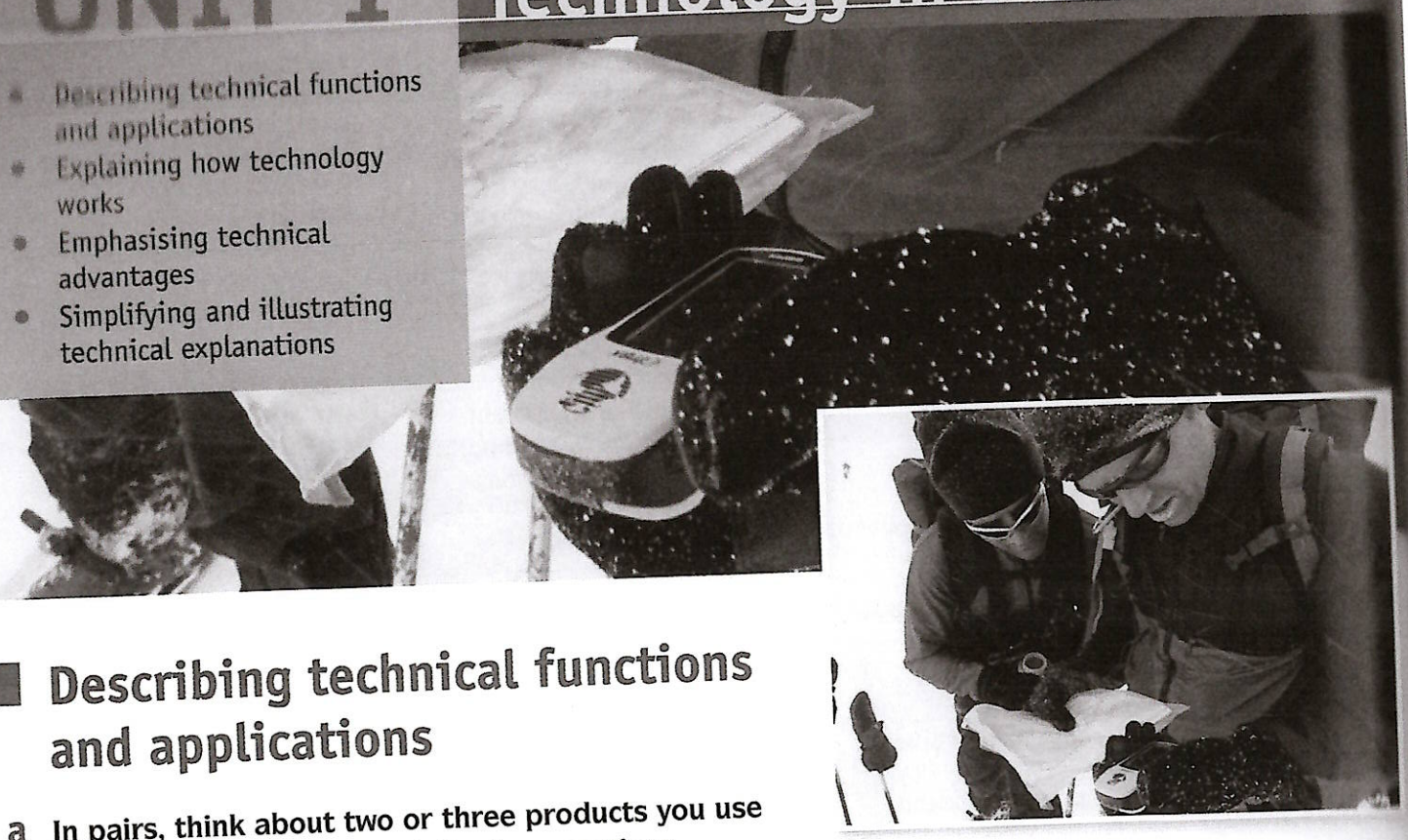
UNIT 1 Technology in use

- Describing technical functions and applications
- Explaining how technology works
- Emphasising technical advantages
- Simplifying and illustrating technical explanations



Describing technical functions and applications

1 a In pairs, think about two or three products you use regularly and discuss the following questions.

- What are the main functions of the products? (What do they do?)
- What are their different applications? (What are they used for?)

b What do you know about Global Positioning System (GPS) devices? In pairs, describe their main function, and give some examples of different applications of GPS devices.

2 a ▶1.1 Paula, a design engineer for a GPS manufacturer, is discussing product development with José, a senior manager new to the company. Listen to the conversation and complete the following notes.

- the primary application of GPS — (1) _____
- associated applications — Tracking systems for (2) _____; Tracking systems for (3) _____
- more creative features — (4) _____ alarms; (5) _____ buttons
- not technical innovations — (6) _____ the technology

b Complete the following extracts from the discussion with words that come from *use*.

1 *Then you've got associated applications, _____ that are related to navigating …*
2 *… tracking systems you can _____ for monitoring delivery vehicles …*
3 *… from the end-_____ point of view, accuracy is no longer the main selling point. Most devices are accurate enough. The key is to make them more _____ .*

a **Match the GPS applications (1–6) to the descriptions (a–f).**

1	topographical surveying	a	navigation and safety at sea
2	geological exploration	b	setting out positions and levels of new structures
3	civil engineering	c	mapping surface features
4	avionics equipment	d	applications in mining and the oil industry
5	maritime applications	e	highway navigation and vehicle tracking
6	GPS in cars and trucks	f	air traffic control, navigation and autopilot systems

b **In pairs, practise explaining the applications of GPS in Exercise 3a to a colleague who has limited knowledge of the devices using the following phrases.**

used for -ing	used to	useful for	another / a similar use

a **Complete the following extracts from the conversation by underlining the correct words.**

1 *... there's a setting on the GPS that* ***allows/prevents*** *it to detect the movement ...*
2 *... an alarm sounds to warn you, and* ***allows/prevents*** *the boat from drifting unnoticed.*
3 *... and* ***enables/ensures*** *that you don't lose track of where you were, which then* ***enables/ensures*** *you to turn round and come back to the same point ...*

b **Match the words in Exercise 4a to the synonyms.**

1 _____ = makes sure 2 _____ / _____ = permits 3 _____ = stops

c **Complete the following extract from the user's manual of a GPS device using the verbs in Exercise 4a. Sometimes, more than one answer is possible.**

INTRODUCTION

The core function of your GPS receiver is to (1) _____ you to locate your precise geographical position. To (2) _____ the device to function, it receives at least three signals simultaneously from the GPS constellation – 30 dedicated satellites which (3) _____ receivers can function anywhere on earth. To (4) _____ extremely precise positioning and (5) _____ errors from occurring due to external factors, this device is designed to receive four separate signals (see enhanced system accuracy on page 18).

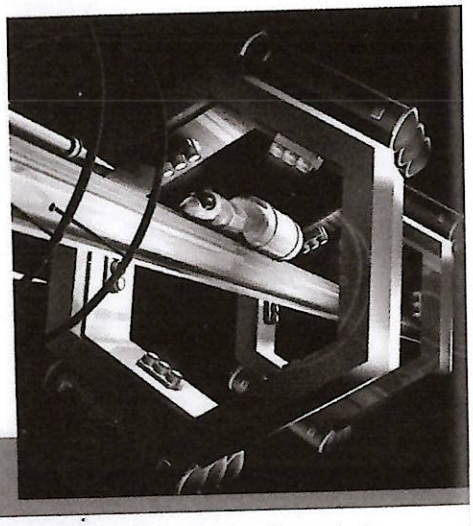
In pairs, explain the main functions and applications of a product made by your company or a product you know about. Student A, you are an engineering manager; Student B, you are a new employee. Use the language from this section and the phrases in the box. Swap roles and practise again.

I see. So ...	OK. In other words ...	So you mean ...

Explaining how technology works

6 a In pairs, look at the picture and discuss the following questions.

- How do you think a space elevator would work?
- What could it be used for?
- What technical challenges would it face?
- How seriously do you think the concept of space elevators is being taken at present?



b Read the following article and compare it to your answers in Exercise 6a.

Space elevators: preparing for takeoff

IN his 1979 novel, *The Fountains of Paradise*, Arthur C Clarke wrote about an elevator **connecting** the earth's surface to space. Three decades later, this science-fiction concept is preparing to take off in the real world. NASA has launched the Space Elevator Challenge, a competition with a generous prize fund, and several teams and companies are working on serious research projects aimed at winning it.

As its name suggests, a space elevator is designed to **raise** things into space. Satellites, components for space ships, supplies for astronauts in space stations, and even astronauts themselves are examples of payloads that could be **transported** into orbit without the need for explosive and environmentally unfriendly rockets. However, the altitude of orbital space – a colossal 35,790 km above the earth – is a measure of the challenge facing engineers. How could such a height be reached?

The answer is by using an incredibly strong and lightweight cable, strong enough to **support** its own weight and a heavy load. The design of such a cable is still largely theoretical. This would be **attached** to a base station on earth at one end and a satellite in geostationary orbit (fixed above a point on the equator) at the other. Lift vehicles would then **ascend** and **descend** the cable, **powered** by electromagnetic force and **controlled** remotely.

c Match the verbs (1–9) from the text in Exercise 6b to the definitions (a–i).

1	connecting	a	carried (objects, over a distance)
2	raise	b	hold something firmly / bear its weight
3	transported	c	climb down
4	support	d	provided with energy / moved by a force
5	attached	e	joining
6	ascend	f	driven / have movement directed
7	descend	g	fixed
8	powered	h	climb up
9	controlled	i	lift / make something go up

7 a James, an engineer, is giving a talk on space elevators. Complete his notes using the correct form of the verbs (1–9) in Exercise 6c.

Space Elevators

- *Challenge of (1)* **connecting** *a satellite to earth by cable is significant.*
- *To (2)* _____ *its own weight, and be securely (3)* _____ *at each end, cable would need phenomenal strength-to-weight ratio.*
- *How could vehicles be (4)* _____ *into space, up cable?*
- *Self-contained energy source problematic, due to weight (heavy fuel or batteries required to (5)* _____ *vehicle).*
- *Two possible ways round problem:*

  1 Transmit electricity wirelessly. But technique only at research stage.

  2 Solar power. But would only allow vehicle to (6) _____ *slowly. Not necessarily a problem, as car could be controlled remotely, allowing it to (7)* _____ *payloads unmanned.*

b ▶1.2 **Listen to part of James' talk and check your answers in Exercise 7a.**

c **What kinds of word are missing from the notes? In pairs, compare the audioscript on page 86 with the notes in Exercise 7a.**

a **Some space elevator designs propose an offshore base station. In pairs, discuss how such a system might work using words in Exercise 6c. What advantages might an offshore base have compared with a land base?**

b ▶1.3 **James goes on to discuss offshore base stations. Listen to the talk and answer the following questions.**

1 How would an offshore base station be supported?
2 What would the function of its anchors be?
3 How would payloads reach the base station?
4 What problem would a mobile base station help to prevent?
5 What would the procedure be if there was an alert?

a **You are members of a space elevator research team designing a concept for offshore base stations. In pairs, analyse the notes below, which were made during a briefing given by your manager. Imagine you are giving a presentation. Begin by reading out the abbreviated notes in full.**

OFFSHORE BASE STATION - ANCHORING & PROPULSION ISSUES

Anchoring system

Wind loads on cable will be huge. What implications for anchoring system? Base will need to be moved continually, sometimes urgently. What temp system could be used to hold base in position?

Base in shallow water near coast, or deep water further offshore? Choice will have impact on design of anchor system.

Propulsion system

Will weight of cable allow base to be moved by own propellers? Or more powerful system for propulsion and control nec.? E.g. extern. power source?

b **In pairs, discuss the questions raised in the notes and think of some suitable solutions for the anchoring system and the propulsion system. At this stage, these should be overall concepts, not detailed designs. Remember to make notes.**

c **In small groups, take turns to give a short talk using your notes to explain how the systems work, in general terms. Imagine you are speaking to a small group of colleagues, including your manager.**

d **Write two or three paragraphs to summarise your talk. These will be included in your manager's longer report on offshore base stations.**

Emphasising technical advantages

10 **In pairs, discuss the term *technical advantage*. Give some examples of technology you are familiar with.**

11 a **Read the first paragraph of some promotional literature from Otis, a leading elevator company. What is the Gen2™ system?**

b **Match the words (1–6) from the text in Exercise 11a to the synonyms (a–f).**

1	conventional	a	decreases
2	eliminates	b	better / the best
3	superior	c	improved
4	energy-efficient	d	standard, usual
5	enhanced	e	gets rid of
6	reduces	f	has low energy consumption

c **Complete the following text using the correct form of the words (1–6) in Exercise 11b. You will need to use some words more than once.**

OTIS Unique Flat Belt

The key to Otis's patented drive technology

At the heart of the Gen2™ elevator system is a flat belt (developed by and unique to Otis). It is just 3mm thick. Yet it is stronger than **conventional** steel cables. It lasts up to three times longer. And it has enabled Otis to completely re-invent the elevator. The flat, coated-steel belt totally **eliminates** the metal-to-metal effect of conventional systems. Coupled with a smooth-surface crowned machine sheave, the result is exceptionally quiet operation and **superior** ride comfort. Furthermore, the flexible flat belt enables a more compact, **energy-efficient** machine, which can be contained in the hoistway. This **enhanced** technology **reduces** building and system operating costs, and frees up valuable space.

Protecting the environment

Neither the belt nor the gearless machine, with its permanently sealed bearings, requires any lubrication so the Gen2™ system is cleaner for the environment. The highly (1) energy-efficient gearless machine, with its permanent-magnet synchronous motor, (2) _____ power consumption by as much as 50 percent over (3) _____ geared machines and 15 percent over other machines with permanent-magnet motors of axial construction.

Reliable by design

Long-lasting flat belts, smooth, crowned sheaves and minimal moving parts in the gearless machine dramatically (4) _____ wear and increase durability and efficiency. To further (5) _____ reliability and safety, Otis developed the Pulse™ system, which continually monitors the status of the belts' steel cords. Unlike visual inspections of (6) _____ steel ropes, the Pulse™ system automatically detects and reports belt faults to maintenance personnel for rapid response, providing owners with greater peace of mind. With flat belt technology, Otis has created a (7) _____ system that (8) _____ the need for a machine room, is quiet, clean, reliable and economical, and easy to install and maintain.

d **In pairs, summarise the advantages of the flat belt system. Discuss durability, wear, noise, space, cleanliness, efficiency, automation, maintenance and cost.**

a **Complete the following tips on emphasising technical advantages using the words in the box.**

conventional	eliminated	enhanced	reduced	superior

When describing technical advantages, it's useful to emphasise …

a (1) _____ performance, compared with the older model of the same product.

b negative issues that have been (2) _____ , or completely (3) _____ .

c special features that differentiate the technology from (4) _____ systems.

d performance levels that make the technology (5) _____ to the competition.

b ▶1.4 **Stefan, an engineer, is briefing some sales colleagues on the advantages of a new pump design. Listen to the briefing and match the tips (a–d) in Exercise 12a to the extracts (1–4).**

Extract 1 _____ Extract 2 _____ Extract 3 _____ Extract 4 _____

c **Complete the following sentences from the briefing by underlining the correct emphasising word.**

1 *We've come up with a* ***completely/significantly*** *unique profile.*
2 *It* ***completely/dramatically*** *reduces vibration.*
3 *Machines like these can never be* ***entirely/highly*** *free from vibration.*
4 *The new design runs* ***dramatically/extremely*** *smoothly.*
5 *Another advantage of the new profile is that it's* ***considerably/entirely*** *lighter.*
6 *So compared with our previous range, it's* ***highly/totally*** *efficient.*
7 *Trials so far suggest the design is* ***completely/exceptionally*** *durable.*
8 *We expect it to be* ***entirely/significantly*** *more reliable than rival units.*

d **Match the words in Exercise 12c to the synonyms.**

considerably	dramatically	entirely	exceptionally	highly	totally

1 _____ / _____ = completely
2 _____ / _____ = significantly
3 _____ / _____ = extremely

You are Otis engineers back in the 1850s, when elevators were new. In pairs, prepare a short talk to brief your sales colleagues on the advantages of elevators for lifting people and goods. Emphasise the points below, using the phrases and techniques from this section. Remember that people at this time are sceptical about the technology.

Elevators are …

- safe – a reliable braking system eliminates the danger of a car falling if a cable fails
- simple – they're controlled from the car and are very easy to operate
- convenient – they're easier on the legs than the conventional alternative (stairs)
- valuable – they enhance the value of land by allowing taller buildings on smaller areas

Simplifying and illustrating technical explanations

14 a ▶1.5 **Richard, a structural engineer, often takes clients on guided tours of their new buildings during construction. He is talking about explaining technical concepts to non-specialists. Listen and answer the following questions.**

1 What does Richard say about explaining technical concepts?
2 What does he mean by *dull* explanations?
3 What is *being patronising*?

b In pairs, think of some tips on how to solve the following problems.

1 not being understood
2 being patronising
3 explaining difficult concepts
4 sounding dull

c ▶1.6 **Richard is giving some advice about the problems in Exercise 14b. Listen and summarise his ideas. Compare his tips with your suggestions.**

15 a Richard has made notes for a guided tour of a site. The project is a skyscraper in the early stages of construction. During the tour he explains the technical terms to the non-specialist group. In pairs, discuss the following terms and try to interpret them using everyday language to rephrase them.

SUBSTRUCTURE

- *Pile foundations (in general)*
- *Bored in situ concrete piles*
- *Pre-cast driven concrete piles*
- *Pile driver*
- *Pile auger*
- *Bentonite*

b ▶1.7 **Richard is giving a tour of a construction site. Listen and make notes of his explanations of the following technical terms. Compare your ideas with his.**

1 the substructure — the part of the structure below ground
2 a pile foundation — .....
3 to bore (a pile) — .....
4 in situ concrete — .....
5 pre-cast piles — .....
6 to drive in (a pile) — .....
7 a pile driver — .....
8 a pile auger — .....
9 bentonite — .....

c ▶1.7 **Listen again and compare Richard's explanations with the tips in Exercise 14c. Which techniques did he use? Were they successful?**

d **Complete the following table using the words in the box.**

basically (x2) call effectively essentially imagine other picture refer ~~simple~~ simply

	Function	Words / Phrases
1	Simplifying the language	in simple terms / put _____ / in _____ words / _____
2	Simplifying the concept	_____ / _____ / _____
3	Focusing on technical terms	what we _____ / what we _____ to as
4	Illustrating with images	if you _____ / if you _____

e **In pairs, practise explaining the technical terms in Exercise 15a using the simplified words and phrases in Exercise 15d.**

Read the textbook description of two types of pile foundation. Use the words and phrases in Exercise 15d and the following notes to rephrase it.

From a structural perspective, pile foundations can be divided into two categories: end-bearing piles and friction piles.

Imagine water and the seabed

End-bearing piles are driven or bored through soft ground in order to attain firm substrata below. The pile then transmits load vertically to firm subsoil or bedrock. The soft ground surrounding the sides of the pile is structurally redundant.

Like standing on stilts in water

Friction piles counteract downward loads from the structure through frictional resistance between the sides of the pile and the surrounding ground, and do not therefore rely on firm substrata. In some cases, the diameter of the concrete at the pile's base is widened by compaction, allowing the increased area to give the friction pile a certain degree of end-bearing resistance.

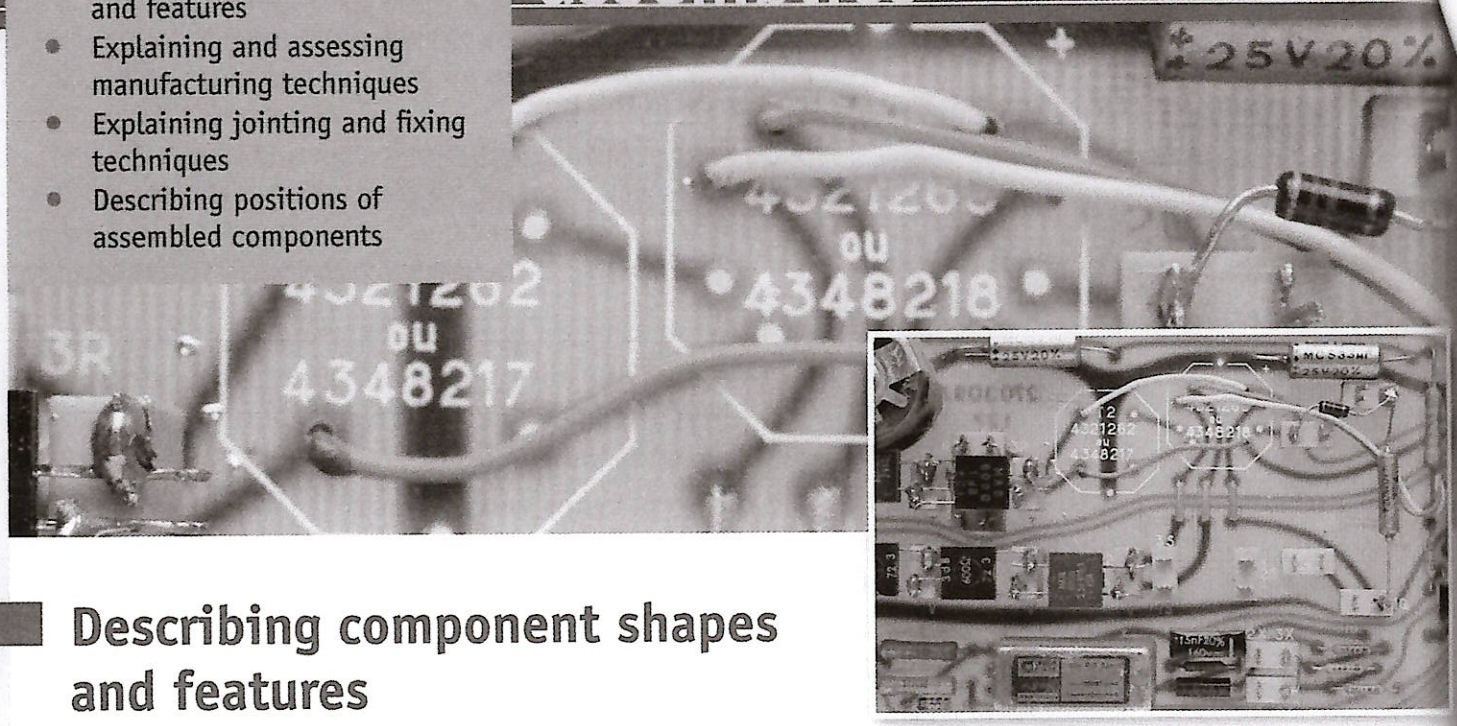
Like a nail in wood

Imagine a leg and a foot

You are showing a non-specialist visitor around your company and explaining technical concepts using simplified language. In pairs, practise explaining a product or type of technology that you are familiar with.

UNIT 3 Components and assemblies

- Describing component shapes and features
- Explaining and assessing manufacturing techniques
- Explaining jointing and fixing techniques
- Describing positions of assembled components



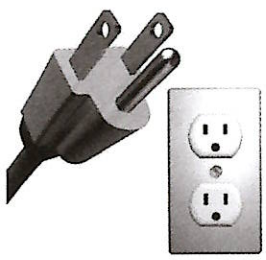
Describing component shapes and features

1 What do you know about the electrical plugs and sockets used in different countries? In pairs, describe some specific designs.

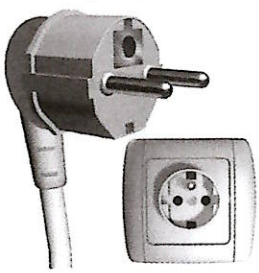
2 a ▶3.1 Jan, a project manager for a firm that manufactures electrical plugs and sockets, is briefing some of his engineering colleagues. Listen to the briefing and summarise the aim of the project.

b In pairs, discuss what is meant by *profile of the pins* and *standard configuration*.

c ▶3.2 Erin, an engineer with the same company, is describing different electrical plug and socket formats during the briefing. Listen and match the descriptions (1–6) to the pictures (a–f).

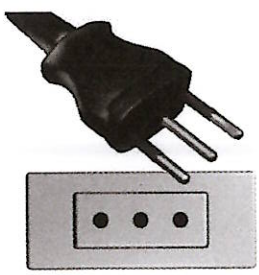


a _____



b _____

c _____



d _____

e _____

f _____

d **Complete the following phrases from the descriptions using adjectives based on the words in brackets.**

1 *... there are* circular *pins for live and neutral.* (circle)
2 *... the earth slot's got a flat base with one side* _____ *over to form a semi-circle.* (round)
3 *This one has* _____ *blades for live, neutral and earth ...* (rectangle)
4 *... it has a* _____ *slot to receive the earth pin.* (cylinder)
5 *... the pins are arranged in* _____ *configuration.* (line)
6 *... they're laid out in* _____ *configuration.* (triangle)

e ▶3.3 **Listen and underline the stressed syllable in each of the following words.**

rectangle	rectangular	triangle	triangular
cylinder	cylindrical	line	linear

a ▶3.4 **Listen to a longer description from the meeting. Which picture (a–f) in Exercise 2c does Erin describe?**

b **Complete the following extracts from the description using the correct form of the words in the box.**

flush with groove ~~hole~~ pin recess ridge set back

1 *... there's a circular slot at the top. It's obviously a blind* hole *, it doesn't go right through.*
2 *... there are two plastic* _____ *, one on either side of the plug casing, and they slot into corresponding* _____ *at each side of the socket. In addition, the centre of the socket is* _____ *. So rather than being* _____ *the front of the socket, on the same face, the circular area that receives the plug is* _____ *from the surrounding casing ...*
3 *These covers only open when pressure is applied to both by the two* _____ *of the plug simultaneously.*

c **In pairs, describe the different plug and socket formats in the pictures in Exercise 2c.**

a ▶3.5 **Andy and Karin, two electrical engineers, are evaluating a plug and socket format in Exercise 2c. Listen to the conversation and make notes of the advantages and disadvantages of the following features.**

1 Plug slots into a recess in the socket:
Advantages _____
Disadvantages _____
2 Covers protect live and neutral slots:
Advantages _____
Disadvantages _____

b **In pairs, discuss the advantages and disadvantages of the plug and socket formats in Exercise 2c. Use the following phrases from the conversation.**

an advantage/disadvantage of this format is ... another advantage/disadvantage is ...
the problem with this system is ... this (shape/format/feature) stops ... from ... -ing
this (shape/format/feature) allows it to / helps it to / makes it easy to / makes it difficult to ...

Explaining and assessing manufacturing techniques

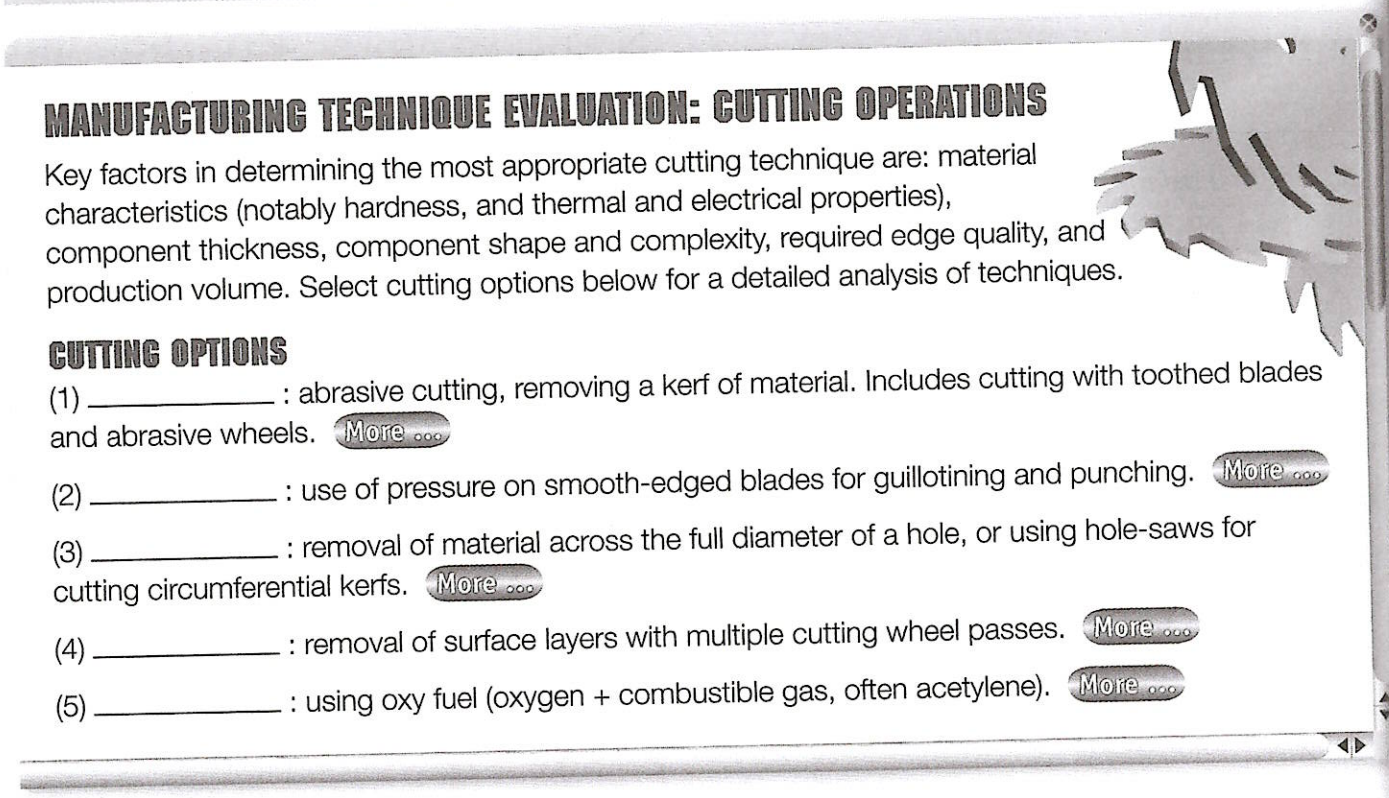
5 **In pairs, think of some examples of machining operations that are often used in manufacturing involving metalworking.**

6 a ▶3.6 **Evan, a sales engineer with a metal fabrication company, is showing Mr Barrett, a new customer, around their plant. Listen to the conversation and mark the statements True (T) or False (F).**

1 The company specialises in sheet metal working.
2 The company does a lot of metal casting.
3 Metal bashing is a precise technical term for hammering.
4 Drills and milling machines are always noisy.
5 Grinding is a process that uses abrasives.
6 The press is used for shearing metal.

b **Complete the following training material for graduate engineers using the words in the box.**

Drilling Flame-cutting Milling Sawing Shearing



MANUFACTURING TECHNIQUE EVALUATION: CUTTING OPERATIONS

Key factors in determining the most appropriate cutting technique are: material characteristics (notably hardness, and thermal and electrical properties), component thickness, component shape and complexity, required edge quality, and production volume. Select cutting options below for a detailed analysis of techniques.

CUTTING OPTIONS

(1) _____ : abrasive cutting, removing a kerf of material. Includes cutting with toothed blades and abrasive wheels. More ...

(2) _____ : use of pressure on smooth-edged blades for guillotining and punching. More ...

(3) _____ : removal of material across the full diameter of a hole, or using hole-saws for cutting circumferential kerfs. More ...

(4) _____ : removal of surface layers with multiple cutting wheel passes. More ...

(5) _____ : using oxy fuel (oxygen + combustible gas, often acetylene). More ...

c **Complete the following definitions using the words in the box.**

abrasive wheel guillotine hole-saw kerf punch toothed blade

1 A punch makes holes by applying pressure to shear the material.
2 A _____ makes straight cuts by applying pressure to shear the material.
3 A _____ is the width of the saw cut.
4 A _____ has sharp edges for cutting or milling.
5 A _____ has a hard, rough surface for cutting or grinding.
6 A _____ cuts a circular piece to remove an intact core of material.

a **Read the following extract of promotional literature from a leading producer of ultra-high-pressure (UHP) waterjet cutting machines. In pairs, explain the phrases in bold.**

Flow

What makes waterjets such a popular cutting option? Water jets require few **secondary operations**, produce **net-shaped parts** with no **heat-affected zone**, heat distortion, or **mechanical stresses** caused by other cutting methods, can cut with a **narrow kerf**, and can provide better usage of raw material since parts can be **tightly nested**. As a result of the FlowMaster™ PC control system and intuitive operation, waterjets are extremely easy to use. Typically, operators can be trained in hours and are producing high-quality parts in hours. Additionally, waterjets can cut virtually any material, leaving a satin-smooth edge.

b ▶3.7 **Evan is talking to Mr Barrett about UHP waterjet cutting. Listen to the conversation and match the phrases in the box to the extracts (1–4).**

heat-affected zone mechanical stresses narrow kerf net-shaped parts

Extract 1 _____ Extract 3 _____

Extract 2 _____ Extract 4 _____

c **Complete the following extracts from the conversation by underlining the correct phrases.**

1 *So they are **especially good when / not so good when** you have intricate shapes.*
2 *Saw blades are obviously **perfect when / useless when** you're cutting curved shapes.*
3 *… sawing is **the ideal solution / not the best solution** if you want to avoid altering the material.*
4 *… it's **ideal for / totally unsuitable for** metals.*

In pairs, assess the different cutting techniques in terms of
- **shape/size of cut**
- **material types/characteristics**
- **cut width/quality.**

Use the phrases in the box.

ideal/perfect/especially good for + -ing the ideal/perfect solution for
not particularly suitable / not so good if you need …
not the best solution if you don't want … totally unsuitable / useless

Cutting techniques
drilling with a bit
drilling with a hole-saw
flame-cutting
grinding
guillotining
milling
punching
sawing
waterjet cutting

Shape/size of cut
angular blind holes curved large small straight
thick thin through holes

Material types/characteristics
ceramics metals plastics timber hard tough
brittle

Cut width/quality
heat-affected zone narrow kerfs no kerf rough edges
smooth edges wide kerfs

Explaining jointing and fixing techniques

9 **In pairs, think of some examples of ways of joining materials together.**

10 a ▶3.8 **Pedro, a purchasing manager with a kitchen appliance manufacturer, is talking to Alicia, a sales manager from one of their main suppliers. Listen to the conversation and answer the following questions.**

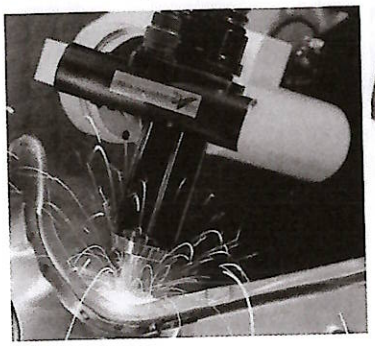
1 What objective does Pedro describe regarding his company's relationship with suppliers?
2 What is Alicia concerned about?
3 How does he respond to her concerns?

b Complete the following table using the words in the box.

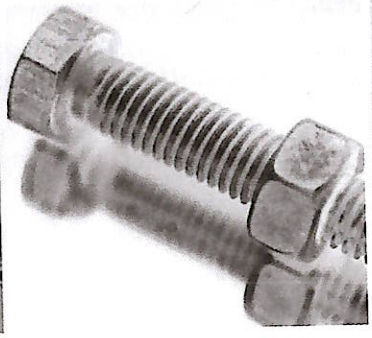
adhesive ~~bolt~~ clip rivet screw weld

Mechanical fixings	Non-mechanical fixings
bolt	

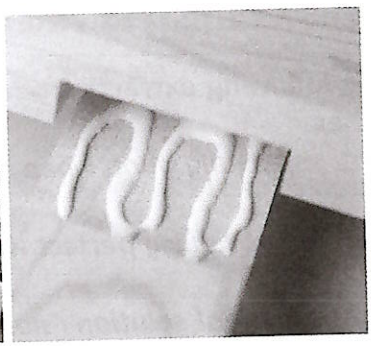
c Label the photos (1–6) with the words in Exercise 10b.



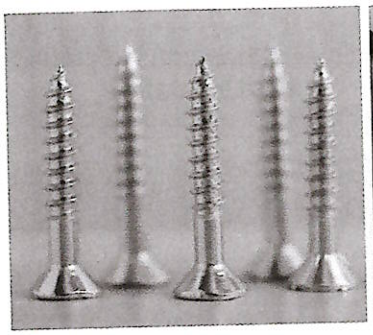
1 weld



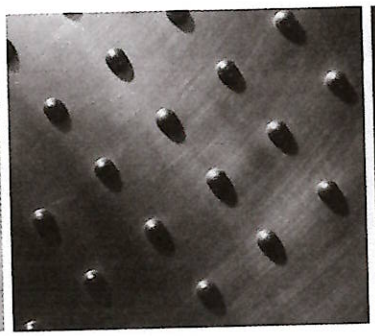
2 _____



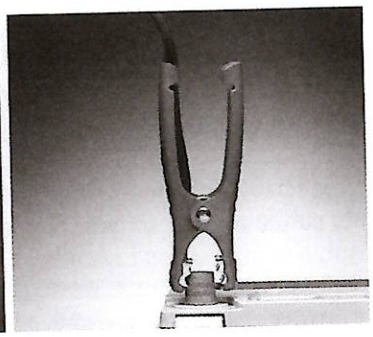
3 _____



4 _____



5 _____



6 _____

d Match the types of connection in the box to the following groups.

bolting bonding ~~connecting~~ fixing gluing joining riveting welding

1 connecting _____ _____ = describes any kind of connection.
2 _____ _____ = describes mechanical connections only.
3 _____ _____ _____ = describes non-mechanical connections only.

a **Complete the following questions using the words in the box.**

each other on onto to together

1 How can we fix these two components _____ ?
2 How can we fix these two components to _____ ?
3 How can we fix this component _____ ?
4 How can we fix this component _____ / _____ this component?

b **Complete the following training web page using the words in Exercise 11a.**

MANUFACTURING TECHNIQUE EVALUATION: JOINTS AND FIXINGS

The most suitable method of joining components depends on many factors, which extend beyond the obvious issue of required strength.

- Will the joint need to be disconnected in the future? If a part is bolted (1) _____ , it can obviously be removed at a later date. If two components are bonded to (2) _____ with strong adhesive, or welded (3) _____ then subsequent removal will clearly be more difficult. More ...
- What external factors might affect the joint? Water or heat can weaken adhesive joints. And no matter how tightly nuts are screwed (4) _____ bolts, vibration can cause them to work loose over time. More ...
- How quality-sensitive is the jointing technique? Components are rarely joined (5) _____ each other in ideal conditions. Inadequately tightened fixings, improperly prepared surfaces, or flawed welds are inevitable. How could such imperfections affect the joint negatively? More ...

c **In pairs, answer the following questions using the information on the web page in Exercise 11b.**

1 What are the main advantage and disadvantage of mechanical fixings?
2 What is the main disadvantage of non-mechanical jointing?
3 What issues can negatively affect mechanical fixings and non-mechanical joints?

a **In pairs, discuss the following jointing techniques used in aircraft and say how the parts are fixed together.**

1 Early aircraft: timber frame / adhesive or screws
2 Modern jet aircraft: alloy body panels / rivets
3 Aircraft cabins: seats/floor/bolts
4 Aircraft cockpit: windshield/fuselage/adhesive

b **Your company has launched a competition for its engineers to build a homemade model glider that is as cheap as possible to assemble. In pairs, discuss what types of materials and joints you could use.**

Describing positions of assembled components

13 **a** **In pairs, read the title of the article and suggest ways of making a garden chair fly. Discuss any potential problems.**

b **Read the article and match the questions (a–d) to the paragraphs (1–4).**

a How did the actual flight differ from the one that was planned? _____
b What incidents occurred just before and just after the landing? _____
c What is said about the modern equivalent of this type of activity? _____
d What components were used to assemble the flying machine? _____

CRAZY BUT TRUE: LARRY WALTERS AND THE FLYING GARDEN CHAIR

1 On July 2, 1982, a Californian truck driver named Larry Walters sat outside his house on a garden chair. To say that he was out to get some air is an understatement, for projecting above him a cluster of ropes was tied to 42 helium-filled weather balloons. Anchor ropes, situated underneath the chair, were fastened around the bumper of his car, which was positioned just below the makeshift flying machine.

2 Mr Walters intended to climb gently to an altitude of a few hundred feet, before drifting slowly out of town and across country. He then planned to use an airgun to shoot some balloons and descend gradually to earth. But as the helium gas contained within the balloons warmed up in the summer sun, it progressively generated more lift. When the anchor ropes were released, the self-assembly airship shot up like a rocket. Too shocked to reach for the pistol inserted in his pocket, the first-time pilot held on for life. In just a few minutes, Larry Walters was 16,000 feet above the ground, floating over the city of Long Beach. A short time later, there were further complications; he suddenly found himself inside controlled airspace, adjacent to Long Beach Airport. The occupants of passing Delta Airlines and TWA aircraft looked on at the curious spectacle outside, as wide-eyed as the garden chair pilot hovering beside them.

3 Eventually, after managing to shoot some balloons, Mr Walters descended safely to earth despite an anchor rope, which was still suspended beneath the chair, getting tangled with a power line located alongside the landing site (in someone's garden). He was immediately arrested by waiting police officers, and was later fined for breaking Federal aviation laws.

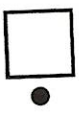
4 Today, cluster ballooning, while still a fairly marginal sport, is steadily starting to gain in popularity.

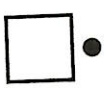
c **Answer the questions in Exercise 13b.**

14 **a** **Label the diagrams using the prepositions in the box.**

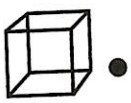
~~above~~ adjacent to alongside around below beneath beside inside outside over underneath within

a  above _____ _____

b  _____ _____ _____

c  _____ _____ _____

d  _____

e  _____

f  _____ _____

b **Complete the following sentences about the flying garden chair using the prepositions in the box. Check your answers against the text in Exercise 13b.**

in	above	around	beneath	within

1 Projecting _____ the chair was a cluster of ropes, tied to 42 helium-filled weather balloons.
2 Anchor ropes were fastened _____ the bumper of the car.
3 Larry Walters had an airgun inserted _____ his pocket.
4 The helium contained _____ the balloons warmed up in the sun.
5 After takeoff, the anchor ropes remained suspended _____ the chair.

c **Complete the following descriptions of how the garden chair airship was assembled by underlining the correct words.**

1 A quantity of helium gas was **contained/suspended** inside each balloon.
2 A tube was **inserted/projected** inside the openings of the balloons, to inflate them.
3 The balloons were **situated/suspended** over the chair, in a large cluster.
4 The chair was **contained/suspended** under the balloons by ropes.
5 Arm rests, **contained/located** beside the pilot, at each side, helped to hold him in place.
6 The landing gear, **inserting/projecting** below the seat, consisted, simply, of the chair legs.
7 The pilot was **positioned/projected** underneath the balloons, so his weight was low down.

d **Which two other words have the same meaning as *positioned*?**

contained	fastened	inserted	located	projected	situated	suspended

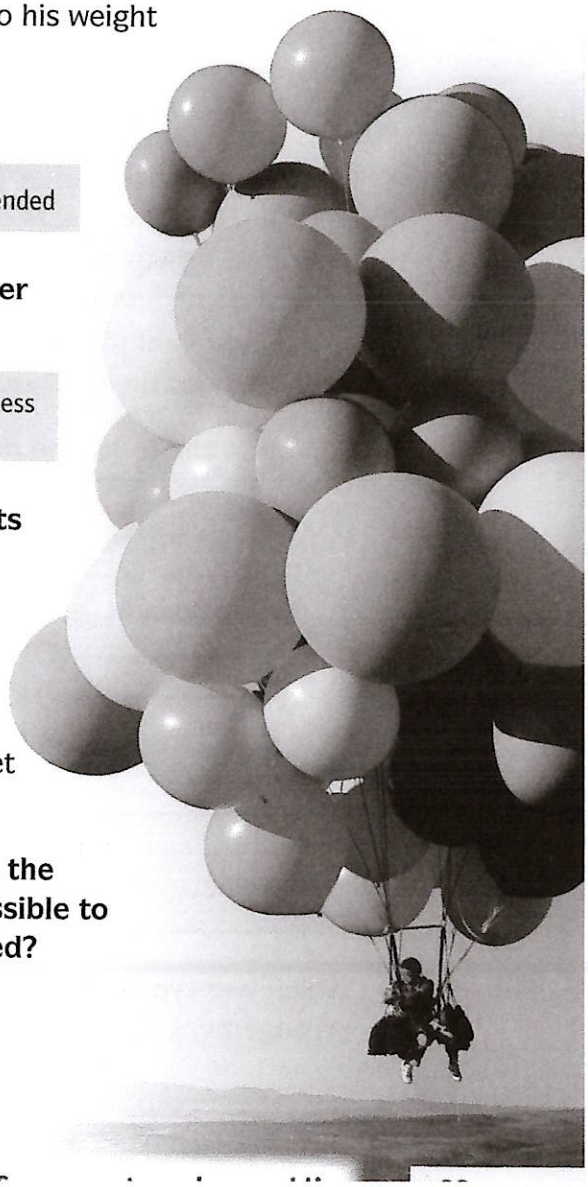
a **In pairs, look at the photo and describe how you think the cluster balloon is assembled from the following components.**

bags	balloons	helium	nylon ropes	nylon straps	paragliding harness
plastic cable	sand/water ballast	ties	tape		

b ▶3.9 **Eva and Lenny, two engineers working for an extreme sports equipment manufacturer, are discussing cluster ballooning. Listen to the conversation and summarise what they say about the following issues.**

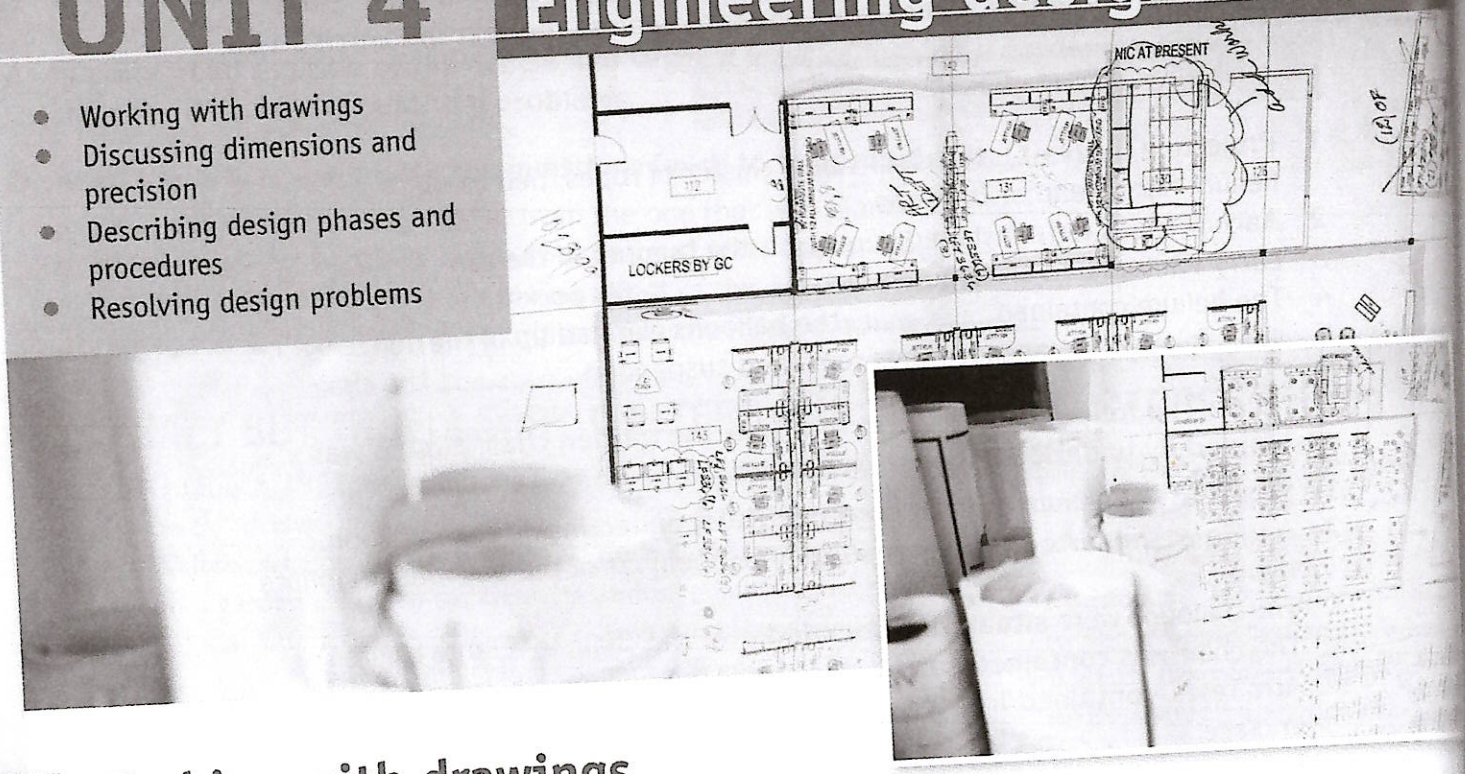
1 assembly time
2 how plastic cable ties are used
3 a tree structure
4 how water bags are used
5 the advantage of tying each individual balloon
6 the problem of using a net to contain the balloons

c **In pairs, discuss ways of overcoming the problems mentioned in the conversation. How could cluster ballooning be made more accessible to a mass market? What other equipment/assemblies could be used?**



UNIT 4 Engineering design

- Working with drawings
- Discussing dimensions and precision
- Describing design phases and procedures
- Resolving design problems



Working with drawings

1 **In pairs, discuss the different types of design information needed on a complex engineering project, such as the construction of a large cruise ship. How many different drawings do you think might be produced for such a project? How would they be organised and categorised?**

2 a ▶4.1 **Joe, a technician at a shipyard, is talking to Linda, one of his engineering colleagues in the design office. He is asking about some information which he can't find on any of the drawings. Listen to the conversation and answer the following questions.**

1 What area of the ship are they discussing?
2 What does the technician need to know?

b Complete the following definitions using the types of drawing in the box.

cross-section elevation exploded view note ~~plan~~ schematic specification

1 A plan gives a view of the whole deck, from above.
2 An _____ gives a view of all the panels, from the front.
3 An _____ gives a deconstructed view of how the panels are fixed together.
4 A _____ gives a cutaway view of the joint between two panels.
5 A _____ gives a simplified representation of a network of air ducts.
6 A _____ gives a brief description or a reference to another related drawing.
7 A _____ gives detailed written technical descriptions of the panels.

c Which two types of drawing in Exercise 2b are examples of general arrangement drawings, and which two are examples of detail drawings?

d **Read the following technical questions that came up during the shipbuilding project and decide which type of drawing is required to answer each question.**

1 How many panels are there altogether on this wall? _____
2 What profile are these hollow beams: rectangular or circular? _____
3 What are the positions of all the floodlights around the deck perimeter? _____
4 How many branches come off the main sprinkler supply pipe? _____
5 How do all the internal components of the fan unit fit together? _____

a **What is meant by *scale* on a drawing? In pairs, explain how a scale rule, like the one shown in the picture, is used.**

b ▶4.2 **After receiving the drawings for the panels, Joe is now discussing some details with Pavel, a colleague. Listen to the conversation and answer the following questions.**

1 What piece of information is not shown on the drawing?
2 What *golden rule* is mentioned?

c **Complete the following extracts from the conversation and explain what is meant by each one.**

1 *Is this drawing _____ scale?*
2 *It's one _____ five.*
3 *... you shouldn't scale _____ drawings ...*
4 *... it's actual size, on a _____-scale drawing ...*

You are engineers on a project to design the metal handrail that will run around the perimeter of the top, outdoor deck of a large cruise ship. In pairs, discuss what drawings you will need to produce for manufacturing and installation with regard to the following issues:

- the types of view that will be required and what each one will show
- the approximate scale of different drawings and views
- what written information you will need to provide in the specification.

You are going to provide design information to enable a production team to manufacture a product or appliance you know well. Make a list of some of the drawings that will be needed, noting what each one will show.

Discussing dimensions and precision

6 a In pairs, discuss what is meant by *precision* and *accuracy*.

b Read the technical advice web page and answer the following questions.

1 How is a superflat floor different from an ordinary concrete floor?
2 What accuracy can be achieved with ordinary slabs, and with superflat slabs?
3 What problem is described in high bay warehouses?

Superflat Floors: FAQ

What is a superflat floor?

Compacting and finishing the surface of wet concrete is an inherently imprecise process. For an ordinary concrete slab to be laid within tolerance, engineers can only realistically expect the surface to be finished to plus or minus 5mm. By contrast, superflat concrete floors are finished to meet extremely close tolerances, being accurate to within 1mm across their upper surface.

Where are superflat floors used?

Floor surfaces with extremely tight tolerances are frequently specified in warehouses where Automated Guided Vehicles operate. Uneven floors are especially problematic in high bay warehouses, which use automated forklifts with a vertical reach of 30 metres or more. At such a height, slight variations in floor level are amplified in the form of vertical tilt, causing inaccurate manoeuvring at high level. If these variations are outside tolerance they can lead to collisions with racking elements, or cause items to be dropped from pallets.

c In pairs, discuss what is meant by *tolerance* in the context of dimensions and precision.

d Complete the following expressions from the web page which are used to describe tolerances.

1 _____ tolerance (inside the limits of a given tolerance)
2 _____ or _____ 5mm (+/– 5mm)
3 _____ tolerance (close tolerance)
4 _____ tolerance (not inside the limits of tolerance)

e Complete the following sentences using the expressions in Exercise 6d.

1 The frame's too big for the opening. The opening's the right size, so the frame must be _____.
2 The total tolerance is 1mm. The permissible variation either side of the ideal is _____.
3 The engineer specified +/– 5mm for the slab finish, and we got it to +/– 2mm. So it's well _____.
4 You can't finish concrete to +/– 0.1mm. There's no way you can work to such a _____.

f In some situations, engineers describe tolerances using *plus or minus*, for example *+/– 1mm*, and in other situations as *within*, for example *within 1mm*. In pairs, discuss the difference in meaning between these two descriptions, giving examples of situations where each description might be used.

a ▶4.3 **Mei, a structural engineer, is talking to Lewis, a project manager, about the floor specification for a manufacturing plant that is currently at design stage. Listen to the conversation and answer the following questions.**

1 What has the client requested with regard to the floor slab?
2 What are free movement floors and defined movement floors?
3 What issue does the engineer discuss regarding quality?
4 What option is discussed involving grinding?
5 What can be done to the reinforcement to permit grinding?

b **Complete the following table using the words in the text in Exercise 6b and audioscript 4.3 on page 89.**

	Name of dimension	Large dimension	Small dimension
1	What's the _____?	Is it _____?	Is it short?
2	What's the width?	Is it _____?	Is it narrow?
3	What's the _____?	Is it high?	Is it low?
4	What's the thickness?	Is it _____?	Is it thin?
5	What's the _____?	Is it deep?	Is it shallow?

c **Mei has done a revised drawing for the floor slab. Read the extract from her email about the new design and complete the message using the correct form of the words in Exercise 7b.**

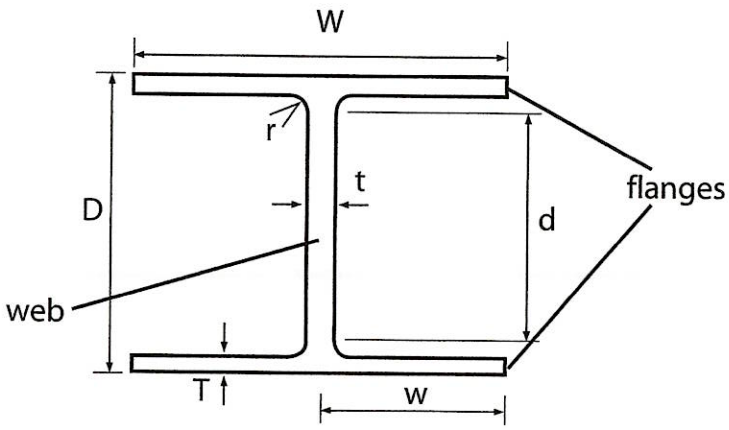
To: Lewis Rosas
Subject: Revised floor slab drawing

Please find attached a revised drawing for the floor slab, now reconfigured for defined movement. In order to accommodate guided vehicles 1 080mm (1) ___wide___ (as specified by the client) we propose a standard (2) _____ of 1 280mm for each superflat lane. At 14.5m, the (3) _____ of the longest lane on the network is within the maximum slab run that can be cast in a single concrete pour, thus avoiding construction joints on straight runs. On curved sections, a standard 8.5m turning radius is used, as per the guided vehicle manufacturer's recommendations.

In order to allow for the eventuality of future grinding, we have located the top layer of reinforcement 10mm deeper below the slab surface. This additional (4) _____ has not, however, been added to the overall slab (5) _____, which remains 275mm. The reinforcing bars also remain in 12mm diameter. As a result, the levels of wall-mounted process installations – many of which need to be fixed at a precise (6) _____ above finished floor level – are unaffected.

d **Which two words in the email relate to circles? What aspects of a circle do they describe?**

The manufacturing plant in Exercise 7 will be built from a steel frame. The vertical elements of the frame will be Universal Columns (UCs). Look at the section of a UC. In pairs, describe the different dimensions that define a UC profile by explaining what the letters on the section refer to.



Describing design phases and procedures

9 **In pairs, discuss what is meant by a *design process*. In engineering, what are the stages in the development of designs?**

10 a **The following extracts from emails relate to a project to build an indoor ski complex in Australia, using artificial snow. The messages were circulated by an engineer to members of the design team, and to a specialist contractor. Read the emails and, in pairs, answer the following questions. Note that the emails are not in the correct order.**

1 What are all the emails about?
2 What different types of documents are mentioned?

a

We now have a full set of working drawings for the main ski lift (attached). These incorporate some amendments requested by the client, which have now been approved. Hard copies have been forwarded to the relevant contractors' premises, for fabrication.

b

I attach a summary of our meeting with the client last Tuesday. It outlines ideas expressed by the client's marketing team, and describes what an experience at the ski complex should be like, from a visitor's point of view. We'll be going through these notes at the project kick-off meeting next Thursday, to clarify the design brief, so please formulate any queries before then.

c

Please find attached a full set of preliminary drawings, as submitted to the client for approval / comments. These are for information only at this stage.

d

Attached are a few rough sketches setting out the overall layout of the ski complex. At this point, these are initial ideas based on the client's suggestions and the approximate dimensions specified in the design brief. I look forward to any feedback by the end of this week.

e

Please note that dwg 18A is currently being revised, to resolve problems encountered during assembly of the ski lift. Revision B will be circulated next week. Until the amended drawing is issued, please treat dwg 18A as superseded. If you require specific details urgently, please contact me, and I will arrange for a suitable sketch to be issued.

b **Put the emails in the correct sequence.**

1 _____ 2 _____ 3 _____ 4 _____ 5 _____

c **Complete the following definitions using the types of drawing in the box.**

design brief preliminary drawing sketch working drawing

1 A _____ is a rough drawing of initial ideas, also used when production problems require engineers to amend design details and issue them to the workforce immediately.
2 A _____ is a written summary intended to specify design objectives.
3 A _____ is an approved drawing used for manufacturing or installation. There is often a need to revise these drawings to resolve production problems. In this case, amended versions are issued to supercede the previous ones.
4 A _____ is a detailed drawing that colleagues and consultants are invited to approve if they accept them, or comment on if they wish to request any changes.

d **Find synonyms for the following words in the definitions in Exercise 10c.**

1 accept / approve
2 amend / _____
3 approximate / _____
4 circulate / _____
5 give feedback / _____
6 replace / update / _____
7 state / _____
8 solve / _____

e **In pairs, suggest what needs to be done next in each of the following situations.**

1 They've found a problem with drawing 63 on site. The detail we've specified doesn't work.
2 I've done a preliminary design for the duct layout, but the client hasn't seen it yet.
3 I've got a feeling the drawing they have on site isn't the latest one.
4 We've just revised drawing 14. The changes are going to affect three different contractors.
5 This is the client's written design brief. How shall we kick off the design work?

a **Leo is the ski complex project manager. With design work about to begin, he is meeting senior engineers from the design teams to discuss design coordination. In pairs, explain the items on the meeting agenda and suggest what kinds of issue might be discussed.**

Australian Ski complex – Design Coordination Meeting Agenda
Tuesday 8th May
Conference room 9.30am – 11.00am
To: RN, LG, SB, CW, SH

Item

a Design interface (mechanical, electrical)
b Design and information flow procedure (structural, mechanical, electrical)
c Inter-team communication – formal and informal

b ▶4.4 **Listen to three extracts from the meeting and match each extract (1–3) to an agenda item (a–c).**

1 _____ 2 _____ 3 _____

c ▶4.4 **Listen again and make notes about the problems discussed in the meeting. In pairs, discuss some possible solutions to the problems.**

d ▶4.5 **Listen to Leo summarising the solutions that have been agreed in the meeting. What has been decided regarding the following points?**

1 The decision that the senior engineer in each team must make, regarding drawings
2 The circulation procedure that will be used for each drawing
3 The role of the M&E coordinator in relation to the senior engineers and the project manager
4 The arrangement that will make informal communication easier

e **In pairs, discuss how the design procedures discussed in the meeting will work in the following situations.**

1 Issuing the first draft of a specialised hydraulic hose drawing for the ski lift
2 Designing an electrical supply system for some water-cooling equipment
3 Revising the connection details between some ski-lift machinery and its concrete foundation

Resolving design problems

12 **In pairs, discuss problems that can arise when different drawings that make up a design are not properly coordinated.**

13 a **The following records are from the indoor ski complex project. They show correspondence between the design team and construction team. Read through the texts quickly and answer the following questions.**

1 What is the general subject of the correspondence?
2 What is meant by *query* and *instruction*?
3 Some queries refer to earlier conversations. Suggest why these have been followed up in writing.
4 What is meant by *dwg* and *dims*?

CONTRACTOR'S QUERY No. 867	ENGINEER'S INSTRUCTION
Following our telephone conversation today, we note that there is a discrepancy between dwgs 76E and 78E, which indicate conflicting dimensions for the width of the roof opening. Please clarify which dimension is correct.	We confirm the correct dimension is on dwg 76E. Please disregard the dims on dwg 78E.
CONTRACTOR'S QUERY No. 868	**ENGINEER'S INSTRUCTION**
As discussed this morning on site, we confirm there is a clash between the proposed cable tray (dwg E56) and air-conditioning ductwork (now installed as per dwg M118) in the ceiling void at Grid D14. Please advise on an alternative cable route.	Please work to attached sketch S33. Revision of dwg E56 to follow.
CONTRACTOR'S QUERY No. 869	**ENGINEER'S INSTRUCTION**
A note on dwg 11A specifies black bolts at the base of the ski lift cable support. This contradicts the specification, which states that all joints to comprise High Strength Friction Grip bolts. We propose using HSFG fixings at this location.	Please provide further details of the HSFG bolts you are proposing.
CONTRACTOR'S QUERY No. 870	**ENGINEER'S INSTRUCTION**
Further to Query 869, the proposed HSFG bolts are as per those specified for all other bolted joints on the ski lift supports. Our intention is to use a single bolt spec to facilitate assembly.	Approved.

b **Read the correspondence in detail. Write the query numbers in Exercise 13a next to the descriptions (1–5). You will need to refer to some queries more than once.**

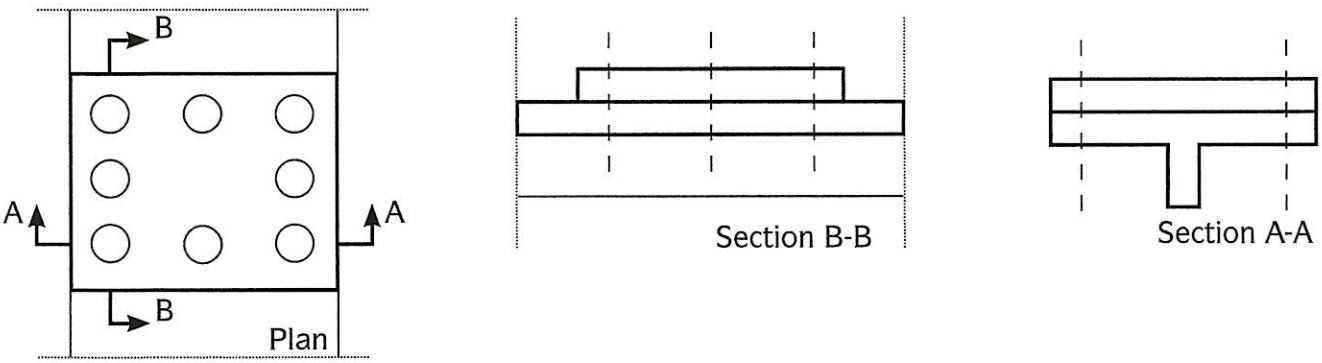
1 An installation that won't fit, as components are in each other's way 868
2 A response from the engineer asking for more information _____
3 Queries that suggest a solution, which will require the engineer's approval _____ _____
4 Requests to the engineer to instruct the contractor or make something clear. _____ _____
5 Separate documents referring to details that don't correspond with each other _____ _____ _____

c Complete the following pairs of sentences using the verbs in the box.

advise clarify clash propose request

1 The components are in each other's way. = The components _____ .
2 Please ask for more information. = Please _____ more information.
3 Can I suggest a solution to the problem? = Can I _____ a solution?
4 Please instruct the supplier to send the parts to this address. = Please _____ the supplier.
5 Any conflicting details must be queried. = You must _____ any conflicting details.

a In pairs, look at the following plan and sections from a drawing on the ski complex project, showing steelwork details on part of a ski lift. Examine how the rectangular plate is bolted to the T profile below it. Can you find the discrepancy between the details, and the clash preventing the connection from being assembled?



b Chen, a technician, is explaining the problem in Exercise 14a to Ron, an engineer. Complete the conversation using the words in the box.

alternative as per clarify clash confirm contradicts ~~discrepancy~~ propose

Chen: *There's a* (1) discrepancy *between these details that you might be able to* (2) _____ *straight away. On the plan of this plate, it shows eight bolts. But on section A, here, there are no bolts shown in the middle. So there would only be six, which obviously* (3) _____ *the plan. But as you can see, this plate's going to be bolted to a T profile. So we couldn't put a row of bolts down the middle, because they'd* (4) _____ *with the flange running along the middle of the T. So I'd* (5) _____ *just going for two rows of bolts. The* (6) _____ *would be to redesign the T section, which would obviously be a bigger job.*

Ron: *Yes. Let's go for two rows of bolts,* (7) _____ *the sections.*

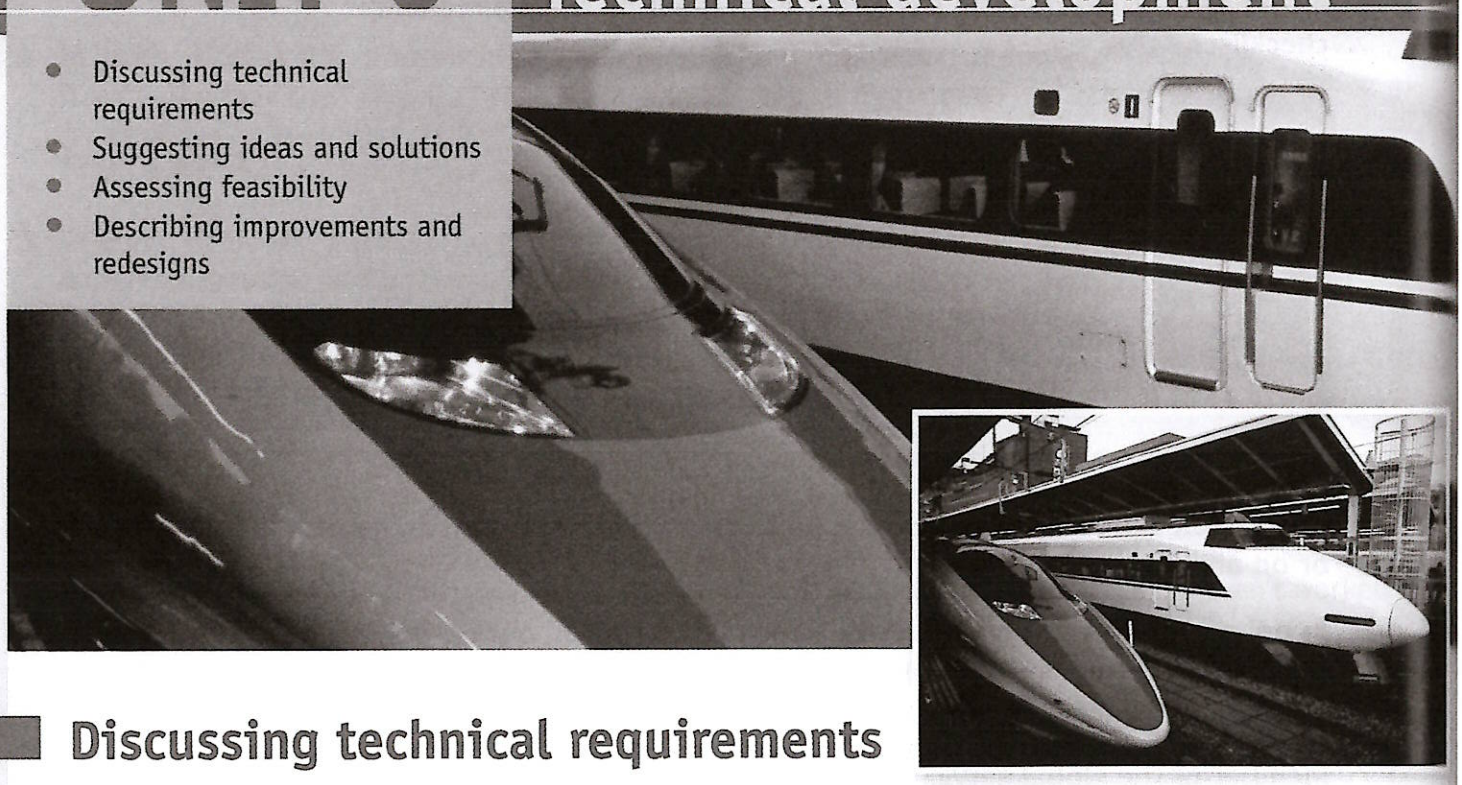
Chen: *OK, fine. Will you send an email to* (8) _____ *that?*

c ▶4.6 Listen to the conversation and check your answers to Exercise 14b. How does the explanation compare with your description of the problem?

d Write an email from Ron to Chen, confirming the revision agreed in the discussion above.

UNIT 6 Technical development

- Discussing technical requirements
- Suggesting ideas and solutions
- Assessing feasibility
- Describing improvements and redesigns



Discussing technical requirements

1 **What is *needs analysis*? In pairs, discuss why the following factors are important in needs analysis, giving examples of products and installations.**

budget capacity dimensions layout looks performance regulations timescale

2 a ▶6.1 **Claudia, an engineer, is asking Kevin and Dave, the managers of a fun park, about their requirements for a proposed space module simulator called *Mars Lander*. Listen to the conversation and note the three main areas Claudia asks about.**

1 _____ 2 _____ 3 _____

b ▶6.1 **How do Claudia and Kevin focus on specific subjects? Complete the following phrases from the conversation using the words in the box. Listen again and check your answers.**

concerned regard regarding regards terms

1 *... with* _____ *to the capacity, ...*
2 *... in* _____ *of the number of people ...*
3 *... as far as size is* _____ .
4 *... And as* _____ *the graphics ...*
5 *...* _____ *the schedule ...*

c **Write questions using the following prompts and the phrases in Exercise 2b.**

1 dimensions: what / overall size / module? With regard to the dimensions, what is the overall size of the module?
2 materials: what / bodywork / made of?
3 schedule: when / work start?
4 power: what / maximum output / need / be?
5 heat resistance: what sort / temperature / paint / need / withstand?
6 tolerance: what level / precision / you want us / work to?

a ▶6.2 **Claudia goes on to ask about the physical effects the simulator needs to produce. Listen to the conversation and make notes on the following points.**

1 Possible variation in simulator movement _____
2 Extent of physical effects required _____
3 Best way to assess physical effects _____

b ▶6.2 **Listen again and explain what is meant by the words and phrases in bold.**

1 *... **to what extent** do you want the experience to be physical?*
2 ***The degree to which** it moves can be varied ...*
3 *... it's obviously difficult to **quantify** something like this ...*
4 *The only way to **determine** what's right is to actually sit in a simulator ...*
5 *... you can **assess** the possibilities.*

c **Following the meeting, Claudia writes an email to update Rod, an engineering colleague. Read the extract and choose a word or phrase from Exercise 3b that means the same as the words in bold. Sometimes more than one answer is possible.**

To: Rod Nelson
Subject: Mars Lander

In order to (1) **find out about** the simulator's dynamic capabilities, we looked at the types of effect the simulator should produce, and (2) **the amount** these physical effects should be felt by passengers. Specifically, the following issues were discussed:

- (3) **How severely** should the module generate vibration, to simulate engine thrust?
- How much buffeting should be simulated? That is, (4) **how severely** the module generates jolting, due to supposed atmospheric turbulence.
- (5) **How much** will passengers be exposed to constant linear G-force, to simulate deceleration?

In order to (6) **work out** the magnitude of the above parameters, it was decided that the prototype will be equipped with variable controls. This will enable the client to (7) **evaluate** different levels of severity through trials inside the simulator.

1 assess
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____

You are consulting engineers preparing to work with a space agency to design an unmanned landing module. The module, which will carry scientific equipment, is intended to detach from a space ship orbiting Mars and land on the planet. At this stage, this is all you know about the project. In pairs, prepare a list of the main questions you will need to ask at the needs analysis meeting using the following ideas.

- type of scientific equipment
- size/weight of equipment
- solidity/fragility of equipment
- surface conditions at landing site

Suggesting ideas and solutions

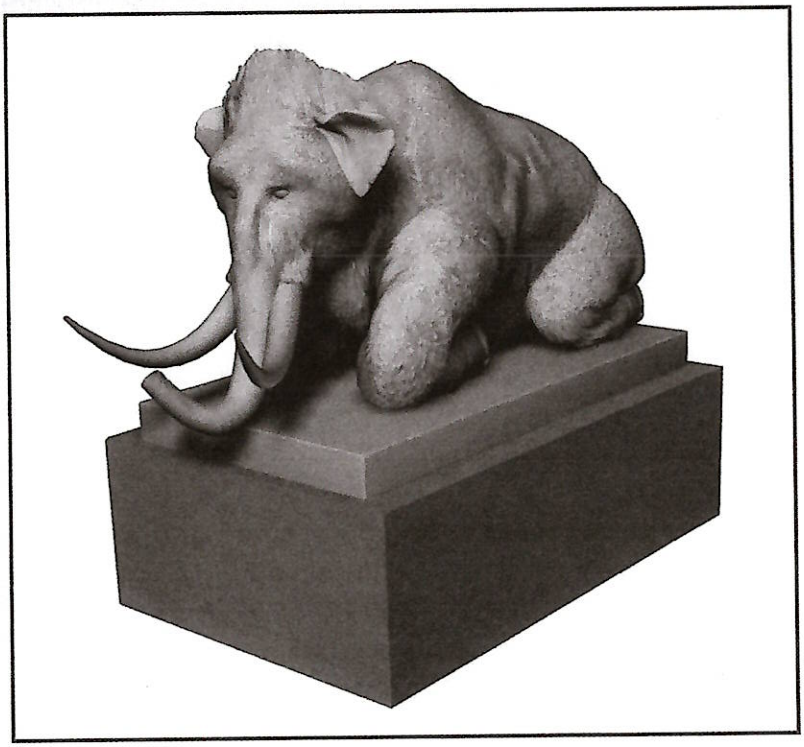
5 **In pairs, discuss the following questions about creative thinking.**

- What are the most effective ways of coming up with ideas and finding ingenious solutions to technical problems?
- What do you think of brainstorming – generating lots of ideas randomly in a group session, without analysis initially, then subjecting each idea to analysis and criticism as a second phase?
- What do you think of evaluating ideas progressively – continually subjecting them to analysis and criticism?
- When creative thinking is required to solve problems, what are the pros and cons of working individually, in small groups, or in large groups?

6 a **Read the newspaper article and answer the following questions.**

1 How is the statue being made, and what is it being made from?
2 What is Rick Gilliam's role?
3 What will the statue be placed on in its final position in front of the museum?
4 What technical problem did they have to solve?

MAMMOTH PROBLEM BAFFLES ENGINEERS, SOLVED BY CAVEMEN



The new statue outside the Museum of Natural History has been a mammoth project, literally. The soon-to-be-completed sculpture portrays a life-sized woolly mammoth, carved from a single block of sandstone. Initially, one aspect of the project had engineers baffled. Rick Gilliam, the engineer overseeing the logistics, admitted that he and his colleagues had fried their brains trying to figure out how the 36-tonne monster could be lowered onto the stone plinth that will support it.

'We knew that we could put slings under the base of the statue, and pick it up with a crane,' he explained, and that transporting it from the stonemason's yard on a low-loader wouldn't be a problem. 'The problem is placing it on the flat plinth that supports it. How do you prevent the crane's slings from getting trapped between the base and the plinth, so that they can be withdrawn? We couldn't think of an easy way to do it.' The creative answer eventually came, not from the engineers, but from the stonemasons, who had affectionately been nicknamed the 'cavemen'.

b **Rick is talking to Gabriella, an engineering colleague, about the problem of placing the statue. Before you listen, explain what is meant by the following terms and try to guess what the three possible solutions are.**

bar drill friction a grab (on the end of a crane jib)
horizontal lifting eyes resin vertical

c ▶6.3 **Listen to the conversation and summarise the ideas. How do their ideas compare with yours? Why is each suggestion rejected?**

d **Complete the following suggestions from the conversation using the words in the box.**

about alternatively another could couldn't don't ~~not~~

1 *Why* ___not___ *come up with a way of hooking onto the side of the statue?*
2 *Well,* _____ *we drill into it, horizontally ...?*
3 *We* _____ *fill all the holes, couldn't we?*
4 *Or,* _____ *, we could make sure the holes were out of sight.*
5 *What* _____ *drilling into the top, vertically?*
6 *I suppose* _____ *option would be to use some sort of grab, on the end of the crane jib.*
7 *Why* _____ *we ask them?*

e **You are engineers working on the mammoth statue project, with the following technical requirements. In pairs, discuss possible solutions to the problem of placing the statue on the plinth using the phrases in the box.**

Alternatively Another option would be ... Couldn't we ... We could ...
What about ... ? Why don't we ... ? Why not ... ?

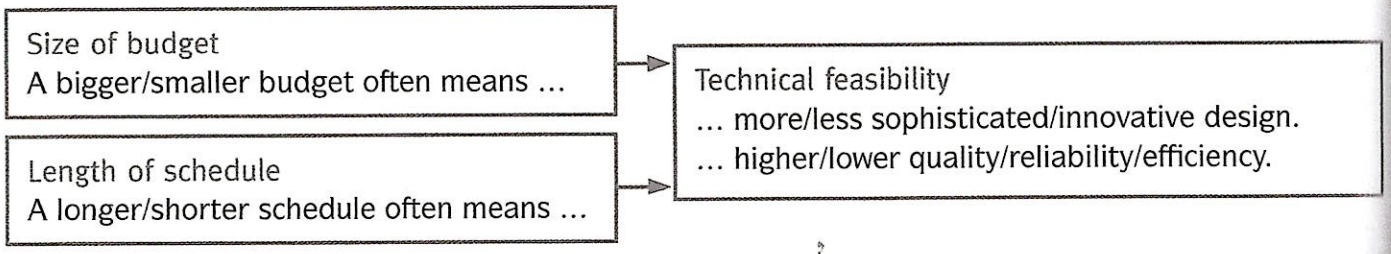
- No holes, slots or grooves may be cut in the statue. All of its surfaces must remain intact.
- No spacers may be left between the underside of the statue's flat base and the flat upper surface of the plinth. The two surfaces must be left in direct contact with each other.
- The statue must not be subjected to shocks. Sudden drops, even of a few millimetres, are out of the question, given the fragility of the sculpture, especially at its corners and edges, which can be damaged easily.
- Any accessory equipment may be used, within the limits of technical possibility and reasonable cost.

f **The stonemasons suggested a solution to the statue problem. Read their idea on page 99 and compare it with your solution. What external factors could cause some problems with their idea? How could these be solved?**

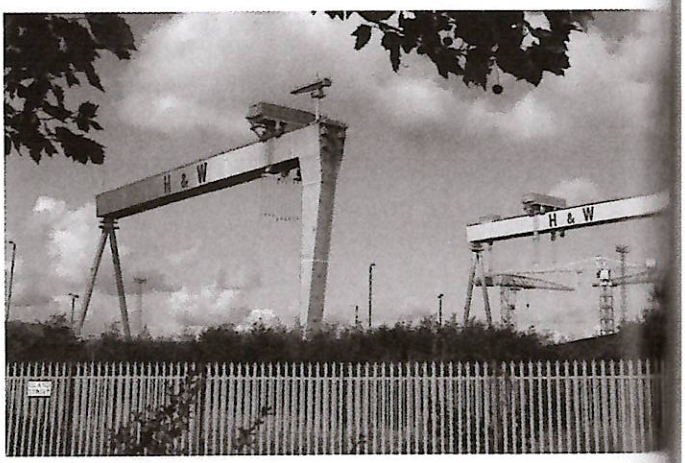
Assessing feasibility

8 a **In pairs, dscuss what is meant by *feasibility*.**

b **Look at the flow chart and, in pairs, discuss how budgets and schedules affect the technical feasibility of design, development and manufacturing solutions.**



9 a ▶6.4 **Viktor, an engineer from a German company that makes and installs industrial gantry cranes, is phoning Rajesh, the construction manager of a manufacturing plant currently being built near New Delhi, India. They are discussing the gantry crane due to be installed at the plant. Listen to the conversation and answer the following questions.**



1 Why are holes needed in the concrete walls?
2 What are *core drilled holes* and what are *preformed holes*?
3 In this context, what is meant by *play*?
4 What impact will the lack of play around the bolts have (on the construction)?
5 Apart from technical questions, what two issues will determine the most feasible way of forming the holes?

b **In pairs, compare core drilling and preforming with regard to the following feasibility issues. Which technique is most suitable for the situation in Exercise 9a?**

cost precision timescale

c ▶6.5 **Viktor and Rajesh are assessing the most suitable method of forming the holes in the walls. Listen to the conversation and compare their answers with yours.**

d ▶6.5 **Listen again and answer the following questions.**

1 What are the advantages of using preformed holes in terms of cost and timescale?
2 What's the main disadvantage of core drilling the holes?
3 What tolerance can easily be achieved with preformed holes?
4 What tolerance is required for the holes on this project?
5 What's the risk of using preformed holes?
6 What key feasibility issue does Rajesh identify?

e Complete the following expressions from the conversation using the words in the box and indicate the degree of feasibility each expression describes.

borderline	~~dead~~	forever	leg	painstaking	peanuts	perfectly	stretching	tall	way

		☺	😐	☹
1	*it'll be* dead *easy*	☑	☐	☐
2	*it'll cost* _____	☐	☐	☐
3	*it'll be quite a* _____ *job*	☐	☐	☐
4	*it's* _____ *feasible*	☐	☐	☐
5	*it's achievable, but it's* _____ *it*	☐	☐	☐
6	*there's no* _____ *you can do it*	☐	☐	☐
7	*it's* _____	☐	☐	☐
8	*it's a* _____ *order*	☐	☐	☐
9	*it'll take* _____	☐	☐	☐
10	*it'll cost an arm and a* _____	☐	☐	☐

perfectly feasible	☺
feasible but challenging	😐
completely unfeasible	☹

f How feasible do you thing the following suggestions are? Label them ☺ 😐 or ☹ according to the key in Exercise 9e.

1 The machine parts are tricky to paint with brushes, or to spray. Why don't we dip them in paint?
2 The steel bar is 100mm in diameter. Couldn't it be cut by hand, using a hacksaw?
3 Silver's a good conductor. Why don't we use it for wiring, instead of copper?
4 Instead of putting lead ballast in the helium balloon basket, why don't we use water containers?
5 They've used the wrong type of fuel in the engine. I'd suggest stripping the whole thing down and cleaning it by hand.
6 They produce 6,000 units per day and normally do a quality check on 1% of them. Couldn't they check every single product?

g In pairs, give an appropriate response to the suggestions in Exercise 9f using the expressions in Exercise 9e.

In pairs, discuss the feasibility of the following solutions to the problem of forming accurately positioned holes through the plant walls in New Delhi. Student A, you are Viktor; Student B, you are Rajesh. Discuss technical issues, cost and timescale, and rank the solutions in order of feasibility.

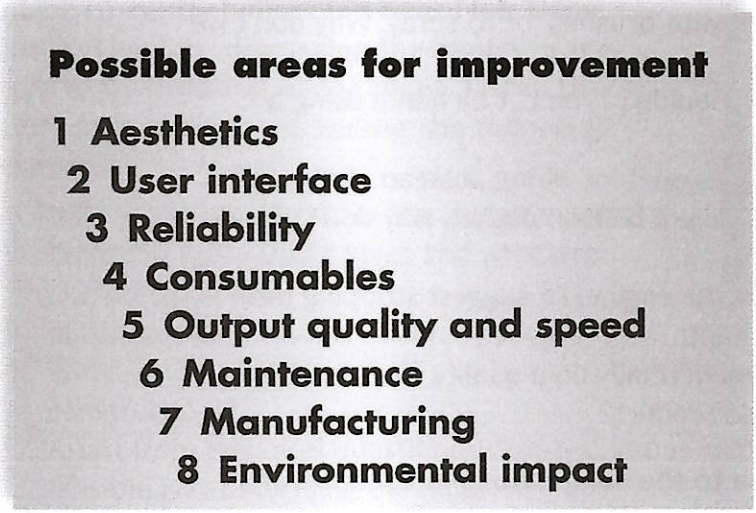
1 Is a diamond drill really needed to go through reinforced concrete? Surely you can drill into concrete with an ordinary hammer-action drill? Wouldn't that reduce the cost?
2 Couldn't they make the preformed holes wider than required, so there's extra tolerance? Then, once the bolts are fixed, the space around them could be filled with cement.
3 Why not drill the holes in the steel beams on site, instead of pre-drilling them? Then they could be positioned to suit the location of the preformed holes in the wall. That way, it wouldn't matter if the holes in the walls were slightly out of position.
4 Instead of bolting through the concrete, what about adding extra steel columns that run down the walls? The beams could then be supported on these, and no holes would be required through the concrete.

Describing improvements and redesigns

11 **Look at the slide from an engineers' training course, *Total Technical Improvement*. In pairs, suggest examples of technical improvements to illustrate each one. Are there other points that could be added to the list?**

12 **a** **Look at the slide from a design meeting at a computer printer manufacturer. In pairs, suggest ways that the following printer factors might be improved in some of the areas on the list.**

cables/connections case ink/toner cartridges paper power software



b ▶6.6 **Marta, a manager at the printer manufacturer, is briefing the design team on key requirements for the redesign of a printer. Listen to the start of the meeting. Which two areas on the slide in Exercise 12a are discussed?**

c ▶6.6 **Listen again and answer the following questions.**

1 Should the layout and components of the new printer differ much from the existing design? Why (not)?
2 How many times has the existing model been improved in the past?
3 What consideration is behind the decision on how different the new software should be?
4 To what extent should the new software system differ from the existing one?

d **Look at the following verbs from the discussion and find three examples where *re-* means *again*. Match the other three verbs to the definitions in the box.**

improve overall improve the details stay (the same)

1 redesign design again
2 reinvent _____
3 refine _____
4 revamp _____
5 rethink _____
6 remain _____

e ▶6.6 **Complete the following expressions from the discussion using the words in the box. Listen and check your answers.**

Achilles	back	drawing board	ground	heel	improvement
leap	quantum	~~reinvent~~	room	scratch	up

1 reinvent *the* wheel
2 *designing the whole thing from the* _____
3 _____ *for* _____
4 *the* _____
5 _____ *to the* _____
6 *make a* _____
7 *designing the system from* _____

f **Match the expressions (1–6) in Exercise 12e to the definitions (a–f).**

a waste time re-creating something that has already been created 1
b the biggest weakness _____
c start again because the first plan failed _____
d make huge progress _____
e design from the beginning _____ / _____
f potential for doing a better job _____

g **Rewrite the following sentences using the correct form of the expressions in Exercise 12e.**

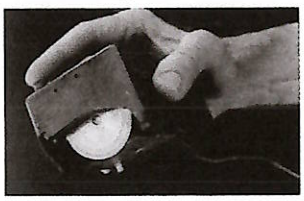
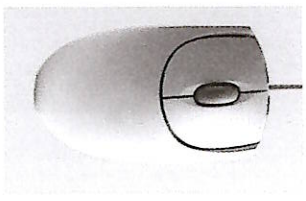
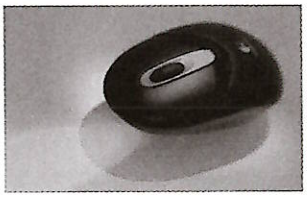
1 Unfortunately, we had to scrap the concept and start again.
We had to go back to the drawing board.
2 This problem is the product's most serious shortcoming.
_____
3 There's no point redesigning what already works perfectly well.
_____
4 It's a totally new design – we started from the very beginning.
_____
5 The new design is so much better – it's a transformation.
_____
6 I think there's definitely a possibility to do better in this area.
_____

a **In pairs, discuss how computer pointing devices have improved since the first mouse was invented. Use the language from this section and the words in the box.**

ball	buttons	first mechanical mouse	optical mouse	optical sensors
refined mechanical mouse	sensitive surface	touchpad	wheel	wireless

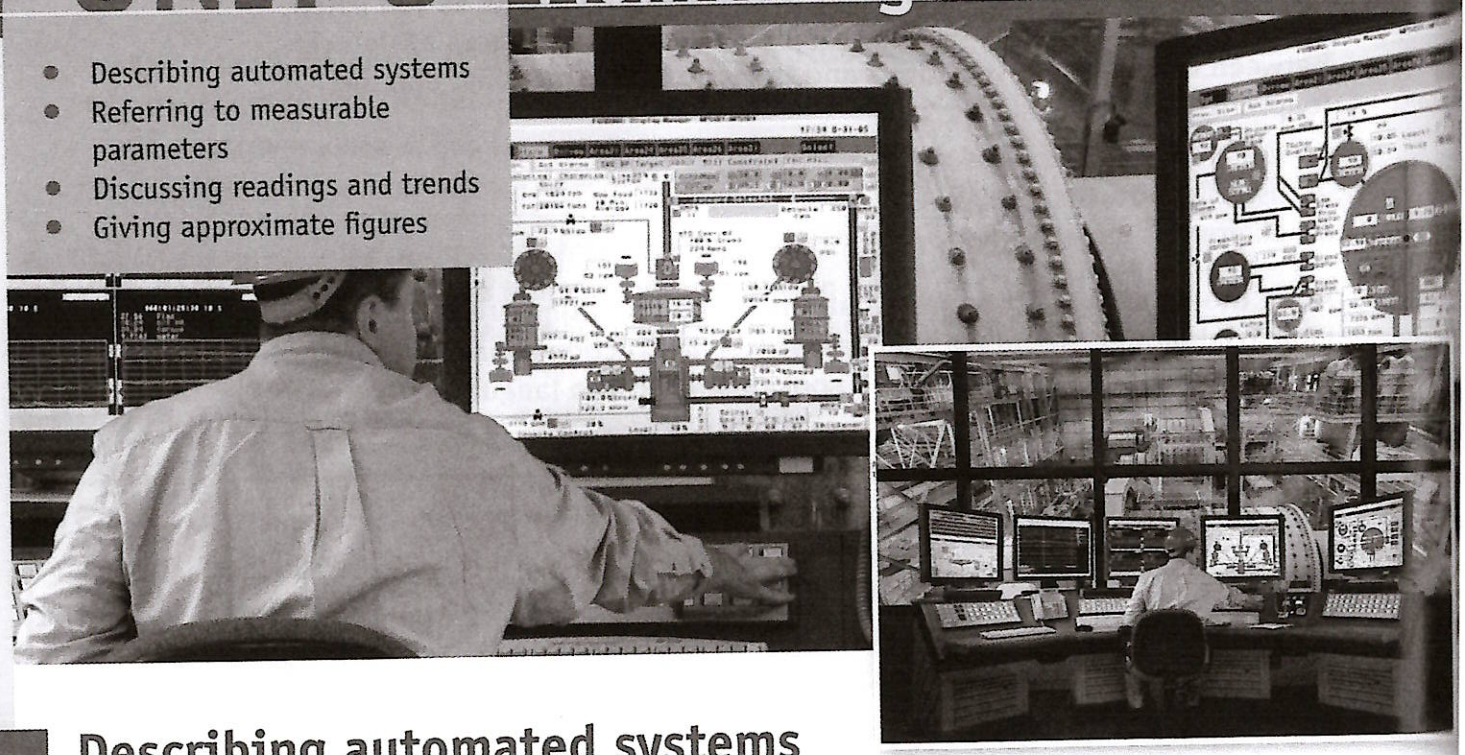
b **You have been asked by a computer hardware manufacturer to think of some functional improvements and technical solutions for pointing devices. In pairs, discuss your ideas.**

c **Present your ideas in Exercise 13b to another pair.**


UNIT 8 Monitoring and control

- Describing automated systems
- Referring to measurable parameters
- Discussing readings and trends
- Giving approximate figures



Describing automated systems

1 **In pairs, discuss the difference between an automated and a manual system. What do you think a Building Management System (BMS) does in intelligent buildings? Suggest some operations that can be monitored and controlled automatically by the BMS in large buildings such as offices.**

2 a ▶8.1 **Roland, a mechanical and electrical services (M&E) engineer, is talking to Saskia, an architect, about the design of a new building. Listen to the conversation and answer the following questions.**

1 What is a key characteristic of the client company?
2 How will this characteristic affect the building design?
3 What do you think is meant by *presence detectors*?
4 What does Roland say about design options and how does he describe option one?

b ▶8.2 **Roland gives some examples of sensors and controls. Listen to the next part of the conversation and tick the points he mentions.**

1 controlling the electric lighting inside the building ☐
2 controlling the amount of solar radiation entering the building ☐
3 controlling the air flowing in and out through the windows of the building ☐
4 controlling the flow of warm and cool air around the interior of the building ☐

c **Match the words in the box to the synonyms (1–5).**

detect	~~detector~~	pick up	reading	regulate	set off	trigger

1 sensor / detector
2 measurement / _____
3 control (adjust) / _____
4 sense / _____ / _____
5 activate / _____ / _____

d **Complete the following extracts from the conversation by underlining the correct words.**

1 *Not just the usual systems that* ***activate/detect*** *the lights …*
2 *We could use presence detectors to* ***pick up/control*** *other systems …*
3 *… a presence detector* ***sets off/senses*** *that everyone's left a meeting room …*
4 *… a temperature sensor picks up a positive* ***detector/reading*** *…*
5 *… the sensor* ***detects/regulates*** *sunlight, and* ***senses/triggers*** *the blinds …*
6 *… those sensors* ***set off/sense*** *a circulation system …*
7 *… we'd use presence detectors and heat sensors to* ***detect/regulate*** *as many systems as possible?*

e **In pairs, describe the following automated systems using the words in Exercise 2d.**

	sensor	parameter	system
1	presence detector	movement	lights
2	smoke detector	smoke	fire alarm
3	thermostat	room temperature	electric convector heater
4	pressure plate	weight of a person	intruder alarm

a ▶8.3 **Roland and Saskia go on to discuss an alternative control system in the building. Listen to the conversation and answer the following questions.**

1 What assumption is the idea based on?
2 What design approach might be taken with regard to controls?
3 What is the advantage of this approach?

b **You are in the M&E design team for the new building project and have received the following email from the project engineer asking for your input. Read the email and, in pairs, discuss what the engineer wants you to do.**

To: Lauren Harvey
Subject: Presence detectors

Could you look into the practicalities of using presence detectors for controlling the lights in different parts of the building? We'll probably have a mixture of detector-controlled systems and manual switches. The question is, which type of control do we want to have in each location? (Please see my list below.) A critical issue will be setting the switch-off delay in different locations, i.e. how long the lights remain on after the last movement is detected. On my last project, we had a lot of complaints from the client about the lights going off while people were still in rooms. So can you think about different timer delays for different locations in the building?

Main locations: open-plan offices, individual offices, meeting rooms, corridors, store rooms

c **Prepare notes for a short talk to brief the project engineer using your ideas from Exercise 3b. Student A, you are an M&E engineer. Brief the project engineer on your ideas. Student B, you are the project engineer. Listen to the briefing and ask questions about specific details. Swap roles and practise again.**

Referring to measurable parameters

4 **In pairs, think of monitoring and control systems that are widely used around the home. Discuss how the following parameters are measured and/or controlled in these common domestic appliances.**

Parameters: temperature pressure time actions/movement
Appliances: boilers heating systems refrigerators washing machines

5 a **Match the sensor or measuring system (1–5) to the industrial applications (a–e).**

1	pressure measurement	a	monitoring the speed of water travelling along a supply pipe
2	temperature measurement	b	measuring the level of heat generated by an exothermic reaction
3	flow measurement	c	monitoring the number of cans moving along a conveyor belt
4	level measurement	d	monitoring the amount of ethanol contained in a storage tank
5	process recorders	e	checking the force exerted by steam inside a vessel

b **In pairs, think of other uses for the kinds of sensor and measuring equipment in Exercise 5a.**

6 a ▶8.4 **Jochem and Katerina, two process engineers at a chemicals plant, are discussing the monitoring and control systems that will be needed for a new production line. Listen to three extracts from their discussion and answer the following questions.**

Extract 1 a What problem is discussed?
b What mechanical safety precaution is proposed?
Extract 2 c What issue is discussed?
d What three parameters related to consumption are important?
e To calculate the parameters, what does consumption need to be continuously measured against?
Extract 3 f What issue is discussed?
g Which two measurements need to be taken?
h What optimum value needs to be determined?

b **Match the words (1–10) from the discussion to the definitions (a–j).**

1	input	a	the best / the most effective/efficient
2	output	b	how often something happens
3	optimum	c	the amount of supplies/fuel used
4	differential	d	the total quantity so far
5	consumption	e	a specified period
6	cumulative	f	a value often expressed with per, for example units per hour
7	rate	g	the exit value, for example at the end of a process
8	cycle	h	the entry value, for example at the start of a process
9	frequency	i	the gap between two values
10	timescale	j	all the steps in a process, from start to finish

c **The following specification was written following the conversation. Complete the text using the words in Exercise 6b.**

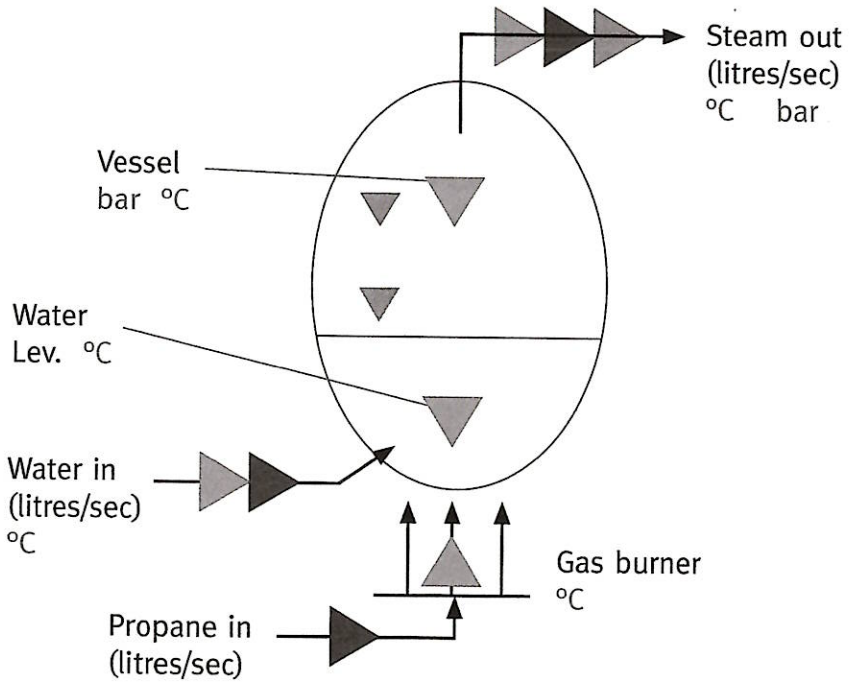
Vessel B1: Sensor and Measuring System Requirements

Two pressure sensors: one located inside the vessel, and a second situated on the pipe running downstream, to enable any pressure (1) differential to be detected.

A flow meter to monitor gas (2) _____ . Data will be recorded as a (3) _____ figure (total usage), and as flow (4) _____ , in litres per second. Note: Software will be configured to log flow against the (5) _____ of a system clock, in order to pinpoint peak flow periods occurring between the start and finish of a given reaction (6) _____ , and to assess the (7) _____ with which they occur.

Two temperature sensors: one at the entry point of the vessel, to measure (8) _____ temperature, and a second at the outlet point to monitor (9) _____ temperature. Note: Precise regulation of the entry temperature will be key to obtaining (10) _____ reaction performance.

a **You and your partner are process engineers working with Jochem and Katerina at the chemical plant. You need to assess the sensors and measuring equipment required for the steam production facility. In pairs, discuss the requirements using the information in the diagram. Make notes of your ideas.**



b **In pairs, discuss what parameters can be determined for the installation of a heating cycle using your ideas from Exercise 7a. You should assume that all the measurements will be recorded against a timescale.**

Discussing readings and trends

8 a **In pairs, discuss the factors that cause mains electricity consumption to vary.**

b ▶8.5 **Helen, an electrical engineer at a power station, is giving a talk to a group of visiting investors. Listen to the talk and note the five factors that influence electricity consumption.**

1 _____ 3 _____ 5 _____
2 _____ 4 _____

c **Complete the following extracts from the talk using the correct form of the words in the box.**

decrease fall increase rise

1 *During periods of very cold or very hot weather, demand* increases *. The* _____ *in demand is obviously due to millions of electric radiators coming on …*
2 *… a key factor which* _____ *or* _____ *demand, is whether or not it's light or dark …*
3 *… on cold, dark, winter evenings, the* _____ *in demand is significant …*
4 *Generally, demand* _____ *during the week, when factories and offices are operational …*
5 *So demand* _____ *at the weekend.*
6 *There can be a sudden* _____ *when people rush to switch kettles on, or heat up snacks in microwaves, and then a sudden* _____ *shortly afterwards.*

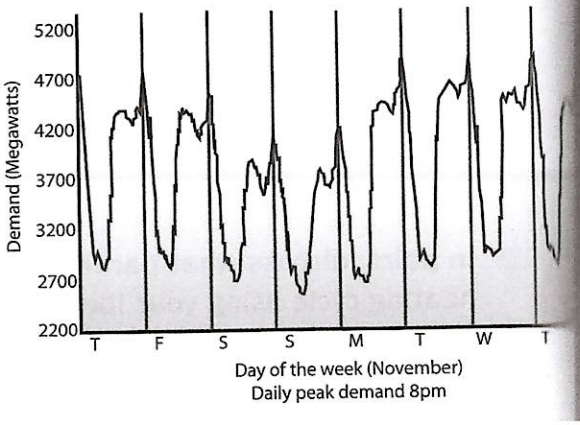
d ▶8.6 **Listen to the next part of Helen's talk and answer the following questions.**

1 Why does the company often have significant spare generating capacity?
2 What ideal situation does Helen describe?
3 Why is this ideal situation difficult to achieve?

e **Match the words (1–8) from the talk to the definitions (a–h).**

1	continuous	a	maximum power requirement at a given time
2	fluctuations	b	amount between an upper and lower limit
3	peaks and troughs	c	without interruption
4	peak demand	d	high points and low points on a graph curve
5	range	e	regular and repetitive
6	band of fluctuation	f	momentary rises followed by a fall
7	blips	g	changes, movements in general
8	continual	h	zone of up-and-down movement

f **Look at the graph showing electricity demand fluctuations over a week in the UK. Find parts or patterns on the graph described by the words in Exercise 8e and analyse the fluctuations. How do they compare with Helen's explanation?**



a **Read the document on energy saving aimed at industrial plant and facility managers. Complete the text using the words in Exercise 8e.**

Dynamic demand control systems can be fitted to electrical appliances that operate on duty cycles, i.e. appliances that start up, run for a time, shut down again, and then remain on standby for a while before repeating the same cycle. Heating and refrigeration units are common examples of power-hungry equipment that operate on this start-run-stop-wait basis.

Dynamic systems exploit the fact that duty cycle appliances do not require (1) continuous power. The purpose of the systems is to help smooth power demand for the benefit of electric utilities. To achieve this, they delay the start-up of the appliances they control during periods of (2) _____ . However, only minor adjustments are made to timing as, generally, the appliances concerned can only be held on standby for short periods as they need to run on a (3) _____ basis. But this still benefits electric utilities as it helps to avoid problematic, momentary (4) _____ on the demand curve.

Dynamic controls work by detecting slight (5) _____ in the frequency of the mains AC supply. Although this varies only within a very narrow (6) _____ , small drops in frequency indicate that power station turbines are working close to full capacity. The dynamic control system can therefore hold the appliance on standby for a short time until mains frequency increases again.

b **Read the text again and answer the following questions.**

1 What is meant by *duty cycle*?
2 What problem is dynamic control designed to avoid?
3 What sensor input do dynamic controls rely on to allow them to function?
4 What does the sensor input in (3) indicate with regard to power stations?
5 To what extent do dynamic systems modify duty cycles?

a **Read the extract from the talk and, in pairs, discuss the following questions.**

... electrical charge is extremely difficult to store in large amounts, you can't just charge up huge batteries. So we use an innovative technique to store up power potential during off-peak periods.

1 Why do you think this is such a major issue for power stations?
2 Can you suggest what innovative technique is used to solve the problem?

b ▶8.7 **Helen goes on to describe the solution to the problem. Listen to the talk and make notes on pumped storage.**

c **Prepare a short talk on the operation of a pumped storage hydroelectric power station for visitors to the power generation company. Use your notes from Exercise 10b and the words in the box. Student A, you are an electrical engineer; Student B, you are a visitor on a tour of the plant. In pairs, give your talk and ask and answer questions. Swap roles and practise again.**

gravity	high level	low level	mountain	pumps	reservoir	turbines

Giving approximate figures

11 a Read the email extract and answer the following questions.

1 Who do you think sent the email? What is their role within the company?
2 What type of review is the company going to undertake?
3 What is the objective of the review?

To: Gerry Klein
Subject: Internal review

Dear colleagues,

As you know, we are preparing to undertake a comprehensive internal review of the company's organisation and facilities. A key area of this review will be to assess how efficiently your engineering expertise is being utilised. I would emphasise that the aim of this assessment is not to question your professional competence. On the contrary, I and the company's new shareholders recognise the high degree of technical expertise within the organisation. Our intention is to work towards optimising this valuable resource by identifying the demands on your time that are largely unproductive (such as administrative tasks) in order to allow your skills to be used more productively.

b The following extract is from a questionnaire used in the review which was sent to staff in the company's design department. Read the questionnaire and match each question (1–3) to points (a–c).

Approximately what percentage of your time do you spend on the types of task below? For each question, the sum of values given for A + B should equal 100%.

1 A Doing technical tasks that use my engineering skills extensively _____ %
B Doing moderately technical tasks that a less qualified colleague could do _____ %

2 A Doing technical tasks that add value (e.g. designing, problem-solving) _____ %
B Doing tasks that do not add value (e.g. administration) _____ %

3 A Doing tasks that are purely technical _____ %
B Doing tasks that relate to technical organization and decision-making _____ %

a The extent of technical role versus management role _____
b The degree of commercial exploitation of technical skills _____
c The degree of application of expertise and experience _____

c ▶8.8 Eleanor and Gerry, two design engineers, are talking about the questionnaire. Listen and write approximate values, to the nearest 10%, for Gerry's answers to the questions.

d Complete the following sentences using the words or phrases in the box. Sometimes more than one answer is possible.

~~ballpark figure~~ off the top of my head nowhere near pretty much roughly somewhere in the region of

1 They asked for a ballpark figure for setting up the new system.
2 I've got the figures in my computer, but I couldn't tell you _____ .
3 The work is _____ finished, there's just the tidying up to do.
4 The actual cost of the stadium was _____ the estimate at £2m over budget.
5 I think it'll take _____ two weeks to complete the report.
6 The development will cost _____ $10m.

e **In pairs, ask and answer the questions from the questionnaire in Exercise 11b using the phrases in Exercise 11d. Note down your partner's answers.**

1 A _____ % B _____ %
2 A _____ % B _____ %
3 A _____ % B _____ %

a ▶8.9 **As part of the company's internal review, an assessment is being made of the hardware and software that make up the firm's Computer Aided Design (CAD) system. Dan, a design engineer, is talking to Beatrice, his manager, about the state of the system. Listen and mark the following statements True (T) or False (F).**

1 Most of the screens are too small.
2 Engineers spend a lot of time working on screen.
3 Large numbers of drawings are printed at their office.

b **Find words and phrases in audioscript 8.9 on page 93 to match the following definitions (1–5).**

1 approximately / _____
2 much more than / _____
3 at least / _____ (two thirds)
4 most / _____
5 almost zero / _____

c **Complete the following replies to express the figures in approximate terms using the words in Exercises 11d and 12b. Sometimes more than one answer is possible.**

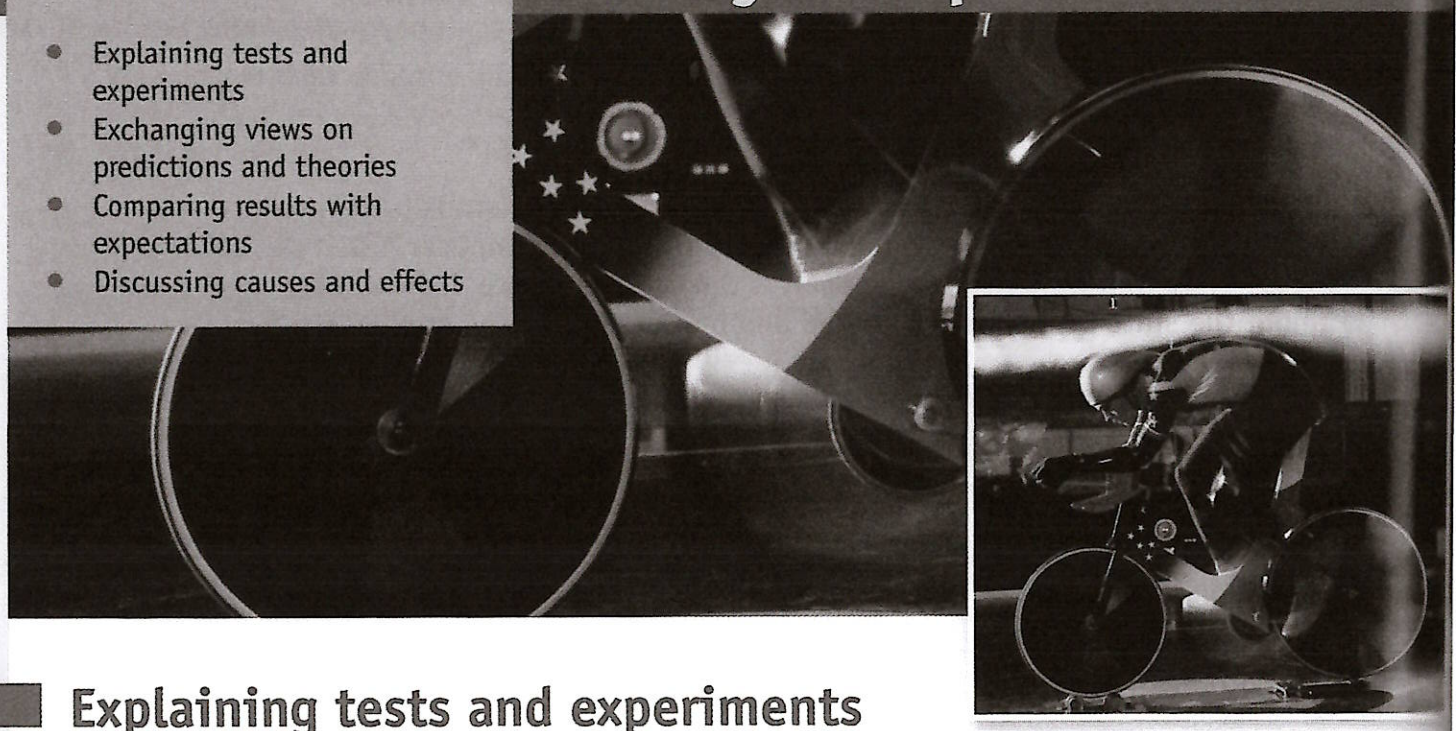
1 How old is this equipment? A good five years old. (at least 5 years)
2 What percentage of the PCs need changing? _____ all of them. (95%)
3 How many of the computers are up to spec? _____ all of them. (70%)
4 How many of the staff use the CAD system? _____ half of them. (55%)
5 How much would the new printers cost? _____ $2,000. ($3,120)
6 How much does an adapter like this cost? _____ . ($2)
7 How long would a full system take to install? _____ 5 days. (4–6 days)
8 Can most of our clients read these files? Yes, _____ of them. (95%)

You are setting up a small company of consulting engineers employing seven members of staff – five engineers and two assistants. You need to rent an office, equip it with a computer network with CAD system and admin software, and buy other basic office equipment. In pairs, discuss some ballpark figures relating to the following questions.

- What computer equipment will be required and how much will it cost to buy?
- What other items of furniture/equipment will be needed, and how much will this cost?
- How much floor space will be required in the open-plan office?
- How long will it take to set up the office – install the furniture and equipment?

UNIT 9 Theory and practice

- Explaining tests and experiments
- Exchanging views on predictions and theories
- Comparing results with expectations
- Discussing causes and effects



Explaining tests and experiments

1 **In pairs, discuss the following tests and experiments and their main advantages and disadvantages.**

1 computer models and simulations 2 reduced-scale testing 3 full-scale testing

2 a **In pairs, suggest how the following development tools could be used for aerodynamic testing.**

- Computational Fluid Dynamics (CFD)
- a wind tunnel equipped with a rolling road
- field testing

b ▶9.1 **An international team of researchers are collaborating on the design of an experimental energy-efficient vehicle. They are discussing the tools available for developing the vehicle's aerodynamic design. Listen to the conversation and answer the following questions.**

1 What options are available for wind tunnel testing in terms of scale?
2 Why are rolling roads useful in wind tunnels when testing vehicles?
3 What issue will determine whether or not a rolling road is necessary?
4 What point is made about the reliability of CFD and wind tunnel data?
5 What problem is mentioned with regard to outdoor testing?

c ▶9.1 **Listen again and complete the following extracts from the conversation using the words and phrases in the box.**

The acid test	back-to-back testing	in the field	mock-up
trial run	tried-and-tested	validate	~~virtual~~

1 *... the tests would obviously be* virtual *, based on a computer model.*
2 *... go into a wind tunnel, with a scale model, or a full-size* _____ *.*
3 *... it's not just about data gathering. You also have to* _____ *the data.*
4 *The* _____ *only comes when you try out a full-scale prototype in real conditions. We need to make sure that everything is* _____ *outside, with a full-scale* _____ *.*
5 *... with changeable weather, it's not easy to do* _____ *out* _____ *.*

d Match the words and phrases in Exercise 2c to the definitions (a–h).

a a 3D model simulating shape and size, but without internal components
mock-up

b proven to be reliable through real use / trials _____

c outdoors, in a real situation _____

d describes something simulated by software, not physical _____

e a crucial trial to prove whether or not something works _____

f trials to compare two different solutions, in the same conditions _____

g prove theoretical concepts by testing them in reality _____

h a practical test of something new or unknown to discover its effectiveness
_____

e Complete the aerodynamic design development plan of the energy-efficient vehicle using stages (a–e).

a Test model in wind tunnel to validate data from scale tests
b Carry out back-to-back tests in wind tunnel with mock-ups
c Build full-size working prototype
d Select best design, based on data from wind tunnel tests
e Narrow down design options to three, based on computer data

Aerodynamic design development plan

1 Experiment using CFD software
2 _____
3 Produce reduced-scale mock-ups of designs and test in wind tunnel
4 _____
5 Build first full-scale mock-up
6 _____
7 Produce two revised designs to improve on full-scale mock-up
8 _____
9 Select best design, based on data from tests
10 _____
11 Carry out field tests with trial runs outside

You are members of a technological research team similar to the one in Exercise 2b. You have been asked to design a test programme for an experimental system for air-dropping cargo. Read the brief and, in pairs, discuss the types of test required and their sequence.

Design brief

The system allows relatively fragile cargo to be air-dropped from planes into remote locations on the ground. It comprises a parachute, attached to a cylindrical container two metres long with a diameter of 1.5 metres. The container is surrounded by a deformable protective structure.

The aims of testing are to develop the designs of:

a) the parachute

b) the protective structure, in order to minimise the impact to cargo inside the container.

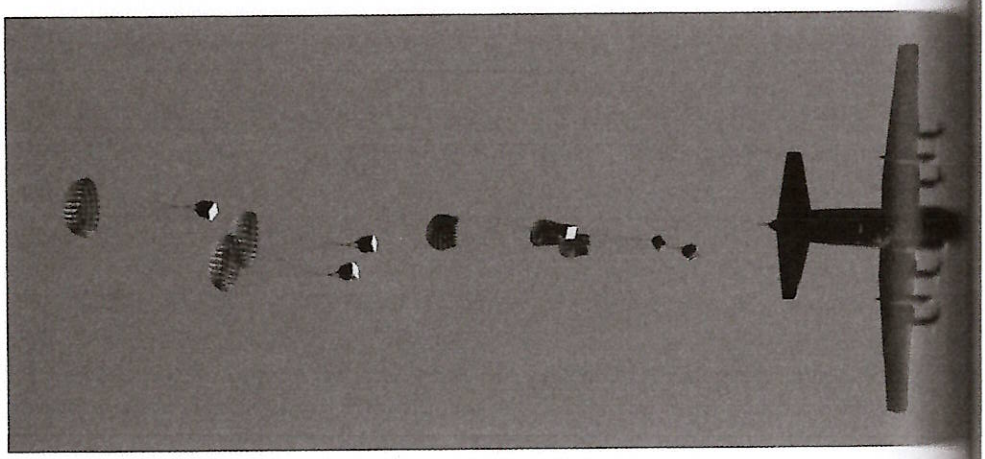
The number of tests must be maximised within a limited budget. As tests involving real drops from aircraft are costly, these must be kept to a minimum.

Exchanging views on predictions and theories

4 a In pairs, answer the following questions.

1 What kinds of cargo is sometimes dropped from aircraft, and why?

2 What are the advantages and disadvantages of air-drops?



b Read the following predictions of how a container air-dropped with parachutes might behave while falling, and on hitting the ground. Complete the predictions by underlining the words you think are correct.

1 The longer the container is in the air, the more its horizontal speed will **decrease/increase**.

2 Compared with a low-altitude drop, the vertical speed of a high-altitude drop will be **lower/higher**.

3 In terms of damage to the container, a high **vertical/horizontal** impact speed is potentially worse.

4 A very low-altitude drop will most likely cause the container to **slide/roll** along the ground.

c ▶9.2 Arnaud and Jenna, two engineers, are talking at the start of an air-drop research project. Which predictions in Exercise 4b do they agree on, and which do they disagree on? How do their ideas compare with yours?

5 a Rephrase the words in brackets to complete the following extracts from the conversation.

1 *So,* _____ (in theory), *the horizontal speed will keep decreasing …*

2 *So,* _____ (assume) *the drop altitude's very low, …*

3 … _____ (sure) *a low vertical speed is the critical factor.*

4 *Because,* _____ (presume), *if the groundspeed's quite high, there's a danger the container will roll …*

5 *So,* _____ (argue), *rolling is the worst problem, …*

b Rephrase the words in bold in the following sentences using the words in Exercise 5a.

1 **I suppose** there'll always be a certain amount of groundspeed.

2 **If we assume** the container will roll, we'll need to protect it accordingly.

3 **According to the hypothesis**, groundspeed will almost always be positive.

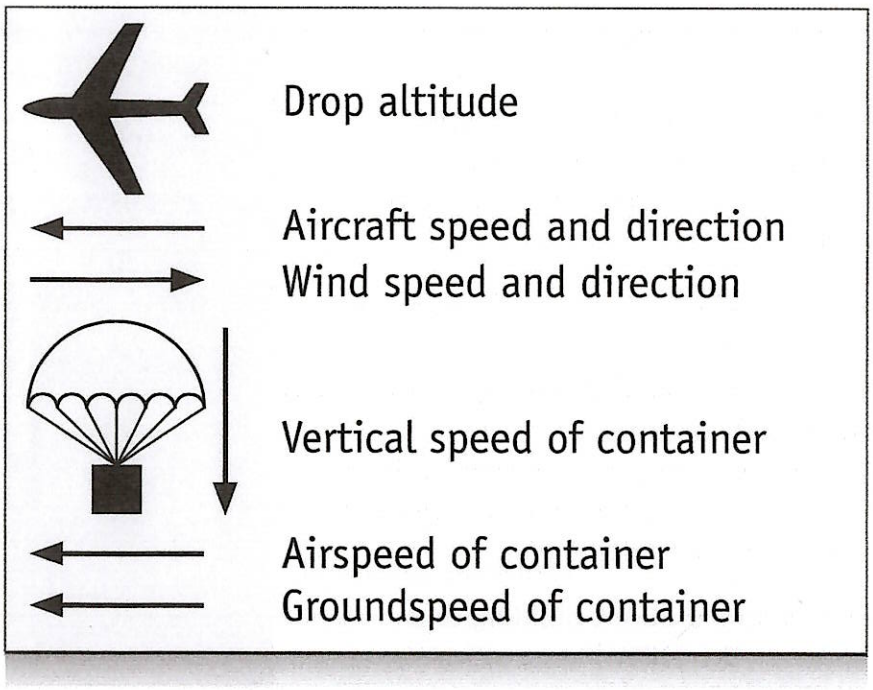
4 **You could say that** it's inevitable the container will roll and bounce along.

5 **I'm convinced that** high vertical speed is less problematic than high groundspeed.

c **In pairs, decide whether the following words and phrases are used to agree or disagree. Can you think of other phrases for agreeing and disagreeing?**

Absolutely I'm not convinced I'm not so sure Not necessarily
Of course True

d **Look at the diagram and, in pairs, discuss the following questions.**

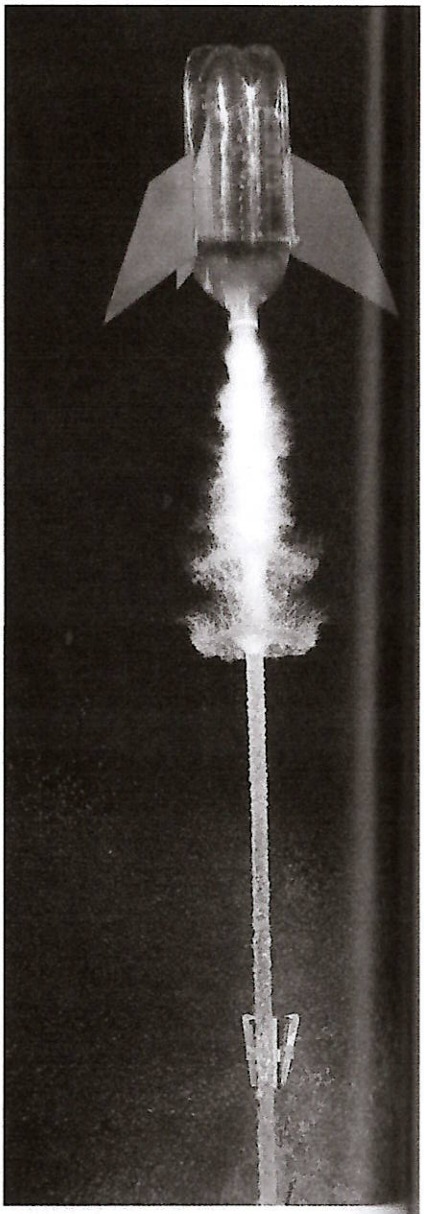


1 What is the difference between airspeed and groundspeed? How do wind speed and wind direction result in a difference between an aircraft's airspeed and its groundspeed?
2 If an aircraft's groundspeed and airspeed are the same, what must the wind speed be?
3 In theory, an aircraft can fly with a groundspeed of zero in certain extreme conditions. What would these conditions be, with regard to wind speed and the aircraft's direction relative to the wind?
4 To minimise the horizontal groundspeed of an air-dropped container on landing, what should the aircraft's direction be, relative to the wind?
5 If several air-drops are carried out from the same altitude with different wind speeds, how will higher wind speeds affect the groundspeed of the container on landing?

a **In pairs, discuss which of the following options you think is preferable and why.**

1 a low-level drop with low vertical speed and high horizontal speed
2 a high-level drop with high vertical speed and low horizontal speed

b **In pairs, discuss how the design of the container used for dropping cargo would be different for each of the two options in Exercise 6a. For each situation, consider how the container could be built to cushion the type of impact. In particular, think about the shape of the container and the protective structure around it.**



Comparing results with expectations

7 a **In pairs, discuss the difference between expectations and results. Give an example relating to research and development (R&D) in engineering.**

b **Manfred Haug, an aeronautical engineer, is describing his early rocket experiments. Read the description and explain what is meant by the expressions in bold.**

*Relying on **trial and error** isn't always the best way to improve technology, but I found it was an effective way to develop rockets. Especially as rocket science was **unfamiliar territory** for me. I was **on a steep learning curve**, hence the numerous explosions.*

c **Read more of the description. What kinds of rocket did they build and how do you think they worked?**

I should say that this had nothing to do with NASA, and happened a long way from Cape Canaveral. It was just me and a few friends on a windswept football field near Hamburg. But the plastic bottle water rockets we built and launched went through an impressive R&D programme, bearing in mind we were only 12 years old!

8 a **▶9.3 Listen to an interview with Manfred about building and launching water rockets and answer the following questions.**

1 How full were the bottles?
2 What coincidence was helpful?
3 How powerful was the rocket?
4 What problem occurred?

b **Read the following extracts from the interview. What is meant by the words in bold?**

1 *... we **expected** it would shoot up reasonably fast ...* _____
2 *... we **didn't anticipate** just how powerful it would be.* _____
3 ***It totally exceeded our expectations.*** _____

9 a **In pairs, discuss two or three solutions to the problem experienced with the rocket, based on basic materials and simple assembly techniques. For each potential solution, explain how you would expect the rocket to perform and why, describing potential problems for each solution.**

b **▶9.4 Manfred goes on to describe how he and his friends solved the problem. Listen to the description and summarise the solution, explaining why it was effective. How does the solution compare with your ideas in Exercise 9a?**

c **▶9.4 Listen again and complete the following phrases from the description.**

1 (as expected) *It didn't go exactly* _____ .
2 (extremely well) *It worked* _____ .

a **In pairs, discuss possible ways of making the water rocket more powerful to allow it to attain higher altitudes. The basis of the design should be the same and you may only use basic materials. For each solution, explain the following points.**

- Why you would expect the rocket to be more effective
- Any potential problems

b ▶9.5 **Listen to Manfred describing how the rocket was developed and the results of further tests. Make notes on the improvements made and their consequences. How do the solutions compare with your ideas from Exercise 10a?**

c **Read the following phrases that Manfred uses. Complete the definitions by underlining the correct words.**

1	*as it turned out*	= what happened in **theory/practice**
2	*what actually happened*	= what happened in **theory/practice**
3	*we underestimated the pressure*	= it was **less/more** than we thought
4	*we overestimated the strength*	= it was **less/more** than we thought
5	*plastic bottles are hardly up to the job*	= they're **adequate/inadequate**
6	*I learned the hard way.*	= it was a **theoretical/practical** lesson

d **In pairs, discuss the following questions.**

- Did you have any experiences of building things when you were younger which didn't turn out as you'd expected? What did you underestimate or overestimate? What lessons did you learn the hard way?
- When you were younger, what experiences were most beneficial in helping you to improve your technical skills? What technical principles did you learn?

Amateur rocket scientists have produced water rockets capable of reaching altitudes of several hundred metres in competitions. In pairs, think of initial ideas for a suitable design which complies with the following competition rules.

Water Rocket Competition

- Rockets must be assembled entirely from consumer products purchased from supermarkets or DIY stores. For safety reasons, no glass or metallic components are permitted.
- Rockets will be pressurised, and anchored during pressurisation using a compressor and launch pad provided by the organisers.
- Release of the rocket will be triggered by competitors, from a distance, by rope, at the moment deemed appropriate by the competitor, based on a reading on the pressure gauge of the compressor.

Discussing causes and effects

12 **In pairs, discuss the difference between cause and effect in each of the following situations.**

1 a vehicle tyre overheating
2 an electrical circuit overloading
3 a ship's hull corroding

13 **a** **Read the title of the article in Exercise 13b and explain what you think it means.**

b **Read the article and answer the following questions.**

1 What are chicken cannons designed to do?
2 Why was a chicken cannon used for a train test?
3 What were the effects of the test?

CHICKEN CANNON GOOF MAKES TECH EGGHEADS LOOK LIKE TURKEYS

When new aircraft are developed, jet engines and cockpit windshields are tested to simulate bird strikes (mid-air collisions with birds), which can result in damage. The tests are carried out using special compressed-air cannons that fire dead chickens. On one occasion such a gun was lent, by an aeronautical company, to some engineers developing a new train. Bird strikes were a potential danger, owing to the train's high speed. Having received instructions in how to use the cannon, the train designers bought an oven-ready chicken from a local supermarket, and subsequently fired it at their prototype.

The effects were devastating. As a result of the impact, a hole was smashed, not just through the windshield, but also through the back of the driver's compartment. It was hard to believe a chicken had caused so much destruction. Consequently, the engineers contacted their aeronautical colleagues to enquire if the problem might be due to an issue with the gun, some sort of fault that could have caused it to exceed its normal firing power. No malfunctions were found. However, it was later discovered that the unexpected damage had occurred because of a temperature issue.

c **The text in Exercise 13b is an urban legend (or urban myth) – a commonly told story that is said to be true, but which is not. Can you guess what temperature issue caused the unexpected effects?**

d **Complete the following sentences using the words and phrases in the box.**

because of (x2)	caused	consequently	due to	owing to	~~result in~~	result of

1 Bird strikes can result in damage to aircraft.
2 Bird strikes were a potential problem for the train, _____ / _____ / _____ its speed.
3 During the test, the train was severely damaged as a _____ the impact.
4 The damage occurred _____ a problem relating to temperature.
5 The impact of the chicken _____ it to enter the train.
6 The engineers thought the gun was faulty, so _____ they called their colleagues.

e **Read the following engineering urban legends and complete the descriptions of causes and effects using the correct form of the words and phrases in Exercise 13d. Sometimes more than one word or phrase is possible.**

1 Apparently, the biggest challenge in space exploration was developing a pen for astronauts to use in orbit as ordinary ballpoint pens don't work in space, because of / due to / owing to the fact that there's no gravity. So _____ this problem, there were teams of researchers working for years, trying to find a solution. Eventually, someone came up with the idea of using a pencil.

2 When they designed the foundations of the library on the university campus, they forgot to allow for the weight of the books on the shelves, which _____ the building to start sinking. So _____ , half of the floors have had to be left empty, without books, to keep the weight down.

3 Did you hear about that Olympic-sized swimming pool that was built? They got the length wrong, _____ the tiles. They forgot to take into account the thickness, which _____ the pool measuring a few millimetres too short. So _____ , it can't be used for swimming competitions.

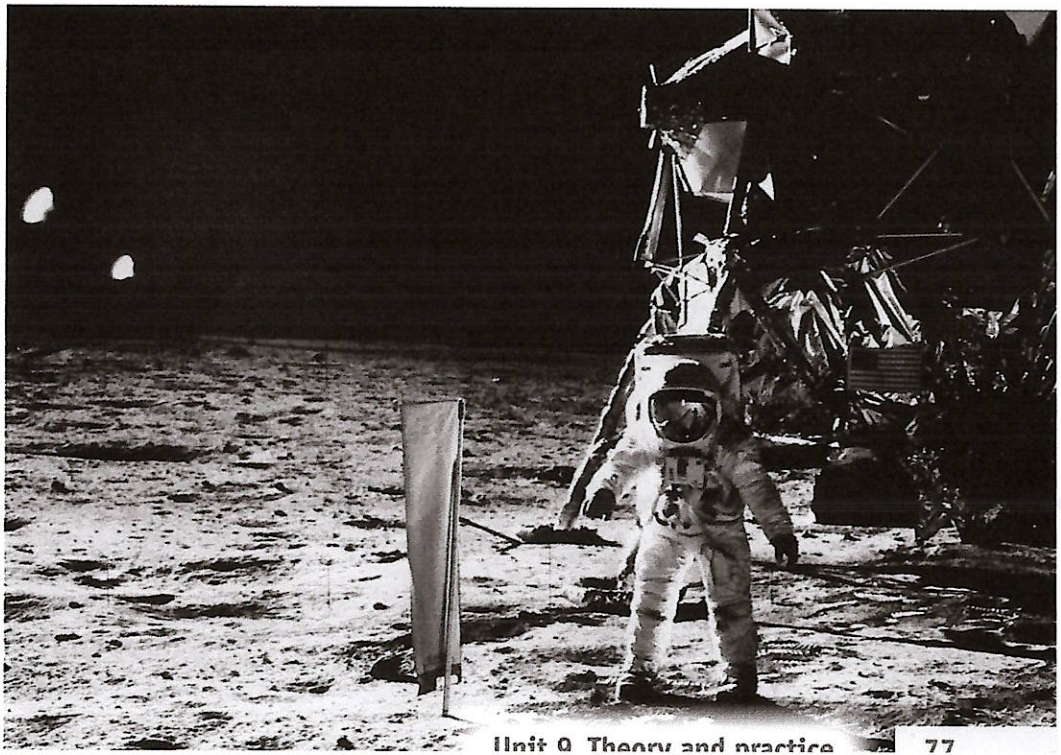
a **One popular topic for urban legends is the suggestion that the moon landings didn't really take place and were filmed on Earth. In pairs, discuss the following questions.**

- In photos taken of astronauts on the moon, why are no stars visible in the sky?
- In film footage, why is the flag planted on the surface of the moon seen moving slightly?
- Why do photos of astronauts' footprints appear to be on a wet surface and not in dry dust?
- Why is no blast crater caused by engine thrust during the landing visible below the module?

b ▶9.6 **Caroline and Renato, two colleagues at an engineering firm, are talking about the moon landings during a coffee break. Listen to the conversation and compare what they say with your ideas from Exercise 14a.**

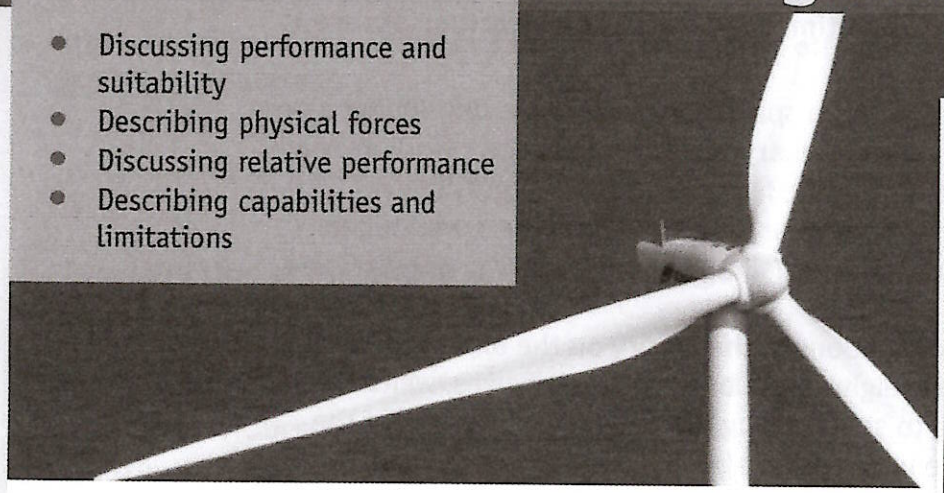
c **In pairs, discuss any urban legends you have heard relating to engineering and technology. Use the following ideas to help you.**

- unbelievable design faults
- bizarre incidents involving cars
- rumours about amazing experimental technology
- bad workmanship by builders, plumbers and electricians



UNIT 10 Pushing the boundaries

- Discussing performance and suitability
- Describing physical forces
- Discussing relative performance
- Describing capabilities and limitations



Discussing performance and suitability

1 a In pairs, answer the following questions about wind turbines.

1 What function do wind turbines perform?
2 What are the main advantages and disadvantages of wind turbines?
3 What types of location are most suitable for wind farms?

b In pairs, discuss the functions and technical characteristics of the following wind turbine components.

blades tower generator

2 a ▶10.1 Mike, Loreta and Hanif, engineers at a wind turbine constructor, are discussing performance and suitability issues relating to offshore wind turbines. Listen to the conversation and answer the following questions.

1 Which wind turbine component do the engineers discuss?
2 What is the big problem with offshore installations?
3 Which two types of construction material are being compared?
4 Why are coastal defences mentioned?
5 What point does Hanif make about regular maintenance?
6 What comparison needs to be made with regard to lifespan?

b Match the words (1–6) from the discussion to the definitions (a–f).

1	appropriate/suitable	a	the right solution for a particular situation
2	consistent/reliable	b	good enough for the intended function
3	cost-effective/economical	c	performs a function well
4	effective	d	works quickly and well
5	efficient	e	makes the most of resources, isn't wasteful
6	sufficient/adequate	f	doesn't break down, always performs in the same way

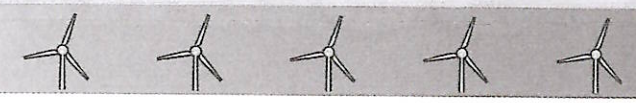
c Make the following words negative by adding the prefixes in- or un-.

1 adequate inadequate
2 appropriate _____
3 consistent _____
4 economical _____
5 effective _____
6 efficient _____
7 reliable _____
8 sufficient _____
9 suitable _____

d ▶10.1 **Listen again. What issues do Mike, Loreta and Hanif agree and disagree on?**

a **The following information is from the web site of Sigma Power, a firm that advises corporate and government clients on wind energy projects. Complete the text using the words in Exercise 2c.**

Wind Turbines - FACT FILE



1 The fact that wind turbines consume no fuel and waste very little energy is clearly a fundamental advantage. But just how efficient are they? Key figures

2 Clearly, wind turbines need to be located on relatively windy sites in order to function. From a meteorological standpoint, what kinds of geographical location are the most _____ ?

3 Turbines are generally placed at the tops of tall towers, where wind speeds are higher, thus making them more _____ . What other positioning factors influence performance?

4 Wind turbines rarely function continuously, due to the fact that wind speeds are _____ . How significant is the impact of variable weather conditions on power generating capacity?

5 Transmitting electricity over long distances is inherently _____ , due to power loss from overhead or underground power lines. Find out more about the advantages of generating power locally.

6 The generating capacity of wind turbines is generally _____ for it to be relied upon 100%. What percentage of total generating capacity can wind turbines realistically provide?

7 Some early wind turbines were _____ , suffering breakdowns caused by inaxial stresses stemming from higher wind loads on the upper blade. However, this problem has been overcome on modern units. Learn more about the technical evolution of wind turbines.

b **You are engineers at Sigma Power. The marketing manager has asked you to provide some technical answers for the frequently asked questions section of the company's website. The FAQ section is aimed primarily at potential clients who are thinking of installing wind turbines at their sites – factories, office complexes, hospitals, and university campuses. In pairs, discuss the following questions and write the answers for the website using the information in the fact file and your own knowledge.**

Frequently Asked Questions

A common-sense introduction to wind turbines

1 What's the big advantage of having a wind turbine at my site?

2 How dependable are wind turbines as a source of power, given that weather conditions are changeable?

3 What kinds of site are most suitable for wind turbines, relative to natural factors such as hills, the coast, and height above sea level?

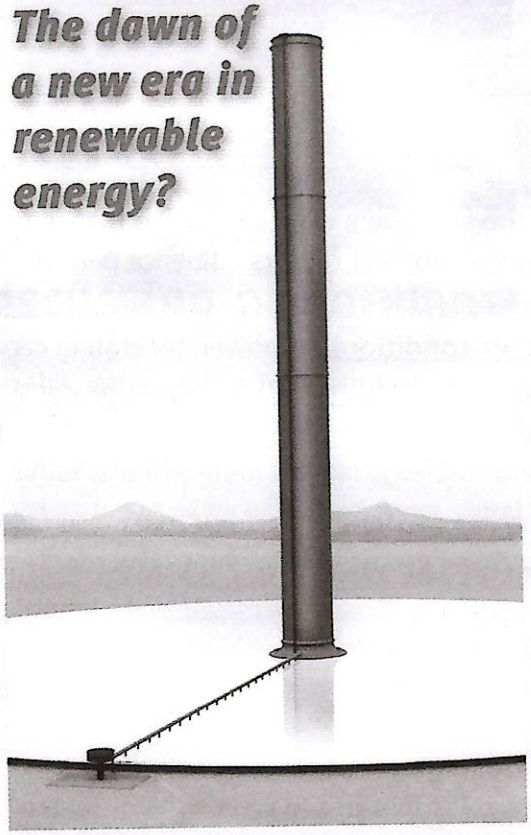
4 What's the most appropriate location for my wind turbine, relative to local features on the site, such as trees and buildings?

Describing physical forces

4 a **Read the following article. What is a solar tower and how does it use the forces of expansion and pressure?**

SOLAR TOWERS

The dawn of a new era in renewable energy?



The need to develop renewable energy is widely seen as a futuristic technological challenge. In reality, some of the most effective ways of harnessing horsepower from nature are based on concepts that have existed for donkey's years. The wind turbine is an obvious example. Another – less well known, but conceived almost a century ago – is the solar tower or solar chimney. And if the Australian company EnviroMission completes an ambitious solar tower project in the New South Wales desert, the technology could capture not just the sun's rays but the public's imagination worldwide. The firm is planning to construct a tower a colossal one kilometre high. If built, it will be the world's tallest structure by a huge margin.

How it works

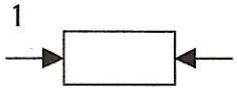
A large glass enclosure is built, with a chimney at its centre. The sun heats the enclosure, causing expansion of the air inside. At the top of the chimney, the lower temperature and lower pressure due to the higher altitude create a pressure differential known as stack effect. This causes air to flow up the chimney. Electricity is generated by turbines at the bottom of the chimney, which are driven by the flow of air. The bigger the area of glass and the taller the chimney, the greater the airflow and the higher the generating capacity.

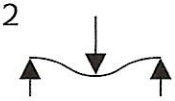
b **What physical forces would act on a solar tower 1 km high?**

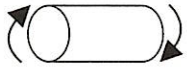
c ▶10.2 **Su, a structural engineer specialising in the design of very tall structures, is giving a talk to a group of engineering students. Listen to the talk. Which of the forces in the box doesn't she mention?**

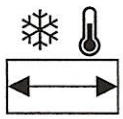
bending centrifugal force compression contraction expansion
friction pressure shear tension torsion/torque

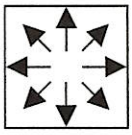
d **Label the diagrams using the forces in Exercise 4c.**

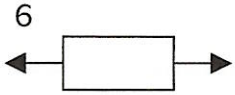
1  compression

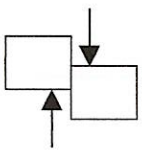
2 

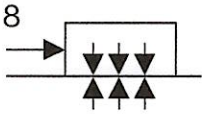
3 

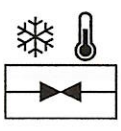
4 

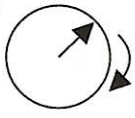
5 

6 

7 

8 

9 

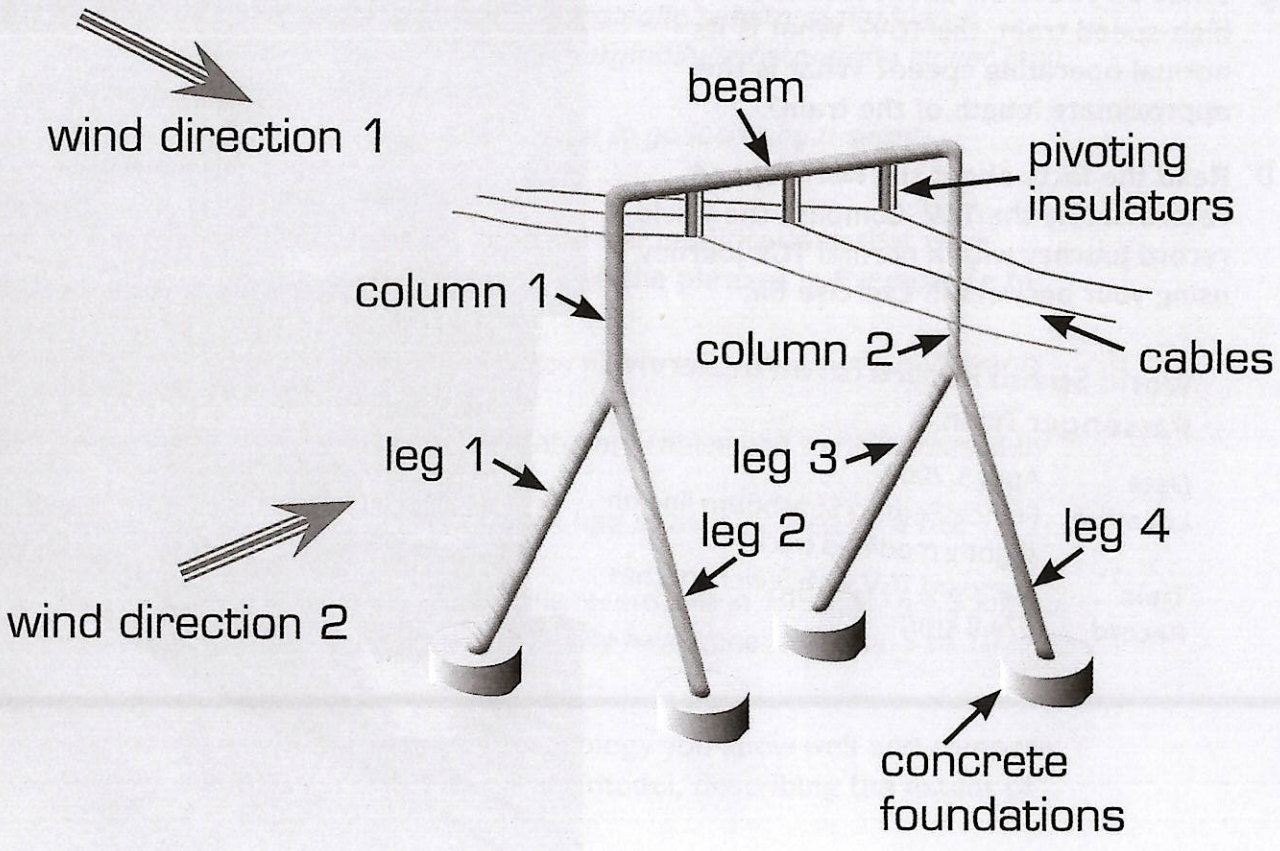
10 

e ▶10.2 **Complete the following sentences from the talk using the forces in Exercise 4c. Listen again and check your answers.**

1 *So that downward force means the structure is in* compression *, especially near the bottom.*
2 *… a horizontal load, exerted by air* _____ *against one side of the structure.*
3 *Because the structure is fixed at ground level, and free at the top, that generates* _____ *forces.*
4 *… when elements bend, you have opposing forces:* _____ *at one side,* _____ *at the other.*
5 *… the wind effectively tries to slide the structure along the ground, and the foundations below the ground resist that. The result of that is* _____ *force …*
6 *… the foundations need to rely on* _____ *with the ground to resist the pull-out force, …*
7 *The action of the wind can also generate* _____ *. You get a twisting force …*
8 *When concrete absorbs heat from the sun, you get* _____ *; as soon as the sun goes in, there's* _____ *.*

f **You and your partner specialise in designing structures for electrical transmission grids. You are currently working on a cable support concept for power lines near wind farms exposed to severe weather. You have come up with the following design. In pairs, hold a short meeting to evaluate your design concept. Explain the forces acting on the structure.**

Severe weather cable support concept



Discussing relative performance

5 a **In pairs, discuss the advantages and disadvantages of air and high-speed rail travel. Focus on trips of between 500km and 1,500km, the journey length over which planes and trains often compete for the same passengers.**

b **Read the extract from an article about transport in a popular science and technology magazine and answer the following questions.**

1 What factors should be considered in the comparative analysis described?
2 What is the purpose of the comparative analysis?
3 What suggestion is made about Europe?

Speed, convenience, efficiency, and environmental-friendliness: four factors with which to assess the relative effectiveness of different long-distance, mass-transport solutions for passengers. Technology: the key criterion in determining what transport solutions are available. And distance: the main consideration when categorising routes. Blend these variables together in varying quantities, and you have a model for calculating the optimum way of moving people.

On a European scale, whichever way you mix the various criteria, the most advantageous way of getting people around the heart of the continent seems to be on high-speed, electric trains.

c **Find words in the text in Exercise 5b to match to the following definitions. Which one of the words has a plural form?**

1 standard by which you judge something _____
2 fact or situation which influences the result of something _____
3 number, amount or situation which can change _____

6 a **What do you know about France's high-speed train, the TGV? What is its normal operating speed? What is the approximate length of the train?**

b **Read the facts about the world speed record set by the TGV. Compare the world record journey with a normal TGV journey, using your answers in Exercise 6a.**

World Speed Record for an In-Service Passenger Train

Date	April 3, 2007
Location	France: Paris to Strasbourg line on slightly modified track
Train	Standard TGV with fewer coaches
Record	574.8 km/h

c ▶10.3 **Andrej, a consulting engineer specialising in rail technology, is talking about the TGV world speed record. Listen to the talk and answer the following questions.**

1 Overall, how heavily modified was the train?
2 How long was the record-breaking TGV?
3 Why was some of the bodywork modified?
4 Why was the diameter of the wheels changed?

d ▶10.3 **Listen again and complete the following table about the modified TGV using the figures in the box.**

+ 68% + 19% – 15% – 50% + 80%

Technical criteria	Modified TGV: % difference from standard model
Maximum speed	
Train length (with coaches)	
Aerodynamic drag	
Diameter of wheels	
Motor power output	

e **Complete the following sentences from the talk by underlining the correct words.**

1 *The record speed exceeded the standard operating speed by a* ***tiny/huge*** *margin.*
2 *The train was modified to a* ***certain/considerable*** *extent …*
3 *… the modified train was* ***significantly/slightly*** *shorter, …*
4 *… changes were made to the bodywork, to make it* ***slightly/much*** *more aerodynamic …*
5 *The wheels on the modified train were* ***marginally/substantially*** *bigger …*
6 *… the power of the electric motors was* ***marginally/substantially*** *higher than the standard units …*
7 *… standard high-speed trains can be made to go faster by a* ***slight/considerable*** *amount.*

Rewrite the following sentences to describe the modifications that were made to the TGV for the record attempt. Use the phrases in Exercise 6e to replace the words in bold.

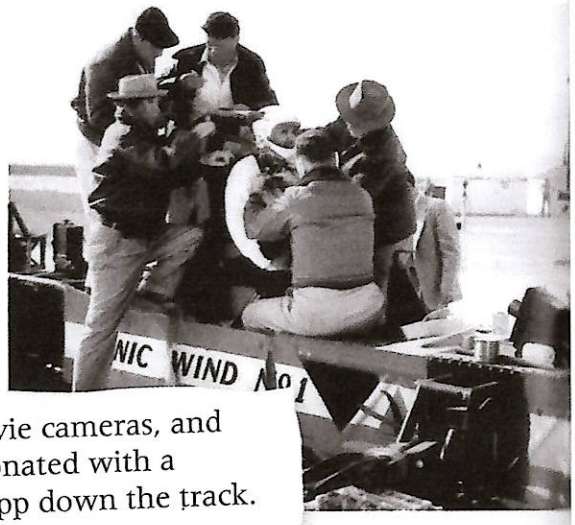
1 The supply voltage in the catenary cables had to be increased **from 25,000 to 31,000 volts**.
2 To limit oscillation, the tension of the catenary cables had to be increased **by 60%.**
3 On some curves, the camber of the track had to be increased **by a few centimetres**.
4 The 574.8km/h record beat the previous record, set in 1990, **by 59.5 km/h.**
5 In perfect conditions the TGV could probably have gone faster **by 5 to 10 km/h**.

In pairs, choose a product or type of technology you know well and compare its performance and quality with an earlier model, describing the extent of the differences.

Describing capabilities and limitations

8 a **Look at the photos and read the extracts from *The Story of John Paul Stapp*, by Nick T. Spark, and answer the following questions.**

1 When and where do you think it took place?
2 What do you think the aim of the test was?
3 What do you think John Stapp's profession was?
4 What equipment do you think was used?
5 What do you think happened in the experiment?



With five seconds to go Stapp activated the sled's movie cameras, and prepared for the shock. *Sonic Wind*'s nine rockets detonated with a terrific roar, sending out trails of fire and blasting Stapp down the track.

... *Sonic Wind* hit the water brake. The rear of the sled tore away. The front continued, hardly slowing at all until it hit the second water brake. Then, spray exploded from the back of *Sonic Wind*. It stopped like it had hit a concrete wall.

b ▶10.4 **Listen to an extract from a documentary about the experiment and check your answers to Exercise 8a.**

c **Complete the following data on the *Sonic Wind* test using the figures in the box.**

1.2	3	20	46	1015

1 Max speed: _____ km/h
2 Acceleration from 0 to max speed: _____ seconds
3 Acceleration force: _____ Gs
4 Deceleration time: _____ seconds
5 Deceleration force: _____ Gs

d ▶10.5 **Listen to the next part of the documentary and check your answers to Exercise 8c.**

e **Complete the following groups of synonyms using the words in the box.**

able to	capable of	cope with	exceed	incapable of
intended for	~~subjected to~~	surpass	unable to	withstand

1 exposed to (a force) / subjected to
2 resist (a force) / _____ / _____
3 go beyond (a limit) / _____ / _____
4 suitable for (a use) / _____
5 can / _____ / _____
6 can't / _____ / _____

f **Complete the following sentences about *Sonic Wind* using the correct form of the words in Exercise 8e.**

1 The bolts fixing the camera to the sled had to cope with high shear forces.
2 The sled's rockets were _____ generating enormous thrust.
3 The pools at the end of the track were _____ stop the sled rapidly.
4 The skids on the sled had to _____ high levels of friction.
5 At full speed, John Stapp was _____ several tonnes of air pressure.
6 The rear of the sled was _____ resist the shock of deceleration, and broke off.
7 Doctors thought people were _____ surviving forces of 17 Gs and above.
8 John Stapp _____ the 17 G limit by a huge margin.

a **You are a consultant engineer and your firm have received an email from an entrepreneur with an ambitious plan. Read the following email extract and note the key information.**

To: Jasmine Murray
Subject: Rocket sled ride

The proposal is to build a rocket sled ride on a desert site in Western Australia. The ride will be aimed at wealthy tourists, and will allow them to experience supersonic speeds. We envisage carrying two passengers at a time, seated behind the pilot. The idea is inspired by the Sonic Wind experiments, which I'm sure you're familiar with. However, it goes without saying that safety will be the number one priority, which means that extremes of acceleration and deceleration must be avoided. For instance, a water brake, like the one used in the Sonic Wind tests, is clearly out of the question.

The site is large enough to accommodate a track up to 16 km long, though I reckon 10 km would be adequate. According to my rough calculations, that would be sufficient to allow progressive acceleration up to and through the sound barrier to about 350 m/s, and progressive deceleration to a standstill without exceeding 2 G (20 m/s^2), while still leaving three to four kilometres of track as a safety margin. However, I'm not an engineer, so would appreciate your professional opinion on that.

In terms of basic technology, I assume the most suitable vehicle would be a rail-mounted sled, with steel skids that grip the track, above and below the rails, to prevent derailing, and avoid problems with aerodynamic lift. I assume wheels wouldn't be feasible given the speeds involved, though I'm not 100% sure about that. Perhaps you can advise. Propulsion would be provided by a rocket or aircraft jet. I already have a consultant sourcing a suitable engine, however, so that angle is being looked into.

As far as your input is concerned, the main area where I need your expertise is on the braking system. As I said, violent braking is out of the question. As I see it, suitably gentle options include systems that apply friction to the rails, aerodynamic flaps, parachutes, or reversed engine thrust. But, again, I'm not an engineer, so I look forward to discussing your thoughts on these issues.

b **In pairs, discuss the key information in Exercise 9a and consider the following points.**

- the level of G force
- a safe length for the track
- the feasibility of using wheels
- the suitability of the braking systems suggested

c **▶10.6 Jasmine and Andrew, consulting engineers, are discussing the issues in Exercise 9b. Listen and compare what they say with your ideas from Exercise 9b.**

d **In pairs, discuss the points raised in their conversation and make notes summarising your thoughts in preparation for a meeting with the entrepreneur.**

e **Prepare a short presentation for the entrepreneur using your notes from Exercise 9d. Student A, you are the consultant engineer. Give the presentation. Student B, you are the entrepreneur. Listen and ask questions about specific details. Swap roles and practise again.**