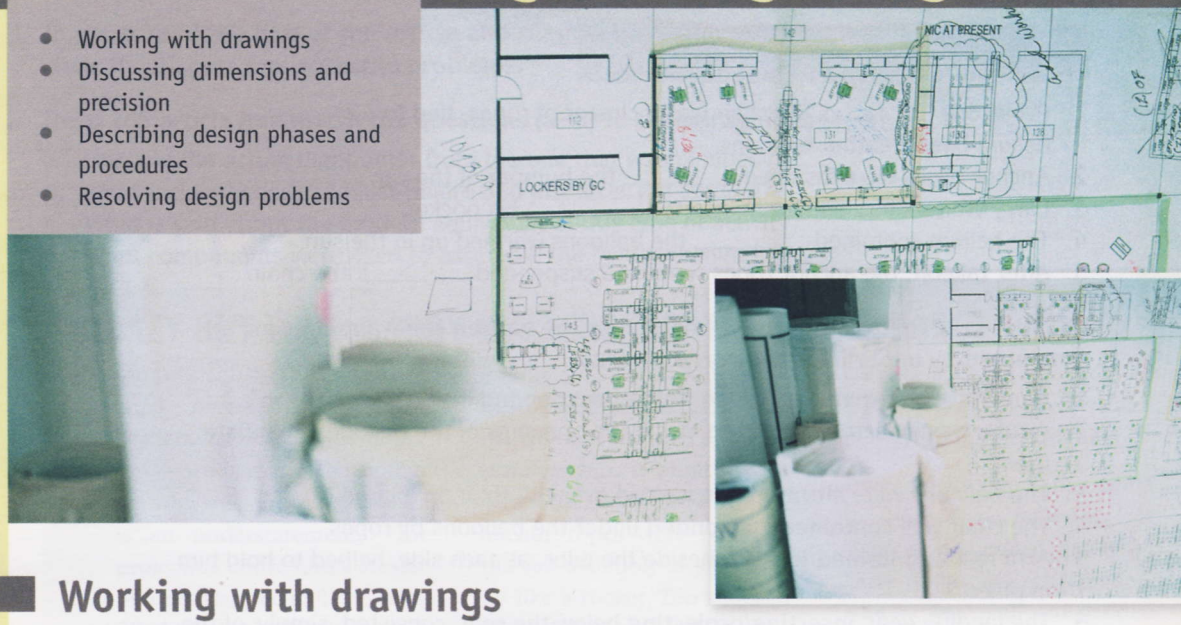
UNIT 4 Engineering design

- 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? _____

3 **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 ...*

4 **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.

5 **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.**

7 **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.

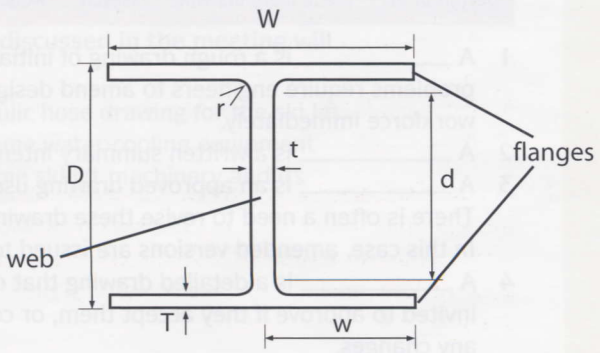
To: Lewis Rosas
Subject: Revised floor slab drawing

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?

8 **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?

11

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.**

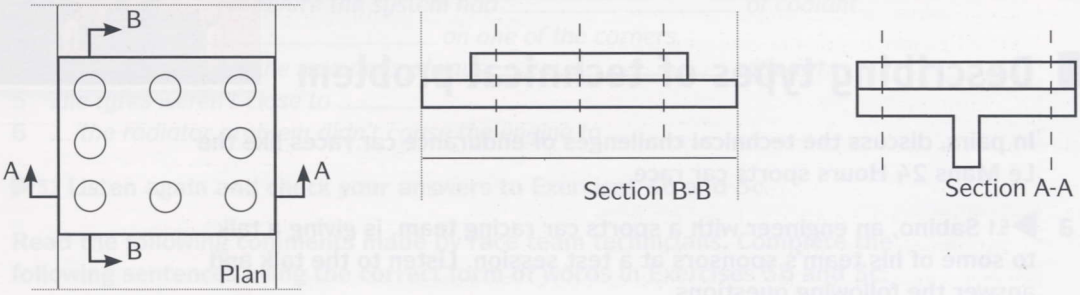
1 An installation that won't fit, as components are in each other's way 868
2 A response from the engineer asking for more information _____
3 Queries that suggest a solution, which will require the engineer's approval _____ _____
4 Requests to the engineer to instruct the contractor or make something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

4 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.*

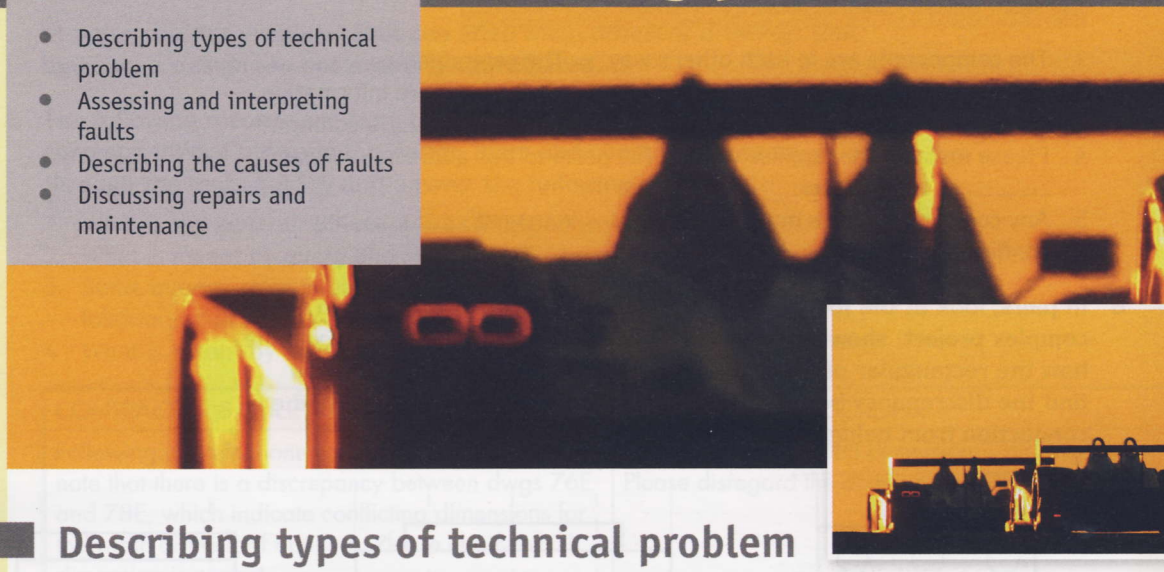
Chen: *OK, fine. Will you send an email to* (8) _____ *that?*

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 5 Breaking point

- Describing types of technical problem
- Assessing and interpreting faults
- Describing the causes of faults
- Discussing repairs and maintenance



Describing types of technical problem

1 **In pairs, discuss the technical challenges of endurance car races like the Le Mans 24 Hours sports car race.**

2 a ▶5.1 **Sabino, an engineer with a sports car racing team, is giving a talk to some of his team's sponsors at a test session. Listen to the talk and answer the following questions.**

1 What saying emphasises the importance of reliability?
2 What expression refers to things that can cause failures?
3 What expression describes damage caused by normal use?

b ▶5.1 **In the talk, Sabino names five engineering enemies. Complete the following list. Listen again and check your answers.**

1 h_____ = high temperatures
2 p_____ = loads from expanding gases or liquids
3 v_____ = continuous high-frequency movement or shaking
4 s_____ = sudden impacts
5 a_____ = damage to surfaces caused by friction

c **In pairs, suggest which engineering enemies in Exercise 2b can be the most problematic for each of the following car parts.**

1 chassis	4 suspension	7 wings
2 engine	5 brakes	8 cooling system
3 gearbox and clutch	6 tyres	9 nuts and bolts

3 a ▶5.2 **Listen to Sabino talking about some technical problems the team have had at the test and mark the following statements True (T) or False (F).**

1 Some liquid was lost from a pipe.
2 A car lost all its coolant with the engine still running.
3 A car's engine stopped on the circuit.
4 Some tyres were damaged.
5 A wheel nut fell off a car on the circuit.
6 A car's suspension was broken.

b **Complete the following extracts from the talk using the words in the box.**

bend blocking crack jam snap

1 *... you don't want anything* _____ *the airflow to the radiators.*
2 *... they had a wheel nut* _____ *, it wouldn't turn.*
3 *... he didn't hit the barriers and* _____ *the suspension or* _____ *it completely.*
4 *... it didn't* _____ *the tub – the chassis.*

c **Complete more extracts from the talk using the correct form of a verb in box 1 and a word in box 2.**

1							2		
blow	clog	cut	leak	run	wear	~~work~~	~~loose~~	up	out

1 *... a nut* worked loose *on a radiator pipe, which resulted in coolant liquid* _____ _____ .
2 *... he switched off before the system had* _____ _____ *of coolant.*
3 *... the engine* _____ _____ *on one of the corners.*
4 *... the openings in the side pods always* _____ _____ *with dirt.*
5 *The tyres weren't close to* _____ _____ *...*
6 *... the radiator problem didn't cause the engine to* _____ _____ .

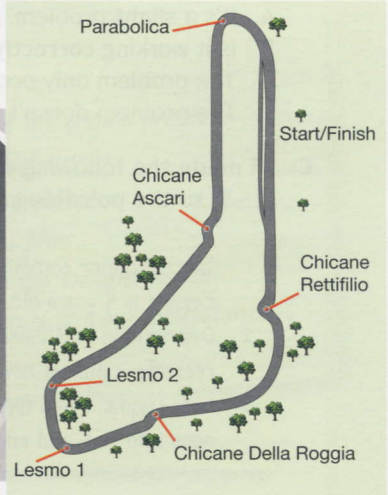
d ▶5.2 **Listen again and check your answers to Exercises 3b and 3c.**

e **Read the following comments made by race team technicians. Complete the following sentences using the correct form of words in Exercises 3b and 3c.**

1 There's smoke and flames pouring out of the engine. It's blown up .
2 There's a pool of oil under the car. Something's _____ .
3 This cylinder head bolt won't loosen. It's _____ .
4 The air filter's full of dirt. It's completely _____ .
5 This wing support's been moving about. The bolts have _____ .
6 Something's stopping the oil flow. The pipe might be _____ .
7 Are you sure that pushrod's straight? It looks as if it's _____ .
8 We'll need to change these brake pads. They're nearly _____ .
9 There's hardly any fuel left in the car. In another lap, we'll _____ .

4 **Read the technical facts about the Italian motor racing circuit, Monza, and summarise how the track is different from most others. In pairs, discuss the technical problems that racing cars could have at Monza as a result of the factors described in the text.**

The circuit is characterised by long straights and chicanes. This means the cars' engines are at full throttle for over 75% of the lap, a higher percentage than most other circuits.
The track requires heavier-than-average braking over a given lap, as the cars repeatedly decelerate at the end of some of the world's fastest straights for the slow chicanes.
The chicanes are lined by rugged kerbs. Riding over these hard is crucial for fast laps.
The long straights require small wings for minimum drag. This means lower downforce, resulting in lower grip on corners and under braking, and less stability over bumps.
The main high-speed corners Lesmo 1, Lesmo 2 and Parabolica are all right turns.
Parts of the circuit are surrounded by trees, which means leaves can be blown onto the track.



Assessing and interpreting faults

5 a **In pairs, discuss a technical problem you've experienced with a device, equipment or vehicle. Describe the fault, and how you tried to solve the problem.**

b **Read the training notes for telephone helpline staff working for a manufacturer of mining plant. In pairs, discuss what each point means.**

Problem-solving checklist

1 User's observations:
- *nature of fault*
- *circumstances of fault*
- *external factors*

2 Process of elimination
3 Identify the failure
4 Determine action and urgency

6 a ▶5.3 **Mr Rooney, an engineer at a quarry firm, is talking to Al, a helpline consultant, about a technical problem with a diesel engine. Listen to the conversation and answer the following questions.**

1 What does the warning message say?
2 What external factor is discussed as a possible cause?
3 Why is this possible cause eliminated?
4 In what circumstances does the fault occur?
5 What does the consultant identify as the most likely cause?
6 What action is required, and how urgent is it?

b **Match the words in the box to their synonyms in the sentences (1–7).**

defect defective ~~fault~~ faulty intermittently major minor properly systematically

1 There's a **problem**. fault / _____
2 Perhaps something in the fuel injection system is **wrong**. _____ / _____
3 It's a **serious** problem. _____
4 It's a **slight** problem. _____
5 Is it working **correctly**? _____
6 The problem only occurs **from time to time**. _____
7 The problem doesn't occur **every time**. _____

c **Al made the following notes about three engine problems. Match the faults (1–3) to the possible causes (a–c).**

1 Starter motor sometimes works, sometimes doesn't. Engine is 9 years old.
2 Distribution belt failed. Engine blew. Belt replaced recently - almost new
3 New engine. Runs for 20 mins, then temp. gauge always goes into red, and engine cuts out (safety override)

a Cooling system problem. Fan? Water pump?
b Electrical contact problem. Loose connection?
c Manufacturing defect? Incorrect fitting? Not wear

d **In pairs, describe the problems in Exercise 6c using the following phrases.**

a faulty part	a sudden problem	a systematic problem	an installation problem
an intermittent problem	caused by wear and tear	It's / It was ...	It's / It was probably ...
Perhaps it's / it was ...	This is / was a ...		

e **Complete the following table using the phrases in the box from the conversation.**

I doubt it's it can't be it could be it might be ~~it must be~~ it sounds like it's

1 It's certainly / it must be	
2 It's probably / _____	
3 It's possibly / _____ / _____	a problem with ...
4 It's probably not / _____	
5 It's certainly not / _____	

f ▶5.3 **Complete the following extracts from the conversation using phrases in Exercise 2e. Listen again and check your answers.**

1 *Obviously, it must be some sort of defect in the fuel injection system.*
2 *So _____ a software problem.*
3 *... maybe _____ a defective sensor.*
4 *Presumably, _____ anything too serious.*
5 *_____ water, then, if the fuel went in directly from a delivery.*
6 *_____ a faulty fuel pre-heater.*

7 a **In pairs, analyse the problem described below. Underline the words in the box that describe it.**

major minor sudden systematic intermittent

The problem
The driver of a dump truck, which operates in a quarry, has noticed that the truck's diesel engine is slightly down on power. The problem has become progressively worse over several weeks. Apart from the power loss, the engine is performing consistently, with no misfiring and no overheating. The degree of power loss remains constant throughout a given period of use, from starting the engine to turning it off. No increase in fuel consumption has been noted.

b **Read the notes and assess the possible causes of the problem in Exercise 7a using the words in Exercises 6d and 6e.**

Possible causes of the engine problem
- *water in the fuel supply*
- *a lubrication problem*
- *a clogged fuel filter*
- *a blockage in the exhaust system*
- *a compression leak from the piston cylinders*

Describing the causes of faults

8 **Look at the following strategies for preventing and dealing with technical problems in aviation. In pairs, discuss what is meant by the following terms and how they are used by engineers and pilots.**

1 checklists
2 standard procedures
3 back-up installations
4 planned maintenance

9 a **Read the article on the right and answer the following questions.**

1 How did the problem start?
2 What were the initial, unseen consequences?
3 What were the subsequent consequences?

b **Complete the sequence of events that followed the fuel leak on the Airbus A330 using the extracts (a–d).**

"We have a problem"

The true story of Air Transat Flight 236.

The chain of events began during routine maintenance work on an Air Transat Airbus A330. An incorrect hydraulic pipe was fitted to the right-hand engine. The component was oversized, leaving inadequate clearance with an adjacent fuel line. Subsequently, the two pipes rubbed together, causing the fuel line to wear progressively. The problem went undetected, until the night of August 24, 2001, at 35,000 feet above the Atlantic. With Flight 236 en route from Toronto to Lisbon, carrying 306 people, the fuel line ruptured, resulting in a major leak. Less than two hours later, the aircraft was completely out of fuel, gliding silently through the night sky …

04:38 The flight data recorder registered an abnormal increase in fuel consumption. At this stage, however, this slight anomaly was insufficient to cause warning lights to come on to alert the crew to any imminent danger.

04:58 _____

05:33 A warning message came up, alerting the crew to an imbalance between the amount of fuel in each wing tank. Initially, the problem was thought to be an instrument malfunction. But further analysis by the crew revealed that the amount of fuel remaining in the right tank was significantly below the planned quantity.

05:36 _____

05:45 As a precaution, the crew decided to divert to the nearest airport - the Lajes military airbase in the Azores.

06:13 _____

06:26 ENG 2 FAIL appeared, and the left engine cut out. Having completely run out of fuel, and with both engines now down, the Airbus A330 was gliding, descending at 2,000 feet per minute.

06:27 _____

06:46 With the airport in sight, the landing gear was lowered manually. The pilot then performed a series of spectacular zigzag manoeuvres to slow the plane down as much as possible. The aircraft touched down on the runway at 370 km/h – exceeding the standard approach speed by over 100 km/h. The pilot applied emergency braking, causing several tyres to blow out and catch fire. But the plane stopped safely, well before the end of the runway.

a An alarm sounded, a red master warning lit up and the message ENG 1 FAIL came up on the screen. Seconds later, the right engine flamed out, due to insufficient fuel.

b During a routine instrument check, the crew noticed a disproportionate amount of oil had been used by each engine. Oil pressure and temperature readings for each engine were also irregular, but the levels were found to be within acceptable parameters.

c As the aircraft was now powerless and potentially uncontrollable, an emergency ram air turbine was deployed automatically to generate back-up electrical power for the fly-by-wire controls and instruments. However, with the main hydraulics shut down, the flaps and spoilers used to slow the plane before and after landing were inoperable. The co-pilot calculated the plane could remain airborne for 15–20 minutes, and that Lajes airbase was an estimated 20 minutes away.

d The crew decided to take action to correct the anomaly, opening a cross-feed valve to transfer fuel from the left tank to the right tank.

c **Make opposites of the following words using the prefixes in the box.**

ab-	dis-	im-	in- (x4)	ir-	mal-	over-	un-

1 correct incorrect
2 undersized _____
3 adequate _____
4 detected _____
5 normal _____
6 sufficient _____
7 proportionate _____
8 regular _____
9 balance _____
10 function _____
11 operable _____

d **Complete the following sentences using the words in Exercise 9c. Sometimes more than one word is possible.**

1 The temperature gauge was faulty. That's why it was giving _____ readings.
2 The shaft was thinner than it should have been, so its strength was _____ .
3 The power output from the motor varies. We don't understand why it's _____ .
4 The bolt's _____ . It's too big to fit into the hole.
5 The machine's not working as it should. There's some kind of _____ .
6 The braking force on both front wheels should be the same. There shouldn't be an _____ .
7 The fault was _____ . None of the maintenance technicians had noticed it.
8 The control panel isn't working, so you can't control the machine. It's totally _____ .

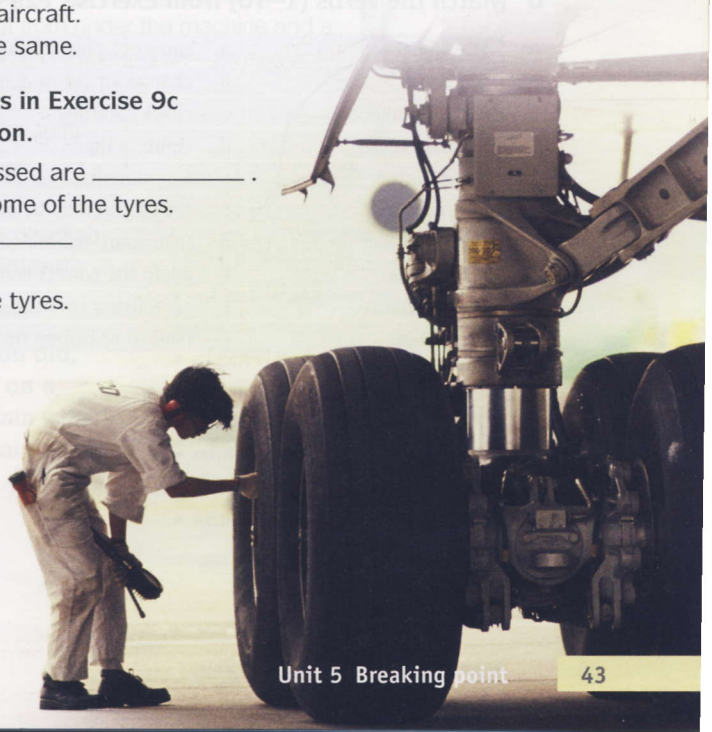
10 a ▶5.4 **Julia, an aircraft service technician, is phoning Alan, a colleague, about a problem with the tyres on a plane. Listen to the conversation and mark the statements True (T) or False (F).**

1 The tyre pressures on the block being discussed are OK.
2 There is too little air inside some of the tyres.
3 The tyre pressures are the same across the aircraft.
4 The degree of wear across all the tyres is the same.

b **Complete the following sentences using words in Exercise 9c to make true sentences about the conversation.**

1 The tyre pressures on the block being discussed are _____ .
2 There is _____ air pressure inside some of the tyres.
3 The tyre pressures on that block are _____ to the rest of the aircraft.
4 The wear rate is _____ across all the tyres.

c **In pairs, discuss the possible causes of insufficient tyre pressure in general, and the specific problem Julia describes in Exercise 10a, and say why each general cause you discussed is likely or unlikely in this case.**



Discussing repairs and maintenance

11 a **In pairs, discuss the difference between repairs and maintenance and decide whether the following words relate to repairs, maintenance or both.**

broken clogged defective faulty worn

b **In pairs, compare car maintenance with aircraft maintenance. Which aspects are quite similar and which are very different?**

12 a **Match the content sections (1–10) of an aircraft service manual to the descriptions (a–j).**

Contents

1	Opening and dismantling access panels	f
2	Topping up, draining and replacing coolants and lubricants	
3	Replacing filters	
4	Safely isolating electrical components	
5	Safely disconnecting and reconnecting electrical components	
6	Mechanical connections to be checked/ tightened at each service	
7	Parts susceptible to wear/damage, to be examined at each service	
8	Sensitive devices to be adjusted at each service	
9	Information on non-serviceable parts / sealed units	
10	Table of component life spans	

a Switching off the power supply
b Making sure certain parts haven't worked loose
c Changing parts that can become clogged
d Adding and changing fluids
e Equipment that needs to be set up precisely
f ~~Taking something to pieces to allow maintenance~~
g Taking parts off and refitting them without danger
h Components that can't be repaired on site
i Details of how long parts are designed to last
j Making sure parts are still in good condition

b **Match the verbs (1–10) from Exercise 12a to the definitions (a–j).**

1	adjust	a	carry out planned maintenance
2	drain	b	change an old or damaged part
3	disconnect	c	check carefully
4	dismantle	d	empty a liquid
5	examine	e	add more fluid to fill a tank to the recommended level
6	replace	f	set up carefully by making small changes
7	reconnect	g	take apart assembled components
8	service	h	apply the correct torque, for example to loose bolts
9	tighten	i	establish a connection again
10	top up	j	remove or isolate from a circuit or network

13 a ▶5.5 **A service technician is examining some machinery and talking to a colleague. What does he say about each point on the maintenance checklist?**

Maintenance Checklist

1 Coolant level _____
2 Coolant condition _____
3 Coolant filter condition _____
4 Blade wear/damage _____
5 Blade alignment _____

b ▶5.5 **Listen again. Do you think the technicians are working on an aircraft or on an industrial machine?**

c **In pairs, discuss what maintenance needs to be carried out on the machinery in Exercise 13a, describing the operations step by step.**

14 a **You work for IPS, a producer of industrial packaging machinery. As a member of the global service team your role is to travel abroad dealing with serious technical problems at your clients' plants. Read the following email from a plant in Helsinki and summarise the problem.**

To: Chris McLean
Subject: Forklift damage to IPS15 Helsinki

Following our phone conversation this morning I confirm that a forklift truck has hit our IPS15 unit. The impact has made a large hole in the main panel on the side of the machine. Our technician who is trained to carry out routine adjustments on the machine has made an external visual inspection. He has advised me that the mechanisms for adjusting the precise alignment of the cutting blades have been damaged. Liquid lubricant is also leaking out from under the machine and a crackling sound can be heard inside the unit when it is switched on – presumably due to earthing/short-circuiting resulting from electrical damage.

I confirm my request for intervention by your service team.

b **In pairs, describe the sequence of steps you'll need to take to carry out repairs when you arrive in Finland, using the notes to help you.**

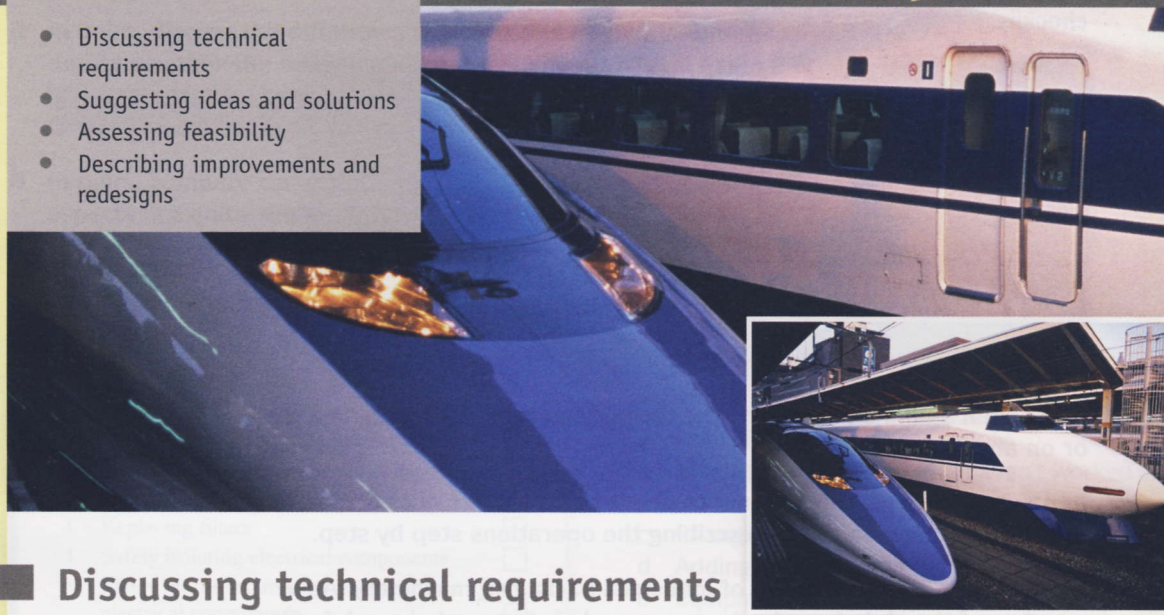
IPS15 Helsinki

- internal damage
- old parts
- electrical supply: on / off
- lubricant: in / out
- external panels
- alignment of cutting blades
- test
- new parts

15 **Think back to some repairs or maintenance you did, or had done for you, in the past, for example on a car, bike or domestic appliance. In pairs, explain what servicing or repairs were required, and the main steps involved in carrying them out.**

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 _____

4 **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

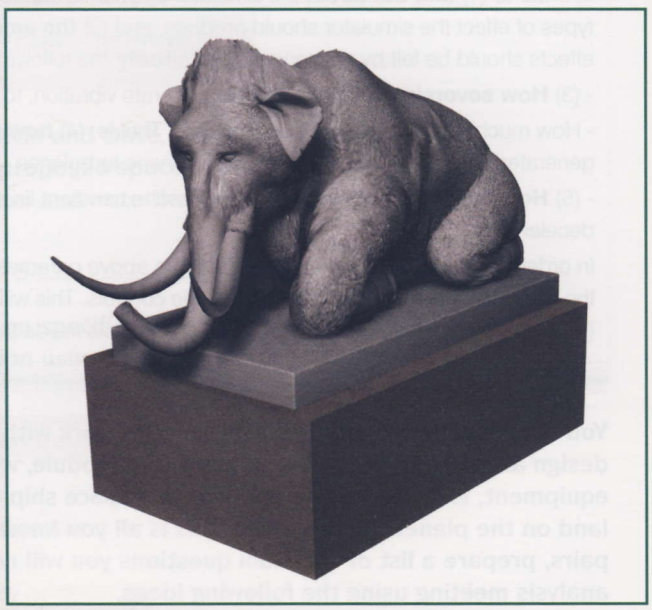
5 **In pairs, discuss the following questions about creative thinking.**

- 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.**

Size of budget
A bigger/smaller budget often means ...

Length of schedule
A longer/shorter schedule often means ...

→ Technical feasibility
... more/less sophisticated/innovative design.
... higher/lower quality/reliability/efficiency.

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.**

10

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?

DEFINING IMPROVEMENT:

- BETTER-QUALITY MATERIALS
- LOWER UNIT COST
- MAKE LIFE EASIER FOR USER

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

Possible areas for improvement

1 Aesthetics
2 User interface
3 Reliability
4 Consumables
5 Output quality and speed
6 Maintenance
7 Manufacturing
8 Environmental impact

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	~~wheel~~

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.
_____

13 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.**