used for printed circuit board applications (see the table on page 306 of the Student Book), good practice when selecting track and pad sizes, and pin distances for integrated circuits. Encourage students to use the table on page 308 of the Student Book to select suitable track widths for particular current values.

Student activity (1): Print and hand out Activity sheet A. Ask students to do the first activity. Students should consider the size of the PCB material in terms of reducing waste and the position and widths of the tracks and pads when designing their board. The boards should be carefully drilled, ready for positioning and soldering the components into position, which is the second activity in Activity sheet A.

Soldering: Use the 'Soldering' section on page 309 of the Student Book to discuss good soldering practice. Students should know why flux is used in the soldering process and the basic 'rules' for producing a successful joint. It is a good idea to demonstrate to students how to solder so that they can see the key principles in action. Explain and stress health and safety guidelines so that they can implement them when carrying out their own soldering work.

Student activity (2): Ask students to do the second activity in Activity sheet A, i.e. to solder components and other parts to the PCB circuits they have made. They should then inspect and evaluate the effectiveness of the PCB circuits.

Strip boards: Use the 'Strip boards' section on page 308 of the Student Book to explain how to use strip boards to make circuits. Show students how components can be positioned onto the strip board and how the tracks are broken at various points to produce the circuit. Encourage students to compare strip board manufacture with the PCB circuits they have made.

Student activity (3): This activity is based on the second activity in Activity sheet A. Ask students to design and make a simple strip board circuit from the circuit diagram given. They should consider the position of the tracks, how components will be positioned on the tracks and where the tracks need to be broken to help complete the circuit. They can then carefully solder the components into place, implementing the good soldering practice they have learnt. Finally, discuss with students the differences between PCB and strip board methods of circuit board manufacture.

Prototype boards: Introduce students to prototype boards for making and testing temporary electronic circuits. Use the third activity in Activity sheet A to introduce students to prototyping for making and testing temporary electronic circuits.

Knowledge check (page 303): Students can complete this at the end of the unit or for homework.

Plenary suggestions

Define it: Print and cut out Activity sheet B. Students define the key terms, giving examples.

Answers to Student Book activities

Knowledge check (page 310)

1. Briefly explain why printed circuit boards are commonly used for electronic circuits. (2)

Possible answers: they are a lower cost option; process can be automated; boards for particular applications can be made quite easily; they are reliable; they can be easily tested; can be made with CAD software *Award 1 mark for each correct answer (to a maximum of 2).*

2. Briefly explain why prototype boards are used for Design & Technology project work. (2)

Prototype boards are used for building temporary circuits. This allows components, wires and other parts to be moved easily to different positions on the board if required. (1) Being able to change the layout of a circuit quickly is useful when designing and testing circuits in the early stages of design. (1)

3. What is the melting temperature range of electrical solder? (1)

180˚C to 220˚C

4. Why has the alloy constituent of electrical solder been changed in recent years? (2)

Till recently, solder contained lead. However, lead fumes are harmful if breathed in, so soldering with lead-based solder is a dangerous activity. (1) Modern electrical solders are lead-free, which eliminates the dangers associated with lead. (1)

Total: 7 marks

4.4 Electronics

4.4.3 Switches

Learning objectives

By the end of this unit students should:

- be able to recognise and be able to use various types of switch, including the micro-switch
- understand the terms *normally open* (NO) and *normally closed* (NC) in relation to switching
- understand the uses of rotary and reed switches
- understand what is meant by the terms SPST and SPDT switches.

Key terms

micro-switch, normally closed (NC), normally open (NO), relay, switch

Resources

Student Book pages 311–315
Activity sheet A (available online on Collins Connect)
A range of switches, including toggle, push, reed, rotary and micro-switches; batteries, battery connectors, wires, wire cutters, wire strippers, electrical pliers, electrical screwdrivers, other electronic construction tools, connecting blocks; prototype boards, relays, bulbs, motors, batteries, battery connectors, resistors for back emf protection

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 4.4.3.

This unit introduces students to switches and switching operations including relays. Students are encouraged to explore the operation of different types of switches and switching states through practical experimentation. This includes building a relay operated circuit so that they can explore the use of relays for practical applications. Switches form part of most circuits, so students need a competent understanding of the terms used and how different types of switch operate.

It is suggested that two lessons should be devoted to this unit.

Lesson starter suggestions

Switched on!: Put students in groups and give them two minutes to write down as many applications of switches as they can think of. Then ask them to pick three switches and say why each is used in a particular application. Outcomes from each group can then be shared with the rest of the class.

Main lesson activities

Introduction to switches: Use pages 311–312 of the Student Book to introduce students to switches and switching states. Let them explore a range of switches, including toggle, push and micro-switches. Explain the terms *push to make*, *push to break*, *normally open* and *normally closed states*.

Student activity (1): Ask students to work in pairs and construct simple circuits consisting of a type of switch, a battery and a light bulb. This activity will allow them to explore the operation of each type of

switch. Encourage them to record the outcomes of their experimental work. As a class, discuss the outcomes to consolidate the insights students have gained from the activity.

EXTENDED **Rotary and reed switches:** Use page 312 of the Student Book to introduce rotary and reed switches and how they might be used in practice.

Relays: Ask students to read pages 314–315 of the Student Book and make sure they understand relays and how they can be used in motor reverse and latching circuits. Explain how relays are used to switch, control or operate a higher voltage circuit using a lower voltage 'supply' circuit. Students should be able to relate the connections of a relay to the circuit symbol and know that a diode is used to protect the transistor from damage due to the back emf when the relay is initially operated. They should also know the principle of latching in the electronic control context.

Student activity (2): Put students in pairs. Ask them to use the circuit diagram on page 314 of the Student Book to explore how a relay can be used to reverse a motor. They should use a prototype board or other component/wire connection method to do the activity.

Knowledge check (page 315): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Knowledge check (page 315)

1. Give a use of (i) a toggle switch and (ii) a push switch. (2)

Responses will vary. Possible answers: A toggle switch can be used for a light switch.
A push switch is used to switch a computer on and off.

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

2. Give two applications of a micro-switch in systems and control applications. (2)

Responses will vary. Possible answers: for limit switches on automatic machines; switches in vending machines

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

3. Explain the terms *normally open* and *normally closed* in relation to switching. (4)

A normally open switch is when the switch is open until activated. This means that the circuit will be off until the switch is operated. (2) A normally closed switch is closed until the switch is activated. For this case, the circuit is on until the switch is operated. This will have the effect of opening the switch. (2)

Total: 8 marks

4.4 Electronics

4.4.4 Resistors

Learning objectives

By the end of this unit students should:

- understand that resistors are divided into three main types: fixed resistors; variable resistors; and special resistors (thermistors, light dependent resistors)

Key terms

nominal resistance value, resistor, resistor tolerance

Resources

Student Book pages 316–319
Activity sheet A (available online on Collins Connect).
A range of resistors; prototype boards, battery connectors, batteries, wires, wire cutters, wire strippers, electrical pliers, electrical screwdrivers, a range of other electronic construction tools, multimeters or voltmeters, variable resistors (including pre-set resistors)

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 4.4.4.

This unit introduces resistors and calculations associated with resistors and resistance. Students should understand and have experience of potential divider networks because they will use them for sensor and timing circuits in future. The activities in the unit develop students' competence in carrying out resistance calculations so that they can use them in Systems and design project work.

It is suggested that two lessons should be devoted to this unit.

Lesson starter suggestions

What colour?: Students need to be able to recognise the resistance value and tolerance of resistors from their colour code. Refer students to the colour code table on page 316 of the Student Book and explain how to use it. Put them in pairs and provide each pair with a range of resistors. Ask them to use the table to identify the value of each resistor.

Main lesson activities

Introduction to resistors (1): Use pages 316–317 of the Student Book to introduce recognition and uses of resistors. The areas to be covered include types of resistors, e.g. fixed and variable, and their common uses, e.g. controlling the current in branches of circuits; protecting components such as LEDs, transistors and integrated circuits from current overload; and as components for potential divider networks.

Introduction to resistors (2): Recap on how to use resistor colour codes to identify resistor values and determine the tolerance of resistors. Go through the tolerance related examples on pages 316–317 of the Student Book.

Resistors in series: Explain to students how to calculate the overall resistance when two or more resistors are connected in series. Explain how resistors in series can be used to produce a resistance

value that is not made in a set series, e.g. the E12 series of resistors. Show them how to calculate the total resistance of a number of resistors in series using the relationship $R_t = R_1 + R_2 + R_3$.

Skills activity (page 317): Students do the activity individually. When they have finished, go over the calculations with them to make sure there are no misconceptions.

Resistors in parallel: Explain how to calculate the overall resistance when two or more resistors are connected in parallel. Explain how resistors in parallel can be used to produce a value of resistance that is not one of a set series, e.g. the E12 series of resistors. Show how to calculate the total resistance of a number of resistors in series using the relationship $1/R_t = 1/R_1 + 1/R_2 + 1/R_3$, etc. Also show the relationship $R_t = (R_1 \times R_2) \div (R_1 + R_2)$ for the case of two resistors in parallel.

Skills activity (page 319): Students do the first skills activity individually. When they have finished, go over the calculations with them to make sure there are no misconceptions.

Potential divider: Refer students to the information about potential divider networks on page 318 of the Student Book. Emphasise how potential dividers can be used to produce a lower output voltage from a higher supply voltage, e.g. a 5 V output from a 12 V supply. Students should be able to do the calculations on page 318, e.g. by using the relationship $V_{out} = (R_2 \div (R_1 + R_2)) \times V_{in}$. Give students calculation examples of potential divider networks to solve. When they have finished, go over the calculations to make sure there are no misconceptions.

Student activity: This activity is based on the potential divider circuits illustrated in the 'Potential divider' section on page 318 of the Student Book. Students can use prototype boards to build a typical potential divider circuit using two fixed resistors. (You can provide them with a range of resistors.) They can then calculate the output value of the potential divider network and use a multimeter to check and confirm the calculated values.

Variable resistors: Explain the difference between fixed and variable resistors. Emphasise that a variable resistor can be used in its variable resistor and potentiometer form. Students should recognise pre-set resistors and know how they can be used in practical circuits for 'permanent' adjustment purposes.

Skills activity (page 319): Students work individually to do the second skills activity.

Knowledge check (page 319): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Answers to Student Book activities

Skills activity (page 317)

1. Combined resistance = 60 Ω + 30 Ω + 130 Ω = 220 Ω

2. Combined resistance = 1 kΩ + 1.2 kΩ + 2.2 kΩ = 4.4 kΩ

Skills activity (page 319)

Combined resistance = $R_t = (R_1 \times R_2) \div (R_1 + R_2)$

Combined resistance = $R_t = (220 \times 330) \div (220 + 330) = 132\ \Omega$

Skills activity (page 319)

220 Ω – red, red, brown

1.2 kΩ – brown, red, red

3600 Ω – orange, blue, red

1.2 MΩ – brown, red, green

Knowledge check (page 319)

1. Give two uses of variable resistors in systems and control applications. (2)

Possible answers: for volume control on a radio; for adjusting the gain on amplifiers

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

2. Define the terms *nominal resistance* and *tolerance* when considering fixed resistors. (2)

Nominal resistance is the stated or rated resistance value of a resistor. (1) *Tolerance* is the stated percentage error of a fixed resistor. (1)

3. If two resistors with resistance values of 330 Ω and 1 kΩ are connected in series, what will be their combined resistance? (2)

Combined resistance = 330 Ω + 1000 Ω = 1330 Ω

4. If the two resistors (330 Ω & 1 kΩ) are now connected in parallel, what will be their combined resistance? (2)

Combined resistance = (330 × 1000) ÷ (330 + 1000) = 248 Ω

Total: 8 marks

4.4 Electronics

4.4.5 Transistors

Learning objectives

By the end of this unit students should:

- be able to recognise the collector, base and emitter connections of a transistor
- understand that transistors can be used as a fast operating electronic switch and as an amplifier
- understand how transistors can be used in simple sensing and timing circuits.

Key terms

base, collector, emitter, NPN transistor, transistor

Resources

Student Book pages 320–322
Activity sheet A (available online on Collins Connect)
A range of transistors, transistor data sheets that show the collector, emitter and base connections for the NPN transistors selected; LEDs, resistors to protect the LED and transistor from current overload, LDRs, PCB materials, PCB making equipment, soldering irons, soldering iron stands, solder, batteries, battery connectors, wires, wire cutters, wire strippers, electrical pliers, electrical screwdrivers, other electronic construction tools

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 4.4.5.

This unit introduces students to the use of transistors for fast automatic switching operations. It uses a transistor sensing circuit as the basis of a mini-project designed to give students experience in designing, making and evaluating a simple electronic circuit, and develops the circuit building techniques introduced in previous units. This includes designing and making a PCB circuit from a schematic diagram, selecting components for the circuit, soldering components, wires and other features in place, and evaluating the design.

It is suggested that three lessons should be devoted to this unit.

Lesson starter suggestions

Quick switching: Put students in groups of three or four. Asked them to think about four situations when they used manually operated switches and record where they have experienced automatic (non-manual) switch examples. Discuss students' collective experiences as a class.

Main lesson activities

Introduction to transistors: Introduce the transistor as a component with three connections: a) the collector, b) the emitter and c) the base. Students should be able to identify the collector, emitter and base connection for common transistors and use manufacturers' data sheets to help them to do this. Emphasise that the connections need to be correctly connected to the circuit for a transistor to work properly. Put students in pairs and provide them with a range of transistors and associated data sheets. Ask them to correctly identify the collector, base and emitter for each component given.

Teacher-led discussion: Discuss with students the operating principle of a transistor, e.g. an NPN transistor, in terms of a small base current controlling the flow of the collector/base current. Emphasise the 0.6 V/0.7 V requirement between the base and the emitter for the transistor to operate. Explain how a potential divider is commonly used to control the base of a transistor and why it is commonly used as part of transistor switching circuits.

NPN transistors: Use the section on NPN transistors on pages 320–321 of the Student Book to discuss the NPN category of transistors. Students should know that NPN transistors are used as amplifiers, where the action of the transistor amplifies the 'applied' base current. They should also have an insight into amplifier gain (hFE). Make sure they understand that a resistor should be connected in series with the base of the transistor to protect it from overload current damage when the base is switched on.

Student activity: Ask students to design and build a sensing circuit similar to one on page 321 of the Student Book, incorporating a transistor as a switch. They should be directed to recognise: a) the potential divider as part of the circuit and how it is used in conjunction with the sensing function; b) the use of resistors R1 to protect the base of the transistor from current overload; and c) that R3 is a protection resistor for the LED. Encourage them to evaluate the outcomes of their design in terms of how well the circuit works.

Knowledge check (page 322): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Answers to Student Book activities

Knowledge check (page 322)

1. What are the names of the three connections on a transistor? (2)

collector, base and emitter

2. What are the two main uses of a transistor? (1)

as a fast automatic switch and as an amplifier

3. Draw a transistor circuit which could be used as a moisture sensor. (3)

See the circuit on page 321 of the Student Book.

Total: 6 marks

4.4 Electronics

4.4.6 Diodes

Learning objectives

By the end of this unit students should:

- be able to recognise the circuit symbol for a diode
- understand that a diode allows current to flow in only one direction
- understand how diodes are used to rectify current
- be able to describe the use of light emitting diodes.

Key terms

diode, forward bias, light emitting diode (LED), reverse bias

Resources

Student Book pages 323–325
Activity sheet A (available online on Collins Connect)
Diodes, bulbs, switches, batteries, battery connectors, wires, wire cutters, wire strippers, electrical pliers, connector blocks / other connection methods; seven segment displays, seven segment display resistor arrays / individual fixed resistors to protect each segment of the display, prototype board, electrical screwdrivers, other electronic construction tools

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 4.4.6.

The main focus of this unit is to introduce the diode as a component commonly used for protecting relays and solenoids. Other forms of diodes include LEDs and seven-segment displays, and the unit introduces these components through a range of practical exploration activities.

It is suggested that two lessons should be devoted to this unit.

Lesson starter suggestions

One way only: Put students in pairs and ask them to think of a way a water tap could be adapted to allow water to flow in one direction only. Encourage them to think and work quickly and produce a roughly drawn sketch or sketches to illustrate their ideas. Design ideas might incorporate components such springs and other simple restriction methods to reduce the flow in one of the flow directions. Students can then share their ideas with the rest of the class.

Main lesson activities

Introduction to the diode: Use page 323 of the Student Book to introduce the principle of a diode. This should include the concept of forward and reverse bias and how to recognise the anode and cathode connection of a particular diode.

Student activity (1): Put students in pairs and provide them with a prototype board or other component/wire connection method. Ask them to build a simple battery, switch, diode and bulb circuit to explore how current flows when the diode is connected in its forward bias mode, and how it prevents

to allow current to flow in one direction only

2. What are the leads of a diode called? Which one is the positive connection and which one is the negative connection? (2)

anode – positive connection (1); cathode – negative connection (1)

Total: 3 marks

decimal point feature is identified as the abbreviation DP. Students should: a) be able to use data such as the ones on page 324 to relate the segments to the appropriate pin numbers; and b) know that the segments of a seven segment display (because each is an LED) need protecting by a resistor or resistor array. Explain how seven segment displays are often operated by special integrated circuit drivers to operate the displays in a particular way.

Student activity (2): Put students in pairs and ask them to use a prototype board or other component/wire connection method to explore how the seven segment displays connect and operate as part of a circuit. They should investigate how the diode bars light up when the a–g and DP connections are made with the supply voltage.

Knowledge check (page 325): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Answers to Student Book activities

Knowledge check (page 325)

1. What is the main purpose of a diode in a circuit? (1)

to allow current to flow in one direction only

2. What are the leads of a diode called? Which one is the positive connection and which one is the negative connection? (2)

anode – positive connection (1); cathode – negative connection (1)

Total: 3 marks

4.4 Electronics

4.4.7 Transducers

Learning objectives

By the end of this unit students should:

- be able to describe the use of an LDR
- be able to describe the use of a thermistor
- understand that thermistors can either have negative or positive coefficients.

Key terms

light dependent resistor (LDR), thermistor

Resources

Student Book pages 326–327
Activity sheet A (available online on Collins Connect)
LDRs, multimeters; LDRs/thermistors, push to make switches, transistors, PCBs, computer software for making PCBs (or pads, track transfers and etch resistant pens for designing PCB circuits by hand), PCB drills and drilling machines, PCB light boxes, PCB etching facility, soldering irons and stands, wires, wire cutters, wire strippers, electrical pliers, electrical screwdrivers, other electronic construction tools, batteries, battery connectors,

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 4.4.7.

This unit provides students with the opportunity to get involved in an extended project where they bring together circuit design practices. In this way, they can extend their skills and knowledge of circuit board design and manufacture and also gain experience in housing such circuits in purpose designed product packages. The circuit used for the activity incorporates a transducer (e.g. an LDR) that is central to the circuit's operation.

It is suggested that four lessons should be devoted to this unit.

Lesson starter suggestions

Making sense of things: Put students in pairs. Ask them to discuss and note down how they use their senses in the classroom environment. They may relate their senses to seeing things, touching things, smelling things, etc. Ask individual students to feed back to the class what they have discussed. Link their ideas to the way in which electronic sensors (transducers) are used for sensing applications.

Main lesson activities

Introduction to light dependent resistors: Use page 327 of the Student Book to describe the operating principle of an LDR. Provide students with an LDR and a multimeter to examine how the resistance changes with the lighting level in practical situations.

LDRs in circuits: Explain to students how an LDR is incorporated in a circuit designed to use the LDR as a sensor. Use page 326 of the Student Book to introduce students to two common transistor sensing circuits, e.g. light and darkness sensing circuits.

Thermistors and strain gauges: Use page 327 of the Student Book to explain the operating principle and uses of thermistors and strain gauges. Emphasise that thermistors can be incorporated into circuits in a similar way to the LDR examples. However, strain gauges form part of a Wheatstone bridge circuit.

Student activity: Ask students to use the circuits on page 326 of the Student Book for an extended design and make project based on a light (or temperature) sensing application. They can base their design on a sensing need and design a printed circuit board housed in a suitably designed package. Encourage them to consider ways in which components such as switches are integrated with the package design.

Knowledge check (page 327): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Answers to Student Book activities

Knowledge check (page 327)

1. What is meant by the term *transducer*? (1)

an electronic device that converts energy from one form to another

2. Explain the principle of a light-dependent resistor. (2)

a device whose resistance changes (1) with the amount of light falling on it (1)

3. Explain the principle of a thermistor. (2)

a component that has a resistance (1) that changes with temperature (1)

Total: 5 marks

4.4. Electronics

4.4.8 Capacitors

Learning objectives

By the end of this unit students should:

- understand the units of capacitance
- understand that capacitors are used for timing applications
- understand the difference between polarised and non-polarised capacitors.

Key terms

capacitor, farad, non-polarised capacitor, polarised capacitor

Resources

Student Book pages 328–329
Activity sheet A (available online on Collins Connect)
A range of hour glass sand timers, graph paper, rules; electrolytic capacitors, non-electrolytic capacitors; prototype boards, resistors, switches, light bulbs, battery connectors, batteries, wires, wire cutters, wire strippers, electrical pliers, electrical screwdrivers, a range of other electronic construction tools, multimeters, oscilloscopes (if available)

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 4.4.8.

This unit introduces students to the way capacitors charge and discharge through experimental work, which forms a basis for understanding aspects of the time delay and timing circuits that feature in Unit 4.4.9. It also consolidates students' skills in using meters to measure electronic quantities.

It is suggested that one lesson should be devoted to this unit.

Lesson starter suggestions

Measuring time: Put students in groups of three or four and provide each group with an hour glass sand timer (these should have different time periods). Ask them to mark lines (measurement ticks) on the face of their timer at equal intervals with a pencil. Four or five lines/ticks will be sufficient. When the sand timers are started, ask students to record the time it takes to reach each line/tick, and the time it takes for the sand timer to discharge fully. They then draw a graph of line distances against time to gain an insight into the timing characteristics of the 'discharge' operation. Briefly discuss students' observations as a class.

Main lesson activities

Introducing capacitors: Introduce capacitors as components that can store electrical charge. Emphasise that the SI unit of capacitance is the farad (F), and for most electronic applications the value of capacitors tends to be in microfarads, nanofarads or picofarads. Students should be able to select polarised and/or non-polarised capacitors and know the purpose of each in simple circuits. Emphasise that a common use of capacitors is in timing circuits (covered in Unit 4.4.9).

Student activity: Students work in pairs and use prototype boards to construct the simple charging circuits on page 329 of the Student Book. The timing characteristics can be measured and visualised using a voltmeter connected across the X point and the 0 volt rail. If available, an oscilloscope can be used to detect the charge and discharge effect.

Knowledge check (page 329): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Answers to Student Book activities

Knowledge check (page 329)

1. What is the SI unit of capacitance? (1)

the farad

2. Name the two basic types of capacitor. (2)

polarised (1) and non-polarised (1)

3. What do capacitors do in a circuit? (2)

They store electrical charge (1) and are widely used in timing circuits (1).

Total: 5 marks

4.4 Electronics

4.4.9 Time delay circuits

Learning objectives

By the end of this unit students should:

- be able to recognise a delay circuit using discrete components **EXTENDED**
- be able to recognise the pin sequence of an integrated circuit
- be able to use a 555-timer for astable and monostable timing applications
- be able to calculate the time periods for astable and monostable operations.

Key terms

555 integrated circuit, astable output, discrete components, integrated circuit, monostable output, programmable interface controllers (PICs)

Resources

Student Book pages 330–334
Activity sheet A (available online on Collins Connect)
A range of capacitors, e.g. axial electrolytic capacitors, non-electrolytic capacitors

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 4.4.9.

This unit introduces students to computer-based circuit design software that can be used to test and design circuits for project work. Encourage them to use such software for Systems and control project design and to construct circuits without having to physically make them. Also encourage them to evaluate the use of such software applications for Design & Technology use.

It is suggested that three lessons should be devoted to this unit.

Lesson starter suggestions

Capacitor recognition: This activity recaps on recognition of capacitors and prepares students for some of the work in the unit. Provide each student with a range of capacitors of different types, e.g. axial electrolytic capacitors and non-electrolytic capacitors. Ask them to determine the values of the capacitors they have been given and to determine the type of capacitor for each example.

Main lesson activities

Time delay circuits using resistor capacitor networks: Use page 330 of the Student Book to introduce students to time delay circuits using capacitors. Relate the operation of the circuits to the charging/discharging characteristics of the resistor–capacitor network that controls the base of the transistor.

Student activity (1): Put students in pairs and ask them to examine the two circuits on page 330 of the Student Book and work out the time delay sequence from the moment the switches are operated. Students should link their descriptions to the charging characteristics of the resistor–capacitor series network and note that the base current will switch the transistor on when there is a 0.6 V–0.7 V potential

between the base and emitter connections. Once this occurs, the bulb will be switched on. They should record their findings and feed back to the rest of the class.

Student activity (2): In pairs, students use computer software to build two simulation circuits. Ask them to explore the effect of changing the values of R1 and C1 on the time delays produced by the circuits. They can use the relationship T = C × R to calculate the theoretical time delay when the two values for each simulated circuit are used. During the activity, they should be able to comment on the accuracy of the timing operations for the circuits and why any inaccuracies might occur.

Integrated circuits: Use page 331 of the Student Book to introduce integrated circuits. Students should be aware of the advantages of using integrated circuits in the design of Systems and control projects and realise that integrated circuits can be selected for different circuit purposes, e.g. timing applications, logic applications and amplifiers. They should recognise the pin numbers on integrated circuits and relate them to the circuit diagrams accordingly.

555 timers: Introduce students to the 555-timer IC described on pages 331–332 of the Student Book. Discuss the 555-timer integrated circuit as a monostable (one-shot) and astable timer. Explain the circuit diagrams of each timer type, i.e. monostable and astable versions, and detail the output characteristics once the switches are closed. Go through the calculations for determining the time a monostable timer will be on given particular R1 and C1 values. Use the relationship T = 1.1 × R1 × C1.

Skills activity (page 333): Students do the activity individually. When they have finished, go over the calculation with them and make sure they have no misconceptions about the calculation process.

555-timer astable calculation: Go through the calculations for determining the on-off sequence frequency for an astable given particular R1 and C1 values. Use the relationship T = 0.7 (R1 + R2) × C1.

Student activity (3): In pairs, students use computer software to build simulation circuits of the two 555-timer circuits. They then explore the effect of changing the values of R1 and C1 for the monostable case, and R1, R2 and C1 for the astable case. They can relate the simulation monostable and astable outputs to calculated values using T = 1.1 × R1 × C1 (for the monostable example) and T = 0.7 (R1 + R2) × C1 (for the astable case). During the activity, they should comment on the accuracy of the timing operations for the circuits and why any inaccuracies might occur.

Programmable ICs for timing and other purposes: Use page 333 of the Student Book to introduce students to programmable ICs and how they are widely used in a number of applications. Explain the advantages and disadvantages of the programmable timers and if possible, show how such circuits are programmed in practice.

Student activity (4): In pairs, students program a PIC using school based software for a timing application. The process can be compared with producing a similar timing circuit using a 555-timer integrated circuit.

Knowledge check (page 334): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Answers to Student Book activities

Skills activity (page 333)

T = 1.1 × R1 × C1

T = 1.1 × (1×10^{6}) × 100 × 10^{-6} = 110 seconds (or 1 minute 50 seconds)

Knowledge check (page 334)

1. What is meant by a monostable output? (1)

an output that is on for a specified length of time while the circuit is operating

2. What is meant by an astable output? (1)

an output that changes between being on and off while the circuit is operating

3. What is the formula for determining the time for one pulse of a 555-timer used in its monostable mode? (3)

$T = 1.1 \times R1 \times C1$

Total: 5 marks

4.4 Electronics

4.4.10 Logic gates and operational amplifiers

Learning objectives

By the end of this unit students should:

- understand the truth tables for NOT, AND, NAND, OR and NOR gates
- understand the difference between TTL and CMOS logic circuits
- be able to use CMOS logic circuits for project work
- recognise and use operational amplifier (Op Amp) integrated circuits in project work
- be able to calculate the gain of an inverting operational amplifier
- understand how to use an op-amp as a comparator.

Key terms

CMOS logic gate family, comparator, logic gate, operational amplifier

Resources

Student Book pages 335–343
Activity sheet A (available online on Collins Connect)
Switches, bulbs, batteries, wires, wire cutters, pliers, screw drivers, connecting blocks; computer software packages, computers; 741 op-amps, LDRs, 12 V batteries / other power supply, battery connectors, LEDs, LED protection resistors, variable resistor for R1, multimeter/voltmeter, prototype boards

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 4.4.10.

It is suggested that five lessons should be devoted to this unit.

Lesson starter suggestions

NOT gate: Ask students to make a simple NOT operation circuit using a switch, bulb and battery. They should connect the components together to form a simple circuit that will switch the bulb on and off in a ‘two state’ fashion. Then ask them to produce a table to show what happens to the bulb when the input switch is either on or off.

Main lesson activities

Logic gates: Use page 335 of the Student Book to introduce students to logic gates and their related truth tables. Students should know how to use truth tables to state the output for given inputs for a) NOT, b) NAND, c) AND, d) NOR and e) OR gates. They should know the circuit symbol used for each type of gate. Emphasise the difference, in selection terms, between the TTL and CMOS families of logic gates. Relate this to supply voltages, how gates within each family can be combined, and the dual in line quad varieties available. Students should be able to identify the pin numbers that relate to each logic gate and supply connections for each type of integrated circuit. Explain that CMOS logic gate circuits are the ones

that tend to be used for school Design & Technology project work. Give examples of how to construct truth tables when more than one logic gate is combined.

Teacher-led discussion: Introduce students to a range of practical examples where logic gates can be used, including safety guard circuits for machinery (see page 337), moisture sensing circuits for greenhouse applications (see page 338), burglar alarm systems (see pages 338–339) and light sensitive doorbells (see page 339). Students should be able to follow the logic sequence through the circuit when the system is activated.

Student activity (1): In pairs, students use computer simulation software to build simulation circuits for each of the circuits on pages 337–339 (i.e. the safety guard, the moisture sensing circuit, the burglar alarm and the light sensitive doorbell). They should observe and record how each logic circuit responds when the input switch/switches is/are closed. They should also be able to construct a truth table that shows the logic characteristics of each circuit.

Operational amplifiers: Use pages 339–340 of the Student Book to introduce students to the operational amplifier, e.g. the 741 type. They should be able to recognise the circuit symbol for an op-amp and identify the inverting and non-inverting inputs. Describe some of the uses of op-amps for practical applications, e.g. amplifying strain gauge outputs and blood pressure monitoring equipment. Students should be able to relate the op-amp integrated circuit pin numbers to the pin connections as shown in the table on page 340 of the Student Book. With students, go through the example on pages 339–340 to determine the voltage gain of the op-amp using the following relationship: voltage gain = change in output voltage ÷ change in input voltage.

The inverting amplifier: Discuss how op-amps can be used in their inverting amplification mode. Explain the merits of amplifying inputs in this way. Emphasise the significance of R_f and R_{in} in determining the amplifier gain, and that amplifier gain = $-R_f \div R_{in}$. With students, go through the example on page 341 of the Student Book.

Skills activity (page 342): Students do the activity individually.

Op-amp as a comparator: Use page 342 of the Student Book to discuss how op-amps can be used as a comparator. Introduce students to a typical op-amp comparator circuit on page 342 and the main features of the circuit. They should understand the significance of setting the inverting pin to a reference voltage, and how the changes in the LDR voltage can go higher than the reference voltage, and in doing so, switch the LED on.

Student activity (2): Ask students to build, test and evaluate the operation of the comparator circuit on page 342 using a prototype board set up. This is a quick way to help students to understand the principle of how the comparator works.

Student activity (3): This activity gives students experience in designing, making and testing a logic based project, and consolidates what they have learnt. Ask them to design and build a logic based circuit for a particular need. They should be able to produce a truth table that models the operation of the logic sequence and design their product accordingly. They can use a computer software simulation package to help in the design process, and design and make the PCB circuit using the experience they have gained. They can also design an integrated product design package to house the circuit.

Knowledge check (page 343): Students can complete this at the end of the unit or for homework.

Plenary suggestions

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.

Answers to Student Book activities

Skills activity (page 342)

Gain = −5600 Ω ÷ 1200 Ω = – 4.6

R_{in} = 2200 Ω ÷ 5 = 440 Ω

R_f = 10 × 1200 Ω = 12000 Ω = 12 kΩ

Knowledge check (page 343)

1. Draw the truth table for:

1. a **NOT** gate (2)

Input	Output
0	1
1	0

2. a **NOR** gate (2)

inputs		output
0	0	1
0	1	0
1	0	0
1	1	0

3. a **NAND** gate (2)

inputs		output
0	0	1
0	1	1
1	0	1
1	1	0

Total: 6 marks

The Project (Component 2)

As part of their study for the *Cambridge IGCSE®/O level Design & Technology* course, students need to carry out a design-and-make project. The project is an important part of the course and it provides students with the opportunity to design and make a product that best reflects their individual abilities and creativity, while demonstrating in an applied way everything they have learnt during the course. Each project should be unique to them and should focus on one of the following specialist options:

- Graphic Products
- Resistant Materials
- Systems and Control

Although students are free to choose the theme for their project, you should support their choice and use your knowledge of their interests and ability to provide them with appropriate advice to help them to decide.

Project work should normally be undertaken during the final two terms of the course, but this may differ from school to school. It will be based within the students' chosen option (Graphic Products, Resistant Materials or Systems and Control), but you may wish to encourage them, where appropriate, to utilise some of the knowledge and skills they have learnt in the other options as well. This is not a requirement, but it could strengthen their project work.

It is your responsibility as a teacher to ensure that each student remains focused on their chosen option and completes project work that does not overlap significantly into other option areas. For example, a student may be focusing on Systems and Control but may also need to create a casing within which to house their circuitry. Creation of a casing would utilise knowledge and understanding gained mainly from studying Resistant Materials. In such a case, it would be important to ensure that the circuitry remained the focus, and that the student did not become too absorbed in creating the casing.

Guidance for Component 2: The Project

The final project should include two components: a design portfolio and a practical 3D outcome. Note the following carefully:

- The design portfolio must be in the form of an A3-size folder.
- The inclusion of CAD/CAM work is permissible if your school has these facilities. However, even if CAD/CAM work is submitted, students must present all of their relevant work in hard copy in an A3-size folder. Electronic submissions are not acceptable on their own.
- The A3 folder must include good quality photographs of the 3D product: an overall view, as well as sufficient views from various angles to show all the necessary detail.

There are further requirements for projects completed for different specialist options.

- **Resistant Materials** and **Systems and Control**: For these options, students need to submit an A3 folder that contains the design work as well as the 3D product.
- **Graphic Products:** For this option, the A3 folder needs to contain all the preliminary design work as well as the product, which should be in 2D or 3D form.
- **Architectural Design:** For this option, the A3 folder should contain the design work, and the product should be a well-constructed 3D architectural model.

Please note that 'models' are *not* appropriate outcomes and should not be submitted as products for Resistant Materials and Systems and Control. For example, it is inappropriate to produce a paper/card model as the final outcome; instead products should be manufactured using resistant materials. For both Resistant Materials and Systems and Control, students should be encouraged to create a product that can be properly tested and evaluated in the environment it is intended for.

Through their project work, students must be able to show that they have worked through the following stages:

1. Identifying a need and establishing a design brief
2. Researching the design brief and developing a specification
3. Generating and exploring design ideas
4. Developing a proposed solution
5. Planning for production
6. Product realisation
7. Testing and evaluation

It is important that students demonstrate outcomes for each of the stages and do not omit any of them. Encourage students to utilise a range of presentation techniques throughout their A3 folder work and also to demonstrate their ICT or computer skills. Work may include CAD-generated graphs, charts, 2D and 3D design work, and CAM.

To support you in providing appropriate advice and guidance to students, here is a detailed analysis of each of the individual stages of the design process.

1. Identifying a need and establishing a design brief

Finding a suitable problem can be a challenging task. If the task is too simple, students may be unable to demonstrate the full range of skills they have learnt. It is important to select a project that will enable them to demonstrate their ability to use a wide range of construction techniques and different materials. If the task is too complex, they may be unable to address the problem sufficiently or to complete the task. Remember that students will spend many months on their project, so it is extremely important to help them to find a problem they are interested in. Students may find it useful to consider:

- developing a product that relates to a hobby or interest they have
- asking friends and relatives for suggestions relating to design problems they may be able to help solve for them
- thinking of an item that they use every day and that could be improved
- thinking of an item that could be developed to help disabled people, young children, the elderly or other group.

When students have identified a design need or opportunity, encourage them to write out a description of the problem. The scaffold below will help you to support your students to do this:

- **What is the problem?** You could encourage students to include photographs or make sketches to illustrate the problem.
- **Where is the problem?** Encourage students to include photographs or make sketches.
- **Why has this problem been identified?** Encourage students to include details about the circumstances that led them to choose their project.
- **Who is the intended user of the product?** Ensure that students can identify an end user, client or target group, and that they make notes to present details of their intended customer profile.
- **What is the intended finished product?** Ensure that students can describe and articulate what they intend to design and make. Encourage them to use photographs and sketches in order to help explain their ideas and thinking.

At this early stage, there is no need for students to be specific about certain details (e.g. what materials they will use). However, the more information you can gather from your students, the better you will be able to ensure that your setting has the facilities and resources students will require to carry out their project.

Ask students to submit a draft of their proposed project so that you can review it. Return it to them with comments for improvement. They can use your feedback to produce their final design brief. This is usually presented in paragraph form. There is an example of a design brief on pages 11 and 348 of the Student Book.

2. Researching the design brief and developing a specification

Once the design brief is established, students can move on to the next stage. It is a good idea to encourage them to gather as much information as they can. They should ask a lot of questions and make sure they record their findings. A good technique is to ask them to highlight key words in the design brief, e.g. *target audience*, *end user* and *client need*, and to analyse them. Students may find it useful to record an analysis of their thoughts for their folder using a mind map. There is an example of a mind map of a brainstorm on page 9 of the Student Book. Another technique you could use with your students is the 'P's analysis method, which is on pages 11–12 of the Student Book.

Other research that your students could carry out includes interviews, observations, surveys and the disassembly and analysis of similar products. When students have completed their research, they will need your support to gather together their findings and to order, analyse and present them logically. Only research that is useful and relevant to their design brief should be included; irrelevant information should be discarded. All research should be evaluated, and students should be encouraged to draw conclusions from each type of research. At the end of each piece of research, students could create a small box on the A3 folder page with a summary of their conclusions. This may take the form of a series of bullet points that will be useful when they come to write their detailed specification.

The specification is a list of key design requirements or considerations that sets out the product's key features, and is usually presented as a list of clear, short statements in bullet point style. Students should refer to the specification throughout the design journey, and its contents will be the criteria against which the final product should be evaluated. If their research has been thorough, it should be relatively easy to summarise each research section and write a detailed specification. There is an example of a specification on pages 12 and 350–351 of the Student Book.

3. Generating and exploring design ideas

As your students engage in this creative stage of the process, encourage them to utilise a range of presentation and communication techniques and to demonstrate a wide range of potential solutions, no matter how impractical they are. This stage is about generating ideas and demonstrating creativity and innovation. Once ideas have been generated, students need to select an idea to develop. This is where real thinking is required. One strategy is to advise them to relate their developing idea or ideas directly to their design specification and record their thoughts through the use of annotated notes on their sketches and drawings. They should include details relating to the construction of their product, the decoration or finish. Guide them to refer back to their research so that they can utilise and incorporate any images or notes that have helped to develop the idea. Annotation must be relevant and relate directly to their specification, which will help them to justify their decisions later, when they choose a specific idea to develop thoroughly. Please refer to pages 351–352 and relevant sections of Section 1: Product Design in the Student Book.

4. Developing a proposed solution

This stage requires students to bring together their best and most suitable ideas. They will need to make decisions about the product: its size, the construction materials, production methods, and finishes to be applied, as well as information about material finishes, fixing methods, joints, structural elements, moving and mechanical parts, and electronic subsystems. They should also consider modelling the form of the product. Encourage them to communicate their thoughts using a range of suitable working drawings, including orthographic and isometric projection, electronic circuits, mechanical diagrams and perspective drawings. They should also demonstrate that they have carried out appropriate and specific testing with regard to most of the points covered in the specification. For example, a student who has designed an electronic system should have tested a range of circuits and be able to show developmental changes that they have made to arrive at a working solution. At this stage, it is important for students' work to be relevant. They should be discouraged from undertaking and submitting folder work that regurgitates lists of materials from a textbook or lists of finishes with images that do not relate to their proposed idea. Please refer to pages 352–353 and relevant sections of Section 1: Product Design in the Student Book.

5. Planning for production

At the end of this stage, the A3 folder should contain sufficient information for a third party to be able to make the intended product. This is a useful point to stress to students; it will help to drive home the importance of the quality of this section of their work. The folder should include a detailed plan for product realisation, working drawings and a list of all the materials required. All working drawings should have the correct measurements and provide all the information required for the complete product. In the case of an electronic product, this could include circuit diagrams, the case to house the product and the associated interface or controls. The plans for the product realisation should include all the steps necessary to make the product, as well as consideration of quality checks at various stages, and safety checks for safe working practice in the workshop. Please refer to pages 353–355 and relevant sections of Section 1: Product Design in the Student Book.

6. Product realisation

This part of the design process is the one that students usually enjoy the most. The process of making provides them with the opportunity to put theory into practice and to manipulate a range of materials to produce a usable, high-quality product. The final product should be based on their design ideas developed during previous stages. Modifications may have taken place in order to address potential problems, but the design should be developed in line with the end users' requirements as identified in the design specification. Students should not be afraid to adapt their design at this late stage, but they will require your support and guidance to do so. If modifications occur, they should make notes of the changes and refer to them in the evaluation stage of their design work. Please refer to pages 355–356 and relevant sections of Section 1: Product Design in the Student Book.

7. Testing and evaluation

With a final product in place, encourage students to undertake testing to ensure that their product is safe and that it functions as it should. Students should also consider the following:

- Has the product been tested in the environment proposed in the brief?
- Has the product been tested with the intended user group?
- Has the product been evaluated against the design specification?

Students should record their outcomes using photographs, text and diagrams, and (if appropriate) include feedback from people who have helped them to test their product. At this stage, they should record details relating specifically to any proposals for future modifications or product development; this is especially important when the final product does not meet the design specification or customer requirements. Please refer to pages 356–358 and relevant sections of Section 1: Product Design in the Student Book.

Trends	1.7.1–1.7.3
1.1 Design method	
Problem solving	The Project section, 1.8.1–1.8.9
Solutions	
Realisation and manufacture	The Project section
Brief	1.1.1
Analysis	1.1.3, 1.1.4
Synthesis	1.2.1–1.2.5, 2.3, 2.12
Realisation	1.3.1, 1.3.2, 2.13, 2.9, 2.10
Evaluation	1.4.1–1.4.4

syllabus has parallels with Cambridge International Examinations O Level Design & Technology (6043), and Cambridge International Examinations O Level CDT: Design & Communication (7048). The Student Book will support the majority of both syllabuses.

Please note that from 2020, the syllabus for O Level Design & Technology (6043) has been aligned with the IGCSE Design & Technology (0445) Resistant Materials option, so support materials for that syllabus option are suitable for use with O Level Design & Technology (6043) from 2020.

How to use this guide

The sections below crosslink the *Collins IGCSE® Design & Technology* Student Book with the relevant O Level syllabus where possible. There is also a section that relates the project element of the course, which is common to most Design & Technology courses of any examination board.

O Level Design & Technology (6043)

CIE O Level D&T (6043)	CIE IGCSE D&T (0445) Student Book
Safety	1.5
Design in society	1.7.1–1.7.3, 1.5.1
Aesthetics	2.3, 2.9
Role of the designer and craftsman	1.7.1–1.7.3
Technologists in society and industry	1.7.1–1.7.3
Developments in technology	1.7.1–1.7.3
Trends	1.7.1–1.7.3
1.1 Design method	
Problem solving	The Project section, 1.8.1–1.8.9
Solutions	
Realisation and manufacture	The Project section
Brief	1.1.1
Analysis	1.1.3, 1.1.4
Synthesis	1.2.1–1.2.5, 2.3, 2.12
Realisation	1.3.1, 1.3.2, 2.13, 2.9, 2.10
Evaluation	1.4.1–1.4.4

1.2 Design content	
Aesthetics	2.3, 2.9, 1.8.7
Anthropometrics and ergonomics	1.7.1–1.7.3, 1.8.1–1.8.9
Research and analysis	1.1.3, 1.1.4
Design influences – natural and man-made forms	1.8.1–1.8.9
Influence of materials and processes	3.1, 3.7, 3.10
Mathematics in design	1.8.1–1.8.9
Design history and evolution	1.8.1–1.8.9
1.3 Graphics	
Drawing techniques	1.2.6, 1.8.7, 1.6.1–1.6.6, 2.3, 1.2, 1.8.4
Freehand sketching	2.1, 1.5
Exploded views	2.2
Pictorial views	2.1
Sectional views	2.2
Orthographic views	2.1, 1.2
Range of media	2.8, 1.2.6
Line, shape, texture	2.9
Sequence sketches	1.3.1, 1.3.2, 2.9, 2.10
Flow charts	1.3.3–1.3.5, 2.1
2.1 Materials	
Properties and applications of materials	3.1
Materials testing	1.3.1
Environment and sustainability	1.9.1–1.9.9, 1.7.1
2.2 Materials theoretical knowledge	
Metals	3.6
Plastics	3.3
Wood	3.4
Smart materials	3.2
2.3 Practical processes	
Hand and machine tools	2.14, 3.7, 3.9, 3.10
Stock forms of materials	3.7
Conversion/cutting/seasoning	3.4
Datum surfaces	1.3, 3.7
Measuring	3.7
Marking out	3.8, 1.3
Shaping, deforming/reforming	3.9
Wastage/addition	3.9
Treatment of materials	3.6, 3.4
Joining and assembly	3.10
Finishing	3.11
2.4 Supporting technologies	
Structures	1.6.7, 1.2, 4.2.1–4.2.5
Pneumatics	4.3.3
Mechanisms	4.3
Electronics	1.6.7, 4.4, 4.1
Microcomputing	1.6.7
Kits and components	1.2.3

Control	1.6.7
Loci	4.3
Presentation	2.9, 2.13
Shading, colour, thick- and thin-line	2.9, 2.13
Light, shade, shadow	2.9, 2.13
Rendering and surface finish	2.9, 2.13
Convey information	
Charts and diagrams	2.10
Flow charts	1.3.3–1.3.5, 2.1
Analysis of products	1.1.3, 1.1.4
Designing	2.3, 1.2, 2.9, 1.8.1–1.8.9, The Project section
Artefact realisation	1.3.1, 1.3.2, 2.9, 2.10, 1.3.3–1.3.5, 2.14, 2.12
Evaluation	2.10, 1.4.1–1.4.4, 1.8.5

O Level CDT: Design & Communication (7048)

CIE O Level CDT: D&C (7048)	CIE IGCSE D&T (0445) Student Book
Use of drafting aids	2.6
Sketching	2.3, 1.2, 2.9
Geometrical figures	2.4
The circle	2.4
The ellipse	2.4
Isometric views	2.1, 1.2
Planometric views	2.1
Oblique	2.1
Perspective	2.1
Orthographic	2.1, 1.2
Sectional views	2.2
Auxiliary	2.1
Exploded views	2.2
Developments	2.5, 2.4
Control	1.6.7
Loci	4.3
Presentation	2.9, 2.13
Shading, colour, thick- and thin-line	2.9, 2.13
Light, shade, shadow	2.9, 2.13
Rendering and surface finish	2.9, 2.13
Convey information	
Charts and diagrams	2.10
Flow charts	1.3.3–1.3.5, 2.1
Analysis of products	1.1.3, 1.1.4
Designing	2.3, 1.2, 2.9, 1.8.1–1.8.9, The Project section

Make modification and improvements	1.4.1–1.4.4
Packaging	2.11
Disassembly of products	1.4.1, 1.9.1

Design project (7048)

CIE O Level CDT: D&C (7048)	CIE IGCSE D&T (0445) Student Book
	The Project section
Problem identification	1.1.1, 1.1.2, 1.8.1
Research and analysis	1.1.3
Specification	1.1.2
Proposal for a solution	1.2.1, 1.2.2, 1.2.3, 1.3.1, 1.3.2, 1.8.3, 1.8.9–1.8.10
Development and planning	1.3.1, 1.8.3
Realisation	1.3.1, 1.3.2, 2.9, 2.10, 1.3.3–1.3.5, 2.14, 2.12
Record of making process	
Evaluation	2.10, 1.4.1–1.4.4, 1.8.6, 1.8.5

1 Product Design

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
1.1 Getting started	**1.1.1 Observing a need** • Understand a design need or situation • Understand the importance of having a client	Student Book – pp. 8–10 **Teacher Guide Activities** Activity sheet A: Methods for collecting feedback – students complete a table with a plan for collecting data. Activity sheet B: Define It – Matching activity for learning key terms.	Design need The importance of a client and user or user group
	1.1.2 Design brief and specification • Understand the importance of a design brief and what it should include • Analyse the brief to fully understand what they need to do	Student Book – pp.11–13 **Teacher Guide Activities** Activity sheet A: A bad specification – students complete a table with ideas on how to improve a badly written specification. Activity sheet B: Define It – Matching activity for learning key terms.	Design brief Specification
	1.1.3 Research • Put together a research plan • Identify different research methods • Identify constraints imposed by knowledge, resources and external sources • Gather, order and assess information relevant to the solution • Produce and interpret data (e.g. diagrams, flow charts, graphs, test results)	Student Book – pp.14–17 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	The importance of research in design Organising research Existing products and product analysis

This Scheme of work is provided as an aid to planning; it is not intended to be prescriptive nor complete. Availability of resource, time and individual school calendars will all impact on what is practical and achievable. The Scheme of work as offered here is presented to provide ideas on which teachers can build as appropriate for their context.

Core topic(s)	Learning objectives	Student Book pages / Teacher Gui
1.1 Getting started *continued*	**1.1.4 Initiating and developing ideas, and recording data** Extract relevant information from sources, interpret and record information and data	Student Book – pp.18–19 **Teacher Guide Activities** Activity sheet A: Extracting and interp students decide which information is which is irrelevant.
1.2 Design ideas and techniques	**1.2.1 Generating possible ideas** • Generate and record a range of design ideas • Identify what resources are needed to solve problems	Student Book – pp.20–25 **Teacher Guide Activities** Activity sheet A: Generating ideas – s SCAMPER to generate ideas about a Activity sheet B: Define It – Matching learning key terms.
	1.2.2 Use of media for mock-ups Use a variety of media and equipment to produce models and mock-ups as a means of testing a solution	Student Book – pp.26–29 **Teacher Guide Activities** Activity sheet A: Students use a star rate models they have created. Activity sheet B: Define It – Matching learning key terms.
	1.2.3 Generation of possible ideas • Recognise the need for continual appraisal and evaluation • Relate appraisal and evaluation to the specification	Student Book – pp.30–31 **Teacher Guide Activities** Activity sheet A: Evaluating designs - star diagrams, SWOT analysis, pass- and a score card to evaluate their des
	1.2.4 Communicating design ideas Be aware of a range of methods for communicating design ideas	Student Book – pp.32–35 **Teacher Guide Activities** –

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Core topic(s)	Learning objectives
1.1 Getting started *continued*	**1.1.4 Initiating and de recording data** Extract relevant inform interpret and record in
1.2 Design ideas and techniques	**1.2.1 Generating pos** • Generate and re ideas • Identify what res solve problems
	1.2.2 Use of media fo Use a variety of media produce models and m testing a solution
	1.2.3 Generation of p • Recognise the n appraisal and ev • Relate appraisa specification
	1.2.4 Communicating Be aware of a range o communicating design

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
1.3 Making	**1.3.1 Selection and organisation** • Select and develop a solution based on time, cost, skill and resources • Understand that making needs to be planned and organised in detail	Student Book – pp.36–40 **Teacher Guide Activities** Activity sheet A: Matching activity for learning material properties. Activity sheet B: Define It – Matching activity for learning key terms.	Choosing the final solution Materials selection Materials testing Materials and cutting list Planning for manufacture Sequential instructions
	1.3.2 Implementation and realisation • Demonstrate the correct procedures in preparation for making • Draw accurately, mark out and test • Select appropriate methods for manipulating a variety of materials	Student Book – pp.41–47 **Teacher Guide Activities** Activity sheet A: Students disassemble a product and examine the joining methods used (permanent or non-permanent). Activity sheet B: Students walk around the school or classroom looking for products made using specific methods. Activity sheet C: Define It – Matching activity for learning key terms.	Procedures and making preparation Marking out Selecting appropriate processes for making Fixing and joining techniques
1.4 Evaluation	**1.4.1 Evaluation in design** • Evaluate existing products/systems • Test the performance of a product or solution against a specification • Use different strategies to assess effectiveness of products • Suggest possible modifications to a design	Student Book – pp.48–54 **Teacher Guide Activities** Activity sheet A: Labelling activity – students decide where different evaluation techniques may be useful in the design process. Activity sheet B: Students discuss where ACCESS FM evaluation techniques may be useful in the design process and complete a table. Activity sheet C: Students discuss where CAFÉ QUE evaluation techniques may be useful in the design process and complete a table. Activity sheet D: Testing against specification point – students complete a table. Activity sheet E: Define It – Matching activity for learning key terms.	What is evaluating in design? Evaluating existing products Evaluating against the specification Product testing and evaluating Modifications based on evaluations

Core topic(s)	Learning objectives	Student Book pages / Teacher Guid
1.5 Health and safety	**1.5.1 Safety for all** • Show correct use of hand tools, machine tools and equipment • Demonstrate proper regard for mandatory and other safety precautions • Understand the responsibilities of the designer to ensure that products are safe • Understand the importance of personal safety and that of others • Recognise basic safety symbols used in the workshop	Student Book – pp.55–62 **Teacher Guide Activities** Activity sheet A: Following the '5 Step Assessment' process for a workshop p students complete a table. Activity sheet B: Define It – Matching a learning key terms.
1.6 Use of technology	**1.6.1 Use of technology in designing and making** • Understand the need to research existing products (internet) • Understand the benefits of CAD/CAM in different production systems • Understand how CAD can be used to generate 2D and 3D images • Understand how CAD/CAM is used in industry • Be aware of the variety of machines that are computer controlled • Understand how computers can enhance stock and quality control	Student Book – pp.63–68 **Teacher Guide Activities** Activity sheet A: Students use the inte accurate definitions of terms. Activity sheet B: Define It – Matching a learning key terms.

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Core topic(s)	Learning objectives
1.5 Health and safety	**1.5.1 Safety for all** • Show correct use o tools and equipmen • Demonstrate prope and other safety pr • Understand the res designer to ensure • Understand the imp safety and that of o • Recognise basic sa the workshop
1.6 Use of technology	**1.6.1 Use of technolo making** • Understand the nee products (internet) • Understand the ben different production • Understand how CA generate 2D and 3D • Understand how CA industry • Be aware of the var are computer contro • Understand how co stock and quality co

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
1.6 Use of technology *continued*	**1.6.2 Systems** • Identify the features of a control system • Understand the features of a control system and applications	Student Book – pp.69–71 **Teacher Guide Activities** Activity sheet A: Matching activity – students decide if components are inputs or outputs. Activity sheet B: Define It – Matching activity for learning key terms.	What is a system? Control systems diagram
1.7 Design & Technology in society	**1.7.1 Design in society** • Understand the of the role of designers, artisans and technologists in industry and society • Understand the effects of Design & Technology activity on social, moral and economic issues • Understand a range of human factors that need to be considered when designing	Student Book – pp.72–77 **Teacher Guide Activities** Activity sheet A: Students make notes on a Venn diagram for a product of their choice. Activity sheet B: Students complete a table with notes about the life cycle stages of a product and the environmental impact ratings at each stage. Activity sheet C: Students collect anthropometric data and make notes in a table. Activity sheet D: Define It – Matching activity for learning key terms.	The role of the designer Effects of Design & Technology activity and why a designer must think sustainably Considering human factors in design
1.8 Product design application	**1.8.1 Meeting the needs of users** Understand how existing products meet the needs of the users	Student Book – pp.78–79 **Teacher Guide Activities** Activity sheet A: Studying different user needs – students look at photos of four different users. Activity sheet B: Analysing and interacting with a range of drinking vessels – students make notes in a table. Activity sheet C: Define It – Matching activity for learning key terms.	The importance of considering human factors in design Meeting the needs of users

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
1.8 Product design application *continued*	**1.8.2 Considering production manufacturing** Understand one-off, batch and mass production techniques	Student Book – pp.80–82 **Teacher Guide Activities** Activity sheet A: Identifying scales of production and the reason for each – students look at products and make notes in a table.	Production method
	1.8.3 Design ideas Understand different strategies for starting to create ideas	Student Book – pp.83–85 **Teacher Guide Activities** Activity sheet A: Students look at designs and decide who influenced the designer. Activity sheet B: Students use a viewfinder to identify interesting patterns, textures and shapes. Activity sheet C: Students use SCAMPER cards to develop their design ideas. Activity sheet D: Define It – Matching activity for learning key terms.	Starting points for design ideas
	1.8.4 Identifying constraints Understand how to plan the stages of manufacture	Student Book – pp.86–87 **Teacher Guide Activities** –	Planning
	1.8.5 Evaluating against the specification Understand how to evaluate their design against its specification	Student Book – pp.88–89 **Teacher Guide Activities** Activity sheet A from Unit 1.2.2	A design specification Evaluating ideas

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activiti
1.8 Product design application *continued*	**1.8.6 Understanding the relevance of function** • Understand the terms associated with aesthetics, and relate this to design ideas and the work of others • Understand the term *function* and how it relates to design	Student Book – pp.90–91 **Teacher Guide Activities** Activity sheet A: Deciding what the primary and functions of a product are – students look at pro write notes in a table. Activity sheet B: Students look at four products them so that form follows function. Activity sheet C: Define It – Matching activity for terms.
	1.8.7 Aesthetics Understand the relevance of aesthetics, in terms of line, shape, form, proportion, space, colour and texture, in their design solutions and in the work of others	Student Book – pp.92–93 **Teacher Guide Activities** Activity sheet A: Using aesthetics elements in d students re-design four products using element moodboard.
	1.8.8 Style and design movements • Understand the basics of style • Understand the principal design movements	Student Book – pp.94–96 **Teacher Guide Activities** –
	1.8.9 Using models to test proposals • Understand the importance of anthropometrics and ergonomics in design • Use models to test proposals	Student Book – pp.97–98 **Teacher Guide Activities** Activity sheet A: Designing tests to enable the d feedback from the user – students write notes in

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Core topic(s)	Learning objectives
1.8 Product design application *continued*	**1.8.6 Understanding th of function** • Understand the term with aesthetics, and design ideas and the others • Understand the term and how it relates to
	1.8.7 Aesthetics Understand the relevan aesthetics, in terms of li form, proportion, space, texture, in their design s in the work of others
	1.8.8 Style and design • Understand the basi • Understand the prin movements
	1.8.9 Using models to proposals • Understand the impo anthropometrics and in design • Use models to test p

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
1.8 Product design application *continued*	**1.8.10 Modelling** Understand the need to model and test proposals	Student Book – pp.99–100 **Teacher Guide Activities** Activity sheet A: Students look at pictures illustrating hand modelling and CAD modelling and write notes about the advantages and disadvantages of both types.	The importance of modelling an idea
1.9 Environment and sustainability	**1.9.1 Forms of energy** • Know about a range of conventional energy forms • Know about a range of alternative energy forms • Understand the difference between finite and infinite sources of energy	Student Book – pp.101–107 **Teacher Guide Activities** Activity sheet A: Students complete a table with notes about different energy sources – their origin, whether they are finite or renewable, and advantages and disadvantages. Activity sheet B: Students disassemble a product, annotate it and answer questions to analyse whether it is good for the environment or not. Activity sheet C: Students list the advantage and disadvantages of planned obsolescence.	Conventional energy sources Renewable energy sources Efficient and effective use of energy sources How designers can reduce energy consumption The six ‘R’s Recycling Disassembly Planned obsolescence Materials recycling

2 Graphic Products

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
2.1 Formal drawing techniques	**Orthographic, isometric, planometric and perspective** • Be familiar with a range of formal drawing techniques including first- and third-angle orthographic projection, isometric, planometric and estimated two-point perspective • Understand how to use British Standards correctly	Student Book – pp.110–114 **Teacher Guide Activities** Activity sheet A: Students discuss and identify different types of drawings. Activity sheet B: Students add details and scale to a partially drawn orthographic of a trophy, write the views below each view, draw the projection symbol, complete the plan view including hidden detail and complete the end elevation. Activity sheet C: Students look at a pictorial view of a phone holder, add details and scale, write the views below each view, draw the projection symbol, complete the plan view using hidden detail and draw the end elevation. Activity sheet D: Students construct an orthographic third-angle projection. Activity sheet E: Students draw shapes in isometric. Activity sheet F: Students practise estimated two-point perspective drawing. Activity sheet G: Define It – Matching activity for learning key terms. Activity sheet H: Exit cards – each student gets a card; they have to group together an isometric, a plan, a front elevation and an end elevation.	Orthographic drawing Isometric and planometric drawings Estimated two-point perspective drawing

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
2.2 Sectional views, exploded drawings and assembly drawings	• Construct different types of sectional views • Construct exploded and assembly drawings	Student Book – pp.115–119 **Teacher Guide Activities** Activity sheet A: Sectional views – students sketch what they would see if different fruits were cut down the middle. Activity sheet B: Students complete a plan view and a sectional view of a bracket and add dimensions. Activity sheet C: Students identify the front elevation and plan view of a display stand, complete the sectional view and use hatched lines to show where the stand is cut. Activity sheet D: Students identify the front elevation and plan view of a display stand, complete the part sectional view and use hatched lines to show where the stand is cut. Activity sheet E: Students complete a sectional view. Activity sheet F: Exploded drawing – students decide where they might see an exploded drawing like the one shown and how it helps people. Activity sheet G: Students look at pictorial drawings and additional views of objects and draw the exploded view of each object. Activity sheet H: Students look at pictorial drawings and additional views of objects and draw the exploded view of each object. Activity sheet I: Students look at pictorial drawings and additional views of objects and draw the objects assembled. Activity sheet J: Define It – Matching activity for learning key terms.	Sectional views Part, revolved and removed sections Exploded and assembly drawings

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
2.3 Freehand drawing	Sketch in a variety of ways using freehand drawing	Student Book – pp.120–121 **Teacher Guide Activities** Activity sheet A: Freehand drawing – students use the drawings as prompts to discuss freehand drawing. Activity sheet B: Students draw toys using orthographic, isometric, perspective, sectional and exploded freehand. Activity sheet C: Students practise freehand drawing using notes and sketches to solve a number of problems.	Isometric Perspective Exploded view Orthographic Sectional view
2.4 Drawing basic shapes	• Construct a variety of regular and irregular polygons accurately • Construct circles accurately • Construct ellipses accurately • Construct tangents and tangential arcs accurately	Student Book – pp.122–126 **Teacher Guide Activities** Activity sheet A: Matching shapes to the names of shapes – students play shape dominoes. Activity sheet B: Define It – Matching activity for learning key terms.	Drawing basic shapes Regular polygons Irregular polygons Circles and ellipses Tangents and tangential arcs
2.5 Developments	• Understand what a development is and how to construct it • Be aware of a range of different developments • Add constructional details such as tabs and flaps	Student Book – pp.127–129 **Teacher Guide Activities** Activity sheet A: Students cut out and assemble developments. Activity sheet B: Students look at a pictorial view of a menu holder, draw a full size one-piece development and add glue tabs. Activity sheet C: Students look at a pictorial view of packaging for toothpaste, draw a 1:2 size one-piece development of the packaging, add glue tabs and the development of the lid of the packaging. Activity sheet D: Define It – Matching activity for learning key terms. Activity sheet E: Students look at three developments for each of a number of products and decide which one will not assemble into the shape shown.	Truncations Packaging developments and constructional details

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
2.6 Enlarging and reducing	• Enlarge and reduce circles • Enlarge and reduce irregular and regular polygons • Enlarge text • Enlarge and reduce using estimated one-point perspective	Student Book – pp.130–133 **Teacher Guide Activities** Activity sheet A: Students enlarge or reduce shapes and text using the scales given and add dimensions.	Enlarging circles and regular polygons using a compass Enlarging irregular polygons and text using a grid Enlarging and reducing using estimated one-point perspective
2.7 Instruments and drafting aids	• Recognise and use a range of different instruments and drawing aids to create accurate drawings with a good standard of graphical representation	Student Book – pp.134–135 **Teacher Guide Activities** Activity sheet A: Students draw isometric and sectional views of an object using the correct instruments.	Rulers, protractors and set squares Stencils Technical pens Compasses Flexicurves Drawing board
2.8 Layout and planning	• Set up an A3 sheet for drawing in orthographic, isometric and perspective • Plan a drawing	Student Book – pp.136–138 **Teacher Guide Activities** –	Laying out an A3 sheet
2.9 Presentation	• Use the thick- and thin-line technique to enhance a drawing • Understand light source and its effect on light and shade • Use rendering to emphasise three dimensions, textures and materials	Student Book – pp.139–143 **Teacher Guide Activities** Activity sheet A: Students enhance shapes using the thick- and thin-line method. Activity sheet B: Students practise materials rendering techniques. Activity sheet C: Students practise combining enhancement techniques. Activity sheet D: Define It – Matching activity for learning key terms.	Presentation in design Thick- and thin-line technique Light source and rendering Rendering materials and textures Lettering and fonts

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
2.10 Data graphics	• Produce line, pie and bar charts from data provided • Produce sequence drawings and flowcharts	Student Book – pp.144–147 **Teacher Guide Activities** Activity sheet A: Bad graphs – students identify what is wrong with four graphs. Activity sheet B: Students complete a sequential drawing for how to lay out a page for orthographic third angle. Activity sheet C: Define It – Matching activity for learning key terms.	Graphs and charts Sequence drawings and flowcharts
2.11 Reprographics	• Understand a range of commercial printing methods	Student Book – pp.148–149 **Teacher Guide Activities** Activity sheet A: Printing methods inquiry – students photograph printed items and describe them in a table (quality, production run, substrate, production method). Activity sheet B: Define It – Matching activity for learning key terms.	Offset lithography Gravure Flexography Screen printing
2.12 Materials and modelling	• Understand the reasons for modelling • Understand how to use modelling to an appropriate scale • Understand why scale drawings enable a visual model to be made • Understand the properties and uses of a range of modelling materials • Recognise a range of modern adhesives and their uses	Student Book – pp.150–155 **Teacher Guide Activities** Activity sheet A: Materials inquiry – students stick samples of material onto a table, write the name of each sample, its property and the type of model it can be used for. Activity sheet B: Define It – Matching activity for learning key terms. Activity sheet C: Students add tabs and flaps to developments so they can be assembled into the packaging shown.	The importance of modelling in design Modelling to scale Modelling materials Permanent and temporary joining methods

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
2.13 ICT	• Understand that digital images can be captured and stored on a computer • Understand that different types of image manipulation programmes can be used to alter images • Understand that computers can be used to output to a range of devices • Be aware of the use of computer aided design (CAD) and computer aided manufacture (CAM) in design	Student Book – pp.156–158 **Teacher Guide Activities** Activity sheet A: Students look at images and decide if they are bitmap or vector. Activity sheet B: Define It – Matching activity for learning key terms.	ICT in design Manipulating images using CAD Outputting designs using CAM
2.14 Manufacture of graphic products	• Use hand tools safely and accurately to manufacture graphic products • Understand the use of commercial production techniques for forming plastics • Understand the commercial processes used to cut, crease and shape materials	Student Book – pp.159–163 **Teacher Guide Activities** Activity sheet A: Students explain the process of vacuum forming. Activity sheet B: Define It – Matching activity for learning key terms.	Cutting and shaping Thermoforming Vacuum forming Blow moulding

3 Resistant Materials

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activitie
3.1 Types of materials	• 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	Student Book – pp.166–169 **Teacher Guide Activities** Activity sheet A: Material replacement – students the materials used to make three items, classify t materials, suggest a material from a different gro replace each material and give reasons. Activity sheet B: Students sketch or photograph a product and list the materials they can see. They select one of the materials and list the properties which it was selected, giving reasons. Activity sheet C: Define It – Matching activity for key terms. Activity sheet D: Team quiz – properties of mater
3.2 Smart and modern materials	• 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'	Student Book – pp.170–172 **Teacher Guide Activities** Activity sheet A: ACCESS FM – Students use the to investigate a product that utilises a smart or m material. Activity sheet B: CAFÉ QUE – Students use the investigate a product that utilises a smart or mod material. Activity sheet C: Define It – Matching activity for key terms.

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3 Resistant Materials

Core topic(s)	Learning objectives
3.1 Types of materials	• Understand the co physical and worki properties of mater • Understand the co factors that should considered when s materials that are f purpose
3.2 Smart and modern materials	• Be aware of a rang and modern materi including: thermoch materials; polymor memory alloy (SMA memory polymer • Understand the key of common 'smart materials'

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
3.3 Plastics	• 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) and 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	Student Book – pp.173–176 **Teacher Guide Activities** Activity sheet A: Students match thermoforming plastics samples with the names of the materials and the descriptions. Activity sheet B: Define It – Matching activity for learning key terms. Activity sheet C: the six 'R's – students consider a range of plastic products and decide whether they would rethink, refuse, reduce, reuse, recycle or repair them.	Plastic or polymer? Thermoforming plastics Thermosetting plastics
3.4 Wood	• 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.	Student Book – pp.177–183 **Teacher Guide Activities** Activity sheet A: Is hardwood hard? – students look at samples of hardwoods and match the samples with pictures of the trees from which they come. Activity sheet B: Wood or timber? – students look at samples of timber and draw on cross sections of a tree how the plank was cut. Activity sheet C: How does kiln drying work? – students label a diagram. Activity sheet D: Define It – Matching activity for learning key terms.	Natural timber Seasoning timber Softwood examples Hardwood examples Manufactured boards Shaping and joining timber Environmental considerations

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
3.5 Composites	• Understand the term *composite* • 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	Student Book – pp.184–187 **Teacher Guide Activities** Activity sheet A: What is a composite? – students mix materials, make observation notes in a table and decide if a composite material is formed. Activity sheet B: Modern composites – students consider various composites, list their advantages and disadvantages, and note down their common uses and applications. Activity sheet C: Define It – Matching activity for learning key terms. Activity sheet D: Team quiz	What is a composite? Why are composites used? Early composites Modern composites
3.6 Metals	• Understand where metals come from and how they are categorised • 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	Student Book – pp.188–194 **Teacher Guide Activities** Activity sheet A: Metal classification: ferrous or non-ferrous? – matching activity. Activity sheet B: Metal classification: pure metal or alloy? – matching activity. Activity sheet C: Heat treatments – students answer questions. Activity sheet D: Identification of metal tool parts – students complete tables. Activity sheet E: Define It – Matching activity for learning key terms. Activity sheet F: The hardening process – students describe it and produce annotated drawings.	Metal extraction and classification Properties of metals Ferrous metals Non-ferrous metals Changing the structure and properties of a metal

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide ac
3.7 Preparation of materials	• 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 • Explain the preparation needed for machine processes and safe methods of securing materials to work surfaces	Student Book – pp.195–198 **Teacher Guide Activities** Activity sheet A: Define It – Matching activi learning key terms.
3.8 Setting and marking out	• 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 • Accurately produce datum lines • Understand why testing is important	Student Book – pp.199–203 **Teacher Guide Activities** Activity sheet A: Students consider a resist material sample and decide which piece of equipment could be used to set, mark or m it, explaining their choice.

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Core topic(s)	Learning objectives
3.7 Preparation of materials	• Demonstrate know market forms, type • Understand differe cutting • Understand the us surfaces, lines and how to produce the • Explain the prepara machine processes methods of securin work surfaces
3.8 Setting and marking out	• Understand the im accurate measurer • Understand setting marking out and te • Be aware of the fo equipment: rule, pe knife, marker pen, square, bevel, mitr square, dot/centre inside/outside/odd- template, marking/ gauge • Accurately produce • Understand why te

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
3.9 Shaping	• Understand common wastage and addition processes • Understand common deforming and reforming processes	Student Book – pp.204–209 **Teacher Guide Activities** Activity sheet A: Pros and cons – students consider an item of equipment and analyse the benefits and limitations of using the equipment in manufacture. Activity sheet B: Team quiz Activity sheet C: Define It – Matching activity for learning key terms.	Principles of shaping materials Shaping by wastage and addition Shaping by deforming and reforming
3.10 Joining and assembly	• Define both permanent and temporary methods of joining materials and provide examples of both • 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	Student Book – pp.210–221 **Teacher Guide Activities** Activity sheet A: Brazing, soldering and welding – students answer questions. Activity sheet B: Riveting: snap and set – students watch a demonstration. They then label diagrams and describe what is happening in each. Activity sheet C: Riveting: pop rivets – students watch a demonstration. They then label diagrams and describe what is happening in each. Activity sheet D: Constructing an artefact – students suggest suitable joints or joining methods and explain why that joining method is suitable. Activity sheet E: Adhesives – students identify the purpose for which an adhesive is suitable by ticking the correct column in a table. Activity sheet F: Students look at a diagram of a cupboard and explain how it could be constructed. Activity sheet G: Define It – Matching activity for learning key terms.	Temporary joining Permanent joining Holding devices: jigs and formers Brazing Soldering Welding Riveting Joining wood Pre-manufactured components Adhesives Carcase, stool and frame construction

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
3.11 Finishes	• 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	Student Book – pp.222–227 **Teacher Guide Activities** Activity sheet A: Students decide whether an item's finish is suitable / has been designed for internal or external use. Activity sheet B: Define It – Matching activity for learning key terms. Activity sheet C: Types of finish – students identify different finishes on a range of products. Activity sheet D: Types of finish – students apply a different type of finish to different materials and record their findings. Activity sheet E: Health and safety – students create a step-by-step work plan for the safe use of a finish. Activity sheet F: Students answer questions about finishes by pointing to or holding up an appropriate item. Activity sheet G: Students answer questions about finishes.	The importance of finishes Types of finish Choosing an appropriate finish Self-finishing materials Health and safety

4 Systems and Control

Core topic(s)	Learning objectives	Student Book pages / Teacher
4.1 Systems	• Describe systems using block diagrams • Understand that each system block has an input, an output and describes an operation • Draw a system diagram for a simple system	Student Book – pp.230–232 **Teacher Guide Activities** Activity sheet A: Systems orderin the templates for several systems Activity sheet B: Define It – Matcl learning key terms.
4.2. Structures	**4.2.1 Basic concepts** • Understand that structures can be classified as mass, frame or shell structures • Give examples of mass, frame and shell structures • Understand that the principle of levers can be incorporated into a structure • Understand that frame structures are designed to span gaps and support loads • Identify structures which occur in nature	Student Book – pp.233–236 **Teacher Guide Activities** Activity sheet A: How strong is yc students use card to support a m centre without the card deforming Activity sheet B: Define It – Matcl learning key terms.
	4.2.2 Types of frame structure members • Understand that frame structures can be constructed using ties, struts, beams and columns • Understand that ties resist pulling (tension) forces • Understand that struts resist compressive (squeezing) forces • Understand that beams are designed to resist bending • Understand that columns resist compressive forces	Student Book – pp.237–239 **Teacher Guide Activities** Activity sheet A: Students identify ties of structures. Activity sheet B: Define It – Matcl learning key terms.

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4 Systems and Control

Core topic(s)	Learning objectives
4.1 Systems	• Describe systems • Understand that e input, an output a • Draw a system di
4.2. Structures	**4.2.1 Basic concept** • Understand that s as mass, frame o • Give examples of structures • Understand that t be incorporated in • Understand that f designed to span • Identify structures
	4.2.2 Types of frame • Understand that f constructed using columns • Understand that t forces • Understand that s (squeezing) force • Understand that b resist bending • Understand that c forces

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
4.2. Structures *continued*	**4.2.3 Strengthening frame structures** • Understand how triangulation can strengthen a frame structure • Understand how bracing and gusset plates strengthen structures at their corners	Student Book – pp.240–241 **Teacher Guide Activities** Activity sheet A: Exploring structural trusses – students use drinking straws to build models of a roof and bridge truss and explore how the joints can be strengthened using cross-bracing or gusset plate methods. Activity sheet B: Define It – Matching activity for learning key terms.	Triangulation Trusses Space frames
	4.2.4 Nature of structural members • Understand that deflection of a structural member depends on the material it is made from • Understand that deflection of a structural member depends on its cross-sectional shape • Understand that struts can fail by buckling • Understand that deflection of a beam is related to the depth of the beam	Student Book – pp.242–244 **Teacher Guide Activities** Activity sheet A: Students build an I-beam and a composite beam, load them at their centre and explore how each beam deflects under the load. Activity sheet B: Define It – Matching activity for learning key terms.	Buckling of struts Bending of beams Typical member cross-sections
	4.2.5 Applied loads and reactions • Understand that point loads on a beam can be shown by an arrow • Understand that the upward reaction forces are equal to the downward forces acting on a beam • Determine the reaction forces for a simple beam system	Student Book – pp.245–247 **Teacher Guide Activities** Activity sheet A: Students determine the magnitude of reaction forces. Activity sheet B: Define It – Matching activity for learning key terms.	Reaction forces and loads Downward forces equal upwards forces Uniformly distributed beams

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
4.2. Structures *continued*	**4.2.6 Moments** • Understand that a moment is a turning force • Understand the equation M = F × d • Use the principle of moments to determine the reactions of non-symmetrical beams	Student Book – pp.248–250 **Teacher Guide Activities** Activity sheet A: Students determine the magnitude of reaction forces. Activity sheet B: Students determine the magnitude of reaction forces. Activity sheet C: Define It – Matching activity for learning key terms.	What is a moment? Using the principle of moments for non-symmetrical beams
	4.2.7 Materials • Understand that material properties can be divided into mechanical and physical properties • Define the main mechanical properties such as tensile strength, compressive strength and toughness	Student Book – pp.251–252 **Teacher Guide Activities** Activity sheet A: Material properties – matching task for learning the definition of material properties. Activity sheet B: Students select the materials they might use for various items.	Mechanical properties Physical properties
	4.2.8 Testing **EXTENDED** • Understand how dial gauges and strain gauges are used for testing structural parts • Understand that strain gauges form part of a measuring system • Read a dial gauge to measure structural deflections	Student Book – pp.253–254 **Teacher Guide Activities** –	Structural testing Dial gauges Strain gauges

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
4.2. Structures *continued*	**4.2.9 Joints in structures** • Understand that joints can be rigid or moveable • Select suitable jointing methods for wood, steel and concrete • Recognise how cross-bracing and the use of lugs and ribs make joints stronger	Student Book – pp.255–257 **Teacher Guide Activities** –	Types of joints Joining solid and hollow cross-sectional materials Brazing Soldering Welding Machine screws Riveting
	4.2.10 Forces • Know the meaning of the terms *stress* and *strain* • Calculate simple stress values • Calculate simple strain values • Recognise shear and torsional forces acting on structural parts and members • Identify the key features of a stress–strain graph • Understand the use of safety factors in the design of structural members • Use the triangulation of force method to determine unknown forces in a simple framework • Use the parallelogram of force method to determine the resultant of two forces acting on a part	Student Book – pp.258–264 **Teacher Guide Activities** Activity sheet A: Students plot a force–extension curve using data from a tensile test and determine stress and strain values. Activity sheet B: Students use the triangulation of forces method to determine forces in structures. Activity sheet C: Define It – Matching activity for learning key terms.	Forces Strain Stress Shear and torsional forces Stress–strain graphs **EXTENDED** Factor of safety Determining simple forces acting on a structure Using triangulation of forces or parallelogram methods to determine forces **EXTENDED**

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
4.3 Mechanisms	**4.3.1 Basic concepts** • Understand that mechanisms are made up of parts like gears, levers, springs, cranks, and pulley and belt drives • Understand mechanical advantage • Understand that mechanisms are not 100 per cent efficient	Student Book – pp.265–272 **Teacher Guide Activities** Activity sheet A: Students do calculations to determine resistance distance, velocity ratio, etc. Activity sheet B: Define It – Matching activity for learning key terms.	What are mechanisms? Mechanical advantage, velocity ratio and efficiency Load, effort and fulcrum Levers Linkages Pulleys
	4.3.2 Conversion of motion • Describe rotary, linear, reciprocating and oscillating motion • Describe methods of changing one type of motion to another using a crank and slider, cam mechanisms and screw thread methods	Student Book – pp.273–280 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	Types of motion Converting rotary motion to linear motion
	4.3.3 Transmission of motion • Understand how gears are used to transmit motion between shafts which are close together • Understand how belt drives are used to transmit motion between shafts which are relatively far apart • Describe different types of gears; for example, spur gears, helical gears, bevel gears, worm and worm wheels, and rack and pinions • Understand the difference between simple gear trains and compound gear trains • Describe different types of belt systems • Calculate the speed ratios for gear train and belt drive systems	Student Book – pp.281–291 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	Gears and gear systems Velocity ratio of compound gear systems Gear systems and torque Types of gears Belt drives, and sprocket and chains Sprockets and chain drives Systems for maintaining tension in belt drives and chain drives Pneumatic and hydraulic systems Integration of electronic and pneumatic systems **EXTENDED** Selecting mechanisms for design applications **EXTENDED**

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
4.3 Mechanisms *continued*	**4.3.4 Energy** **EXTENDED** • Understand that energy sources include mains electricity, batteries, solar panels and generators • Explain the uses of rechargeable batteries • Understand that photovoltaic (PV) solar cells convert light energy to electricity • Understand that a generator converts mechanical energy to electrical energy	Student Book – pp.292–294 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	Mains supplies Batteries Solar cells Generators Energy costing Selecting energy sources
	4.3.5 Bearings and lubrication • Understand the purpose of lubrication • Describe the use of plain bearings, ball bearings, roller bearings and thrust bearings	Student Book – pp.295–298 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	Bearings Selection and suitability of bearings for specific conditions Lubrication
4.4 Electronics	**4.4.1 Basic concepts** • Understand the terms and units for electrical current, voltage, resistance and wattage • Recognise a range of circuit symbols • Understand how to use the power relationship $P = V \times I$ • Understand the difference between direct and alternating current • Recognise and draw simple direct current circuits • Understand how to use meters to measure electrical current, voltage and resistance	Student Book – pp.299–304 **Teacher Guide Activities** Activity sheet A: Students build circuits consisting of a switch, a battery and a number of light bulbs. They then record how the brightness of the bulbs differs for each circuit and explain the difference. Activity sheet B: Students do calculations using Ohm's Law. Activity sheet C: Define It – Matching activity for learning key terms.	Current flow **EXTENDED** Voltage Potential difference Ohm's Law Calculating electrical power Measuring voltage, current and resistance using meters

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
4. 4 Electronics *continued*	**4.4.2 Circuit building techniques** • Recognise good practice when designing printed circuit boards • Understand that strip board can be used to make simple circuits • Recognise how prototype boards are used for building experimental circuits	Student Book – pp.305–310 **Teacher Guide Activities** Activity sheet A: Students build three circuits using the printed circuit board method, the strip board method and a prototype board. Activity sheet B: Define It – Matching activity for learning key terms.	Printed boards Strip boards Prototype boards Soldering
	4.4.3 Switches • Recognise and use various types of switch, including the micro-switch • Understand the terms *normally open* (NO) and *normally closed* (NC) in relation to switching • Understand the uses of rotary and reed switches • Understand what is meant by the terms *SPST* and *SPDT* switches	Student Book – pp.311–315 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	PTM (press to make) and PTB (press to break) states Micro-switches Rotary switches **EXTENDED** Reed switches Normally open (NO) and normally closed (NC) switches Relays SPDT relay Latch circuit
	4.4.4 Resistors • Understand that resistors are divided into three main types: fixed resistors; variable resistors; and special resistors (thermistors, light dependent resistors)	Student Book – pp.316–319 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	Fixed resistors Tolerance Resistors in series and parallel

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
4. 4 Electronics *continued*	**4.4.5 Transistors** • Recognise the collector, base and emitter connections of a transistor • Understand that transistors can be used as a fast operating electronic switch and as an amplifier • Understand how transistors can be used in simple sensing and timing circuits	Student Book – pp.320–322 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	What is a transistor? How a transistor operates NPN (negative-positive-negative) transistors Transistor switches
	4.4.6 Diodes • Recognise the circuit symbol for a diode • Understand that a diode allows current to flow in only one direction • Understand how diodes are used to rectify current • Describe the use of light emitting diodes	Student Book – pp.323–325 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	What is a diode? Using diodes to prevent damage to a circuit Light emitting diodes Seven segment displays
	4.4.7 Transducers • Describe the use of an LDR • Describe the use of a thermistor • Understand that thermistors can have either negative or positive coefficients	Student Book – pp.326–327 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	Light dependent resistors Thermistors Strain gauge **EXTENDED**

Core topic(s)	Learning objectives	Student Book pages / Teacher Guide activities	Key themes
4. 4 Electronics *continued*	**4.4.8 Capacitors** • Understand the units of capacitance • Understand that capacitors are used for timing applications • Understand the difference between polarised and non-polarised capacitors	Student Book – pp.328–329 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	What is a capacitor? Types of capacitors
	4.4.9 Time delay circuits • Recognise a delay circuit using discrete components • Recognise the pin sequence of an integrated circuit • Use a 555-timer for astable and monostable timing applications • Calculate the time periods for astable and monostable operations	Student Book – pp.330–334 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	Delay circuits **EXTENDED** Integrated circuits 555-timer integrated circuit
	4.4.10 Logic gates and operational amplifiers • Understand the truth tables for NOT, AND, NAND, OR and NOR gates • Understand the difference between TTL and CMOS logic circuits • Use CMOS logic circuits in project work • Recognise and use operational amplifier (op-amp) integrated circuits in project work • Calculate the gain of an inverting operational amplifier • Understand how to use an op-amp as a comparator	Student Book – pp.335–343 **Teacher Guide Activities** Activity sheet A: Define It – Matching activity for learning key terms.	Logic gates NAND, AND, NOR and OR gates Integrated circuits logic gate families Logic control systems in everyday life Operational amplifiers (op-amps) Voltage gain of an amplifier Inverting amplifier **EXTENDED**

Notes

Notes

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