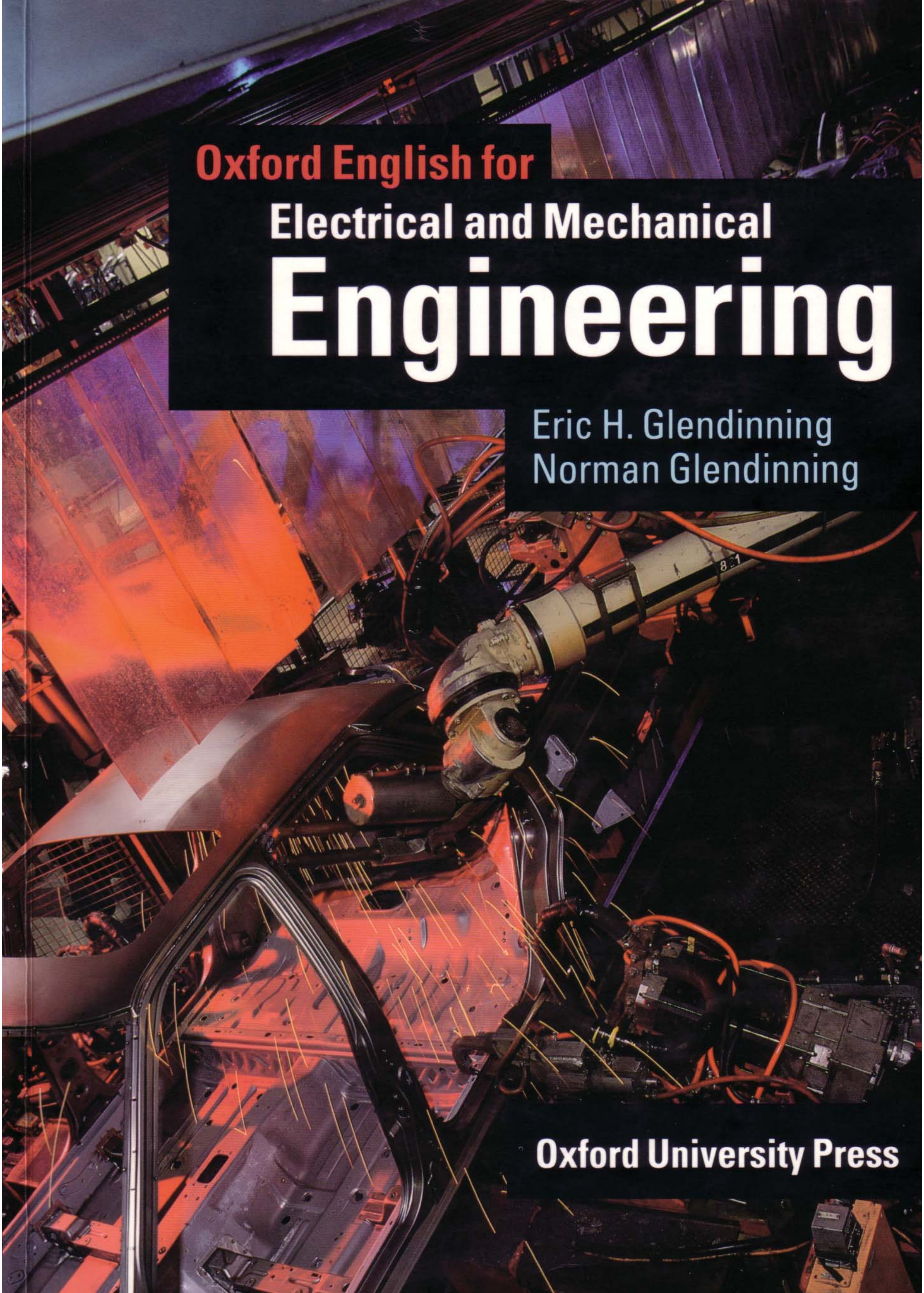
Oxford English for Electrical and Mechanical Engineering

Eric H. Glendinning
Norman Glendinning



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Technical contents

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1 Engineering – what's it all about?

Tuning-in

Task 1

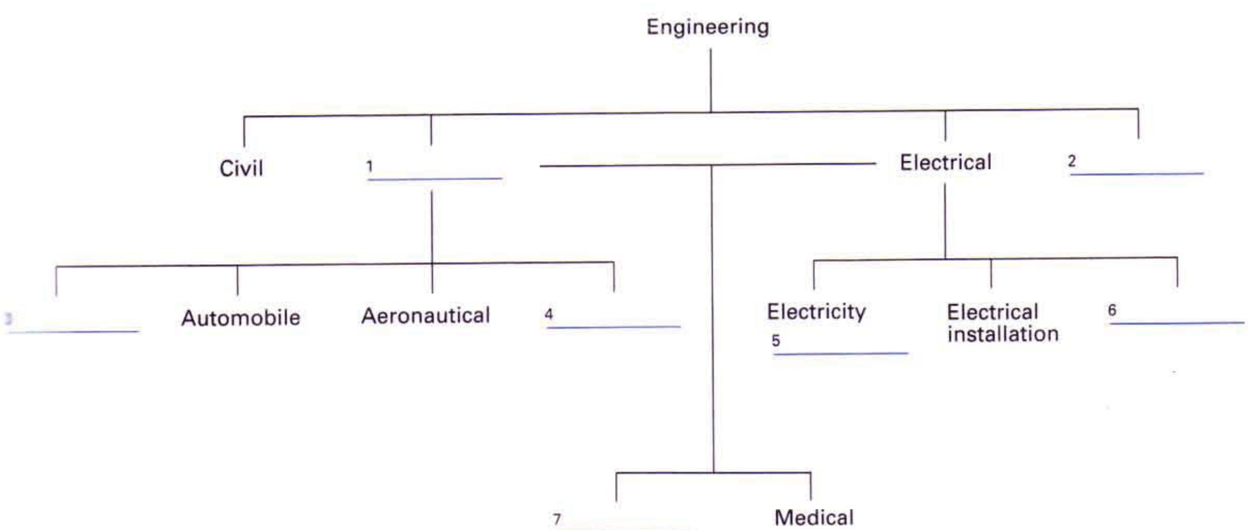
List the main branches of engineering. Combine your list with others in your group. Then read this text to find out how many of the branches listed are mentioned.

Engineering is largely a practical activity. It is about putting ideas into action. Civil engineering is concerned with making bridges, roads, airports, etc. Mechanical engineering deals with the design and manufacture of tools and machines. Electrical engineering is about the generation and distribution of electricity and its many applications. Electronic engineering is concerned with developing components and equipment for communications, computing, and so on.

Mechanical engineering includes marine, automobile, aeronautical, heating and ventilating, and others. Electrical engineering includes electricity generating, electrical installation, lighting, etc. Mining and medical engineering belong partly to mechanical and partly to electrical.

Task 2

Complete the blanks in this diagram using information from the text.

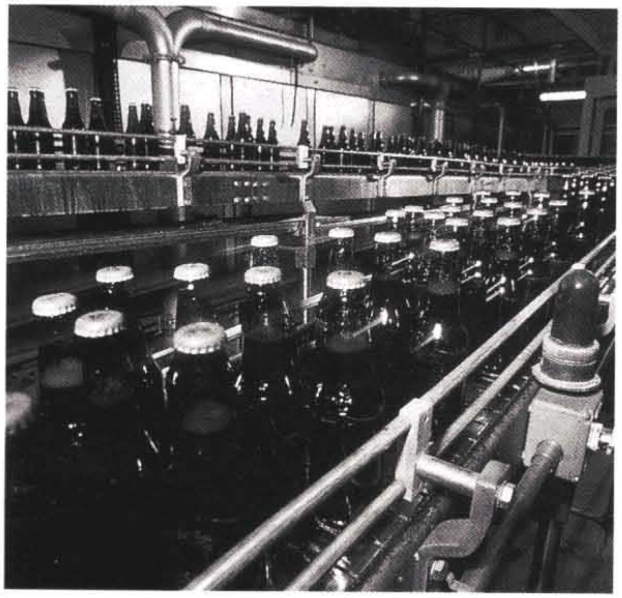


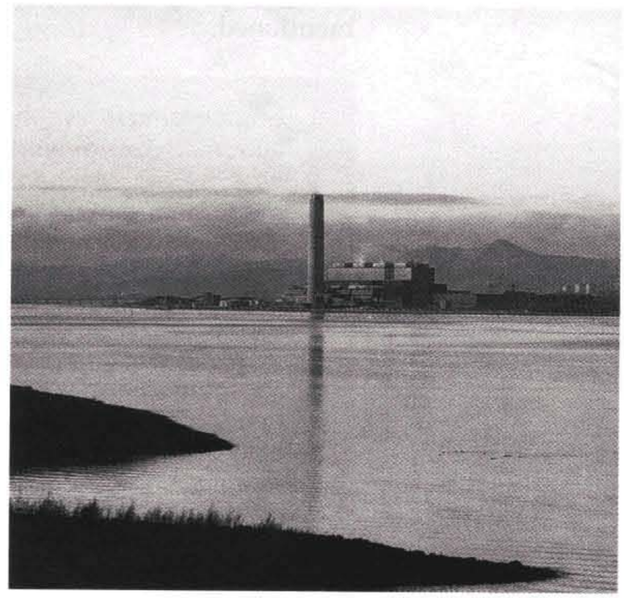
Reading *Introduction*

In your study and work, it is important to think about what you are going to read before you read. This helps you to link old and new knowledge and to make guesses about the meaning of the text. It is also important to have a clear purpose so that you choose the best way to read. In this book, you will find tasks to make you think before you read and tasks to help you to have a clear purpose when you read.

Task 3

Study these illustrations. They show some of the areas in which engineers work. Can you identify them? What kinds of engineers are concerned with these areas – electrical, mechanical, or both?





Task 4

Now read the following texts to check your answers to Task 3. Match each text to one of the illustrations above.

Transport: Cars, trains, ships, and planes are all products of mechanical engineering. Mechanical engineers are also involved in support services such as roads, rail track, harbours, and bridges.

Food processing: Mechanical engineers design, develop, and make the machines and the processing equipment for harvesting, preparing and preserving the foods and drinks that fill the supermarkets.

Medical engineering: Body scanners, X-ray machines, life-support systems, and other high tech equipment result from mechanical and electrical engineers combining with medical experts to convert ideas into life-saving and life-preserving products.

Building services: Electrical engineers provide all the services we need in our homes and places of work, including lighting, heating, ventilation, air-conditioning, refrigeration, and lifts.

Energy and power: Electrical engineers are concerned with the production and distribution of electricity to homes, offices, industry, hospitals, colleges and schools, and the installation and maintenance of the equipment involved in these processes.

Source: Adapted from *Turning ideas into action*, Institution of Mechanical Engineers, and *Engineering a Career*, Institution of Electronics and Electrical Incorporated Engineers.

Language study *deals/is concerned with*

What is the link between column **A** and column **B**?

A	B
mechanical	machines
electrical	electricity

Column **A** lists a branch of engineering or a type of engineer. Column **B** lists things they are concerned with. We can show the link between them in a number of ways:

1 *Mechanical engineering* ***deals with*** *machines.*
2 *Mechanical engineers* ***deal with*** *machines.*
3 *Mechanical engineering* ***is concerned with*** *machines.*
4 *Mechanical engineers* ***are concerned with*** *machines.*
5 *Machines* ***are the concern of*** *mechanical engineers.*

Task 5

Match each item in column **A** with an appropriate item from column **B** and link the two in a sentence.

	A		B
1	marine	**a**	air-conditioning
2	aeronautical	**b**	roads and bridges
3	heating and ventilating	**c**	body scanners
4	electricity generating	**d**	cables and switchgear
5	automobile	**e**	communications and equipment
6	civil	**f**	ships
7	electronic	**g**	planes
8	electrical installation	**h**	cars and trucks
9	medical	**i**	power stations

Word study *Word stress*

Words are divided into syllables. For example:

engine	en.gine
engineer	en.gin.eer
engineering	en.gin.eer.ing

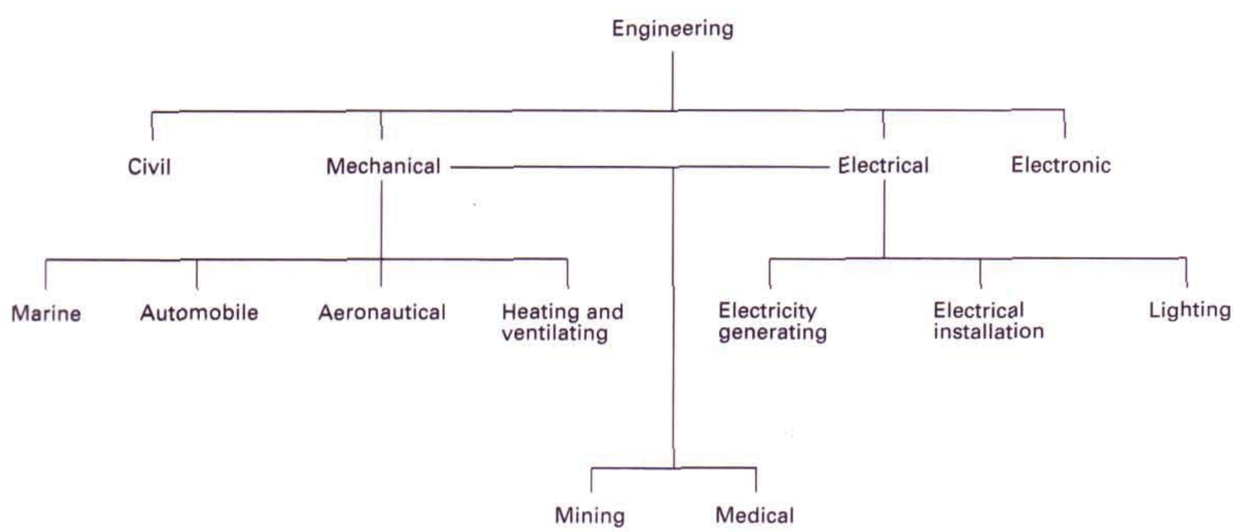
Each syllable is pronounced separately, but normally only one syllable is stressed. That means it is said more slowly and clearly than the other syllables. We say *'engine* but *engin'eer*. A good dictionary will show the stressed syllables.

Task 6 Listen to these words. Try to mark the stressed syllables.

1 machinery
2 mechanical
3 machine
4 install
5 installation
6 electricity
7 electrical
8 electronics
9 aeronautical
10 ventilation

Writing

Task 7 Fill in the gaps in the following description of the different branches of engineering using information from this diagram and language you have studied in this unit.



The main branches of engineering are civil, [1] ________, [2] ________, and electronic. Mechanical engineering is [3] ________ [4] ________ machinery of all kinds. This branch of engineering includes [5] ________, automobile, [6] ________, and heating and ventilating. The first three are concerned with transport: [7] ________, cars and planes. The last [8] ________ with air-conditioning, refrigeration, etc.

Electrical engineering deals with [9] ________ from generation to use. Electricity generating is concerned with [10] ________ stations. Electrical installation deals [11] ________ cables, switchgear, and connecting up electrical equipment.

Two branches of engineering include both [12] ________ and [13] ________ engineers. These are mining and [14] ________ engineering. The former deals with mines and mining equipment, the latter with hospital [15] ________ of all kinds.

Listening

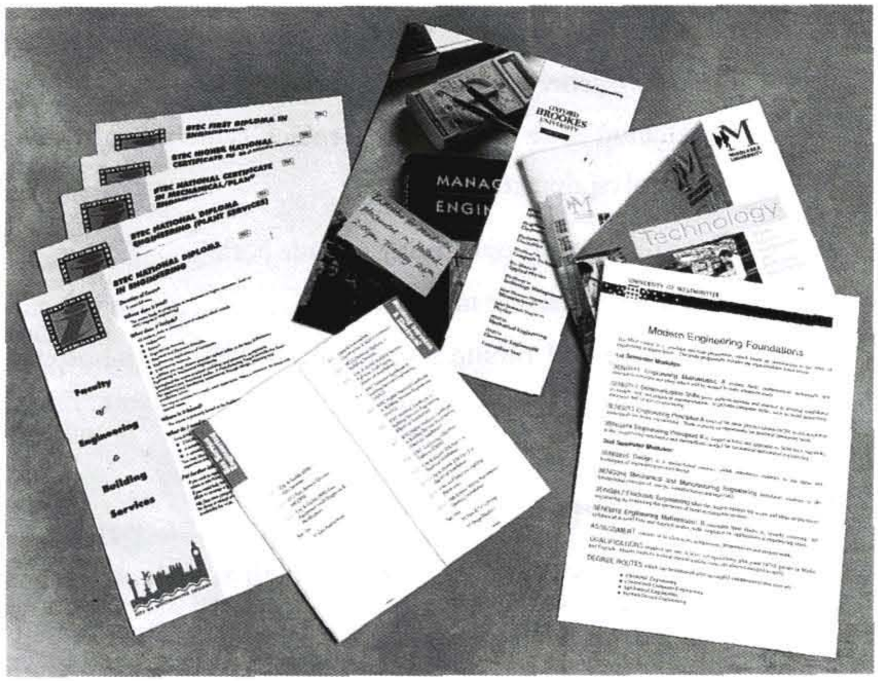
Task 8

Listen to these short extracts. To which branch of engineering do these engineers belong?

Task 9

Listen again. This time note the words which helped you decide on your answers.

2 Choosing a course



Tuning-in

Task 1

Study this list of points to consider when deciding whether to study engineering. Tick [√] the statements which refer to you. Then ask your partner which statements refer to him or her.

1. You enjoy practical projects – creating and investigating things.
2. You like finding out how things work.
3. You are interested in improving the environment.
4. You like helping people.
5. You enjoy solving problems.
6. You enjoy organizing activities.
7. You enjoy science programmes on TV or on the radio.
8. You sometimes read articles on scientific or engineering topics.
9. You have a lot of determination and stamina.

If you have ticked most of these statements, engineering is the right course of study for you.

Source: Adapted from *Cyberpunks and Technophobes*, BBC Education

Task 2

Fill in the gaps in this text. Each gap represents one word. Compare your answers with your partner. More than one answer is possible for many of the gaps.

In the United Kingdom you can [1] ________ engineering at a college of further education or a university. Most college courses [2] ________ from one to two years. University undergraduate courses [3] ________ engineering last from three to four years.

A college will take [4] ________ after four years of secondary school education. Most students study full-time, [5] ________ day-release courses are available for people who [6] ________ in local engineering companies. Students will be given a certificate [7] ________ a diploma at the [8] ________ of their course.

Most university students will have completed six [9] ________ of secondary school. Others will have taken a diploma course at college. [10] ________ give degrees. A Bachelor's degree [11] ________ three to four years. A Master's [12] ________ requires a further year.

Task 3

Listen to the text and note the words used on the tape for each gap.

Reading *Having a purpose*

As a student of engineering or as a professional engineer, you have to read a great deal. Make a list of some of the kinds of texts you may read. It is important that you develop the most effective skills for getting the information you want quickly and accurately when you read.

Task 4

There are examples on the following pages of some of the kinds of texts you may read in your studies or working life. Match them to this list:

1 table
2 index
3 contents
4 book title
5 manual
6 price list of components
7 college brochure
8 job advertisement

a

b

Electrical Applications 3

David W. Tyler
C Eng, MIEE

c

Order Code	Type	Price each
RK65V	PCB Latch Pl 2w	20p
BX96E	PCB Latch Pl 3w	25p
YW11M	PCB Latch Pl 4w	29p
FY93B	PCB Latch Pl 5w	35p
YW12N	PCB Latch Pl 6w	42p
YW13P	PCB Latch Pl 8w	48p
RK66W	PCB Latch Pl 10w	54p
YW14Q	PCB Latch Pl 12w	58p
BH 61R	PCB Latch Pl 17w	60p

d

SALES ENGINEER

Sinclair is one of the UK's largest private engineering groups, with an international reputation. The sealing systems operation requires a Technical Sales Engineer to sell the world-renowned Chesterfield range of products throughout the Midlands.

You should have previous sales and mechanical engineering experience with a bias to maintenance products and mechanical engineering.

The successful candidate will ideally be between 30 and 45 years of age living in the Midlands with a mechanical engineering background.

The company offer a good basic salary, commission and company car. Apply in writing, with full CV to:

J. FORD
SINCLAIR SEALING SYSTEMS LTD.
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BIRMINGHAM B2 0ER Closing date 17 December 19—

SINCLAIR

e

f

Step	Action
1	Open the top cover
2	Set the MTR switch to MTR mode, that is, move it to the left.
3	Close the top cover
4	Switch the system off
5	Wait 5 seconds

g

Bearing bore mm	Shaft limits mm	
	Heavy loading	Light loading
-12	—	+0.003 –0.005
12.1–30	—	+0.005 –0.003
30.1–50	—	+0.007 –0.003
50.1–75	+0.018 –0.003	+0.013 –0.000
75.1–100	+0.023 –0.005	+0.016 –0.003
100.1–120	+0.028 –0.010	+0.020 –0.005

h

EEB NATIONAL CERTIFICATE MODULES IN REFRIGERATION (EVENING)

This course provides students with a basic knowledge of the technology of refrigeration, including system elements, procedures and the need for safe working practice.

Task 5

When you read, it is important to have a clear purpose. Here are some of the purposes you may have for reading the above texts. Match one purpose to each text.

1 finding a job
2 pricing a component
3 finding out how to do something
4 choosing the best chapter to read
5 looking for specific information on a topic
6 learning about electrical equipment
7 choosing a course
8 looking for a specification

Task 6

Choosing a course requires careful reading of college and university brochures. Your purpose here is to find the most appropriate course for each of the following prospective students. Use the Course Guide which follows and answer using the course code.

1 A student who has just left school and wants to become a technician.
2 A student who wants to design ships.
3 A student who wants to get an engineering degree and also improve his knowledge of languages.
4 A student who wants a degree eventually but whose qualifications at present are enough to start an HND course.
5 A student who wants to work as an engineer with the air force.
6 A technician employed by a company which installs electrical wiring in factories.
7 A student with a National Certificate in Electrical Engineering who is prepared to spend another two years studying to improve her qualifications.
8 A student interested in how micro-organisms can be used in industry.

CourseGuide **ENGINEERING**

EE22 Higher National Diploma in Electronic and Electrical Engineering. Two years, full-time. For potential electronic and electrical engineers. The first year is common and the second year allows students to specialize in either electronic or electrical engineering subjects. Successful students may continue to a degree course.

EE17 National Certificate in Electrical Engineering. One year, full-time. For potential technicians or for those who wish to gain entry to an HND course.

EE3 Higher National Certificate Course in Electrical Engineering. Two years, day-release. This course provides the technical education required for senior technicians employed in the electrical installation industry.

H300 Bachelor of Engineering (B Eng) – Mechanical Engineering for Europe. Four years, full-time, including one year study and work attachment in France or Germany.

H400 Bachelor of Engineering (B Eng) – Aeronautical Engineering. Three years, full-time, or four years including one year of professional training in the aircraft industry.

HJ36 Bachelor of Engineering (B Eng) – Naval Architecture and Ocean Engineering. Three years, full-time.

H340 Bachelor of Science (Engineering) – Mechanical

H250 Bachelor of Engineering (B Eng) – Manufacturing Management. A two-year HND course in engineering followed by two years of technology and management designed to produce managers qualified in high technology.

Further information may be obtained by contacting one of these information centres and requesting the appropriate course leaflet by code number.

All **E** courses:	All **H** courses:
Information Centre Fraser College Parlett Street Glasgow GL2 2KL	Information Centre Maxwell University Hunter Square Glasgow GL1 5PN

Writing *Letter writing, 1: requesting information*

Write a letter to either the college or the university mentioned in Task 6 asking for information on a course which interests you. Set out your letter like this:

21 Route de St Fargeau
18900 Russe
FRANCE

30 August 199-

Information Centre
Fraser College
Parlett Street
GLASGOW
GL2 2KL
UK

Dear Sir/Madam,

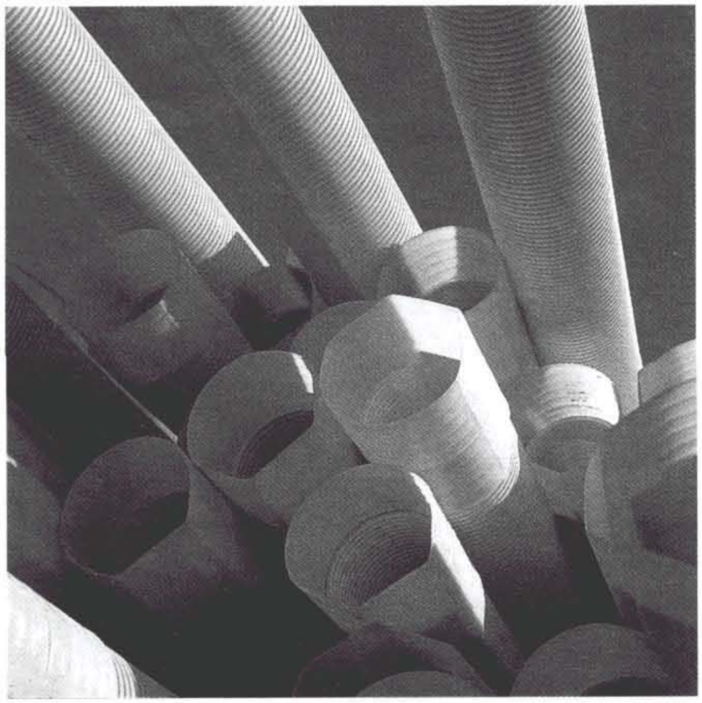
Please send me further information on course EE2 - National Certificate in Electrical Engineering.

Yours faithfully

Daniel Romero

Daniel Romero

3 Engineering materials



Ribbed plastic pipes stacked near a road construction site where they will be laid for drainage along the sides of a new section of motorway.

Tuning-in

Task 1

List the materials you know which are used in engineering. Combine your list with the others in your group and classify the materials as metals, thermoplastics, etc.

Reading *Scanning tables*

In engineering it is important to practise reading tables, charts, diagrams, and graphs because so much information is presented in these ways. We will start in this unit with a table.

Scanning is the best strategy for finding information in a table. With scanning, you know before you read what sort of information you are searching for. To scan a table, you move your eyes up and down the columns until you find the word or words you want. To scan quickly, you must learn to ignore any information which will not help you with your task.

Task 2 Scan the table which follows to find a material which is:

1 soft
2 ductile
3 malleable
4 tough
5 scratch-resistant
6 conductive and malleable
7 durable and hard
8 stiff and brittle
9 ductile and corrosion-resistant
10 heat-resistant and chemical-resistant

Materials	Properties	Uses
Metals		
Aluminium	Light, soft, ductile, highly conductive, corrosion-resistant.	Aircraft, engine components, foil, cooking utensils
Copper	Very malleable, tough and ductile, highly conductive, corrosion-resistant.	Electric wiring, PCBs, tubing
Brass (65% copper, 35% zinc)	Very corrosion-resistant. Casts well, easily machined. Can be work hardened. Good conductor.	Valves, taps castings, ship fittings, electrical contacts
Mild steel (iron with 0.15% to 0.3% carbon)	High strength, ductile, tough, fairly malleable. Cannot be hardened and tempered. Low cost. Poor corrosion resistance.	General purpose
High carbon steel (iron with 0.7% to 1.4% carbon)	Hardest of the carbon steels but less ductile and malleable. Can be hardened and tempered.	Cutting tools such as drills, files, saws
Thermoplastics		
ABS	High impact strength and toughness, scratch-resistant, light and durable.	Safety helmets, car components, telephones, kitchenware
Acrylic	Stiff, hard, very durable, clear, can be polished easily. Can be formed easily.	Aircraft canopies, baths, double glazing
Nylon	Hard, tough, wear-resistant, self-lubricating.	Bearings, gears, casings for power tools
Thermosetting plastics		
Epoxy resin	High strength when reinforced, good chemical and wear resistance.	Adhesives, encapsulation of electronic components
Polyester resin	Stiff, hard, brittle. Good chemical and heat resistance.	Moulding, boat and car bodies
Urea formaldehyde	Stiff, hard, strong, brittle, heat-resistant, and a good electrical insulator.	Electrical fittings, adhesives

Task 3

Scan the table to find:

1. A metal used to make aircraft
2. Plastics used for adhesives
3. Steel which can be hardened
4. An alloy suitable for castings
5. A plastic with very low friction
6. A material suitable for safety helmets
7. A metal suitable for a salt-water environment
8. A metal for general construction use but which should be protected from corrosion
9. A plastic for car bodies
10. The metal used for the conductors in printed circuit boards

Language study *Making definitions*

Study these facts from the table about aluminium:

1 Aluminium is a light metal.
2 Aluminium is used to make aircraft.

We can link these facts to make a definition of aluminium:

1+2 *Aluminium is a light metal* ***which*** *is used to make aircraft.*

Task 4

Use the table on the previous page to make definitions of each of the materials in column **A**. Choose the correct information in columns **B** and **C** to describe the materials in column **A**.

A		B	C
1	An alloy		allows heat or current to flow easily
2	A thermoplastic		remains rigid at high temperatures
3	Mild steel		does not allow heat or current to flow easily
4	A conductor	a metal	contains iron and 0.7% to 1.4% carbon
5	An insulator	a material	becomes plastic when heated
6	High carbon steel	an alloy	contains iron and 0.15% to 0.3% carbon
7	Brass		formed by mixing ~~other~~ metals or elements
8	A thermosetting plastic		consists of copper and zinc

Writing *Adding information to a text*

Study this text about aluminium.

Aluminium is used to make aircraft, engine components, and many items for the kitchen.

We can add extra information to the text like this:

> Aluminium, **which is light, soft, and ductile**, is used to make aircraft, engine components – **for example, cylinder heads** – and many items for the kitchen, **such as pots**.

Note that the extra information is marked with commas or dashes:

, which ... ,
– for example, ... –
, such as ... ,

Task 5

Add this extra information to the following text about plastics.

1 Plastics can be moulded into plates, car components, and medical aids.
2 Thermoplastics soften when heated again and again.
3 Thermosetting plastics set hard and do not alter if heated again.
4 ABS is used for safety helmets.
5 Nylon is self-lubricating.
6 Nylon is used for motorized drives in cameras.
7 Acrylic is a clear thermoplastic.
8 Acrylic is used for aircraft canopies and double glazing.
9 Polyester resin is used for boat and car bodies.
10 Polyester resin is hard and has good chemical and heat resistance.

Plastics are synthetic materials. They can be softened and moulded into useful articles. They have many applications in engineering. There are two types of plastics: thermoplastics and thermosetting plastics.

ABS is a thermoplastic which is tough and durable. Because it has high impact strength, it has applications where sudden loads may occur.

Nylon is a hard, tough thermoplastic. It is used where silent, low-friction operation is required.

Acrylic can be formed in several ways. It is hard, durable, and has many uses.

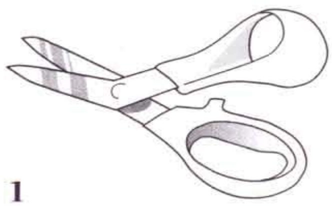
Polyester resin is a thermosetting plastic used for castings. It has a number of useful properties.

4 Mechanisms

Tuning-in

Task 1

Identify these simple mechanisms. Try to explain the principles on which they operate.



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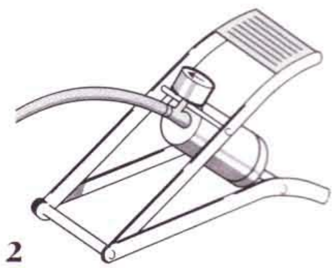

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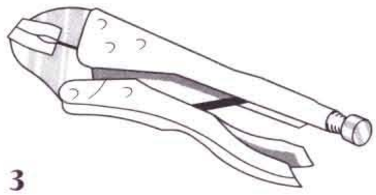

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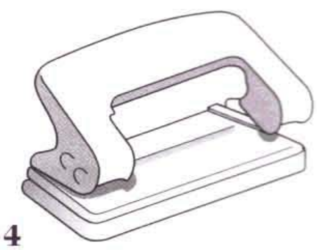

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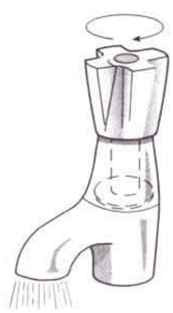


5

Reading *Scanning a text*

Scanning is the best strategy for searching for specific information in a text. Move your eyes up and down the text until you find the word or words you want. Again, try to ignore any information which will not help you with your task.

Task 2

Scan the text opposite quickly to find out which of these mechanisms are mentioned.

1. cam
2. tap
3. pendulum
4. foot pump
5. escalator

Mechanisms

Mechanisms are an important part of everyday life. They allow us to do simple things like switch on lights, turn taps, and open doors. They also make it possible to use escalators and lifts, travel in cars, and fly from continent to continent.

Mechanisms play a vital role in industry. While many industrial processes have electronic control systems, it is still mechanisms that deliver the power to do the work. They provide the forces to press steel sheets into car body panels, to lift large components from place to place, to force plastic through dies to make pipes.

All mechanisms involve some kind of motion. The four basic kinds of motion are:

Rotary: Wheels, gears, and rollers involve rotary movement.

Oscillating: The pendulum of a clock oscillates – it swings backwards and forwards.

Linear: The linear movement of a paper trimmer is used to cut the edge of the paper.

Reciprocating: The piston in a combustion engine reciprocates.

Many mechanisms involve changing one kind of motion into another type. For example, the reciprocating motion of a piston is changed into a rotary motion by the crankshaft, while a cam converts the rotary motion of the engine into the reciprocating motion required to operate the valves.

Task 3

Now read the text to find the answers to these questions.

1. What does a cam do?
2. What does oscillating mean?
3. How are plastic pipes formed?
4. What simple mechanisms in the home are mentioned directly or indirectly?
5. What is the function of a crankshaft?
6. Give an example of a device which can produce a linear movement.
7. How are car body panels formed?
8. What do mechanisms provide in industry?

Writing *Ways of linking ideas, 1*

When we write, we may have to describe, explain, argue, persuade, complain, etc. In all these forms of writing, we use ideas. To make our writing effective, we have to make sure our readers can follow our ideas. One way of helping our readers is to make the links between the ideas in our writing.

What are the links between these pairs of ideas? What words can we use to mark the links?

1 Mechanisms are important to us.
2 They allow us to travel.

3 Mechanisms deliver the power to do work.
4 They play a vital role in industry.

5 Friction is sometimes a help.
6 It is often a hindrance.

Sentence 2 is a *reason* for sentence 1. We can link 1 and 2 like this:

Mechanisms are important to us ***because*/*since*/*as*** *they allow us to travel.*

Sentence 4 is the *result* of sentence 3. We can link 3 and 4 like this:

Mechanisms deliver the power to do work ***so*** *they play a vital role in industry.*

Mechanisms deliver the power to do work; ***therefore*** *they play a vital role in industry.*

Sentence 6 *contrasts* with sentence 5. We can link 5 and 6 like this:

Friction is sometimes a help ***but*** *it is often a hindrance.*

Task 4

Show the links between these sets of ideas using appropriate linking words.

1 Copper is highly conductive.
It is used for electric wiring.

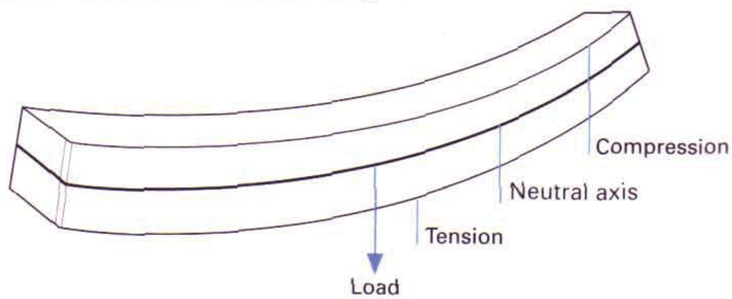
2 Weight is measured in newtons.
Mass is measured in kilograms.

3 Nylon is used for bearings.
It is self-lubricating.

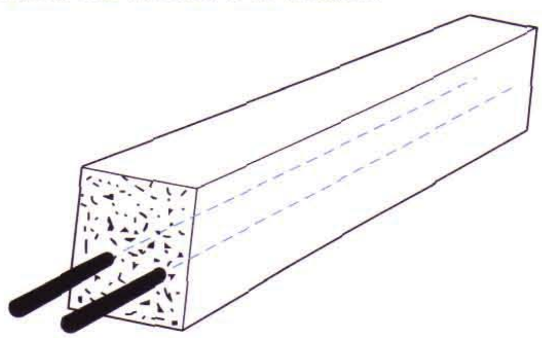
4 ABS has high impact strength.
It is used for safety helmets.

5 The foot pump is a class 2 lever.
The load is between the effort and the fulcrum.

6 Friction is essential in brakes.
Friction is a nuisance in an engine.



7 The upper surface of a beam is in compression.
The lower surface is in tension.



8 Concrete beams have steel rods near the lower surface.
Concrete is weak in tension.

Language study *Dealing with technical terms*

One of the difficult things about the English of engineering is that there are many technical terms to learn. Newer terms may be the same, or almost the same, in your own language. But many terms will be quite different and you may not always remember them.

When this happens, you will have to use whatever English you know to make your meaning clear.

The same thing may happen in reverse when you know a technical term but the person you are communicating with does not recognize it. This may happen in the *Speaking practice* tasks in this book. Again, when this happens, you will have to make your meaning clear using other words.

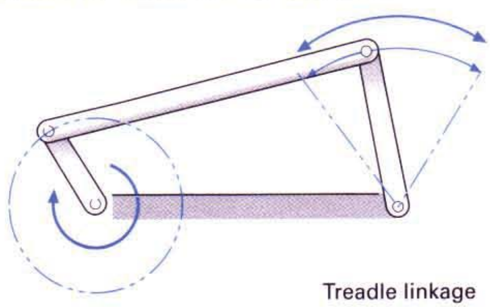
Task 5

The technical words in column **A** are similar in meaning to the more general English in column **B**. Match them.

	A		B
1	oscillates	**a**	changes
2	rotates	**b**	large, thin, flat pieces
3	reciprocates	**c**	moving stairs
4	has a linear motion	**d**	goes round and round
5	converts	**e**	movement
6	motion	**f**	goes in a line
7	escalator	**g**	swings backwards and forwards
8	sheets	**h**	goes up and down

Task 6

Try to explain how this simple mechanism operates using whatever English you know. Write your explanation down. Compare your explanation with the technical explanation given on page 4 of the Answer Book. Learn any technical terms which are unfamiliar to you.



Treadle linkage

Speaking practice

Task 7

Work in pairs, **A** and **B**. Each of you has a diagram of a cam. Describe your diagram to your partner. Your partner should try to reproduce your diagram from the spoken description you provide.

Student A: Your diagram is on page 177.
Student B: Your diagram is on page 181.

Thes text on the next page will help you with the vocabulary you need.

Cams are shaped pieces of metal or plastic fixed to, or part of, a rotating shaft. A 'follower' is held against the cam, either by its own weight or by a spring. As the cam rotates, the follower moves. The way in which it moves and the distance it moves depends on the shape of the cam. Rotary cams are the most common type. They are used to change rotary motion into either reciprocating or oscillating motion.

If you do not understand what your partner says, these questions and phrases may be helpful.

1 Could you say that again/repeat that, please?
2 What do you mean by X?
3 Where exactly is the X?
4 What shape is the X?
5 How does the X move?

If your partner does not understand you, try to rephrase what you say.

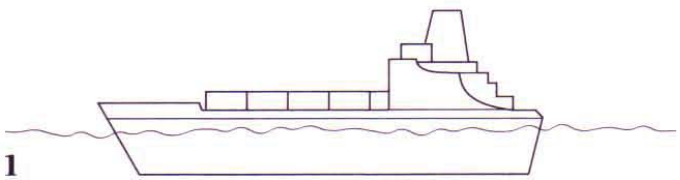
5 Forces in engineering

Tuning-in

Task 1

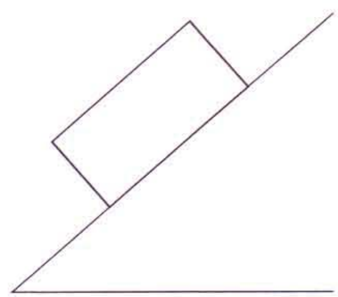
Working in your group, try to explain these problems.

1 Why doesn't the ship sink?
2 What makes the spring stretch and what keeps the weight up?
3 Why doesn't the box slide down the slope?



1

2



3

Reading 1 *Predicting*

As you learnt in Unit 1, it is important to think about what you are going to read before you read. Do not start to read a text immediately. One way to help your reading is to think about the words which might appear in the text. The title might help to focus your thoughts. Which words might appear in a text with the title *Forces in engineering*?

Task 2

The text you are going to read is called *Forces in engineering*. Here are some of the words it contains. Can you explain the link between each word and the title of the text?

weight	buoyancy	equilibrium
elasticity	magnitude	resultant
newton	gravity	

Task 3 Now read the text. Use the information in the text to check the explanations you made in Task 1.

Forces in engineering

To solve the ship problem, we must look at the forces on the ship (Fig. 1). The weight, W, acts downwards. That is the gravity force. The buoyancy force, B, acts upwards. Since the ship is in equilibrium, the resultant force is zero, so the magnitudes of B and W must be the same.

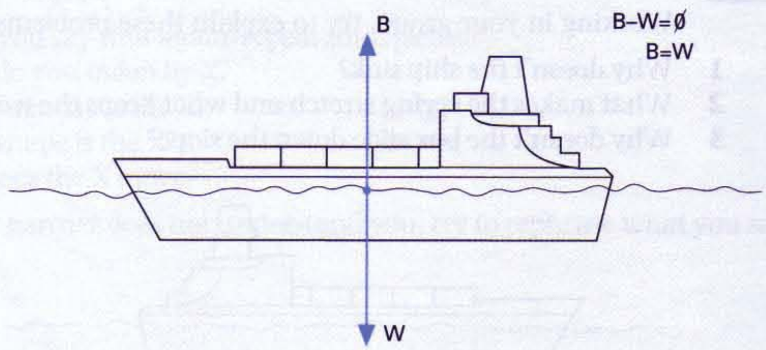


Fig. 1

Another very important force in engineering is the one caused by elasticity. A good example of this is a spring. Springs exert more force the more they are stretched. This property provides a way of measuring force. A spring balance can be calibrated in newtons, the unit of force. The block in Fig. 2 has a weight of 10 newtons. The weight on the balance pulls the spring down. To give equilibrium, the spring pulls up to oppose that weight. This upward force, F1, equals the weight of the block, W.

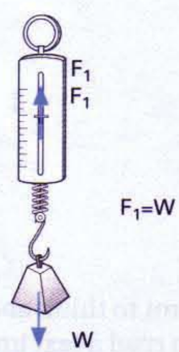


Fig. 2

It is important to get the distinction between mass and weight absolutely clear. Mass is the quantity of matter in an object. Weight is the force on that object due to gravity. Mass is measured in kilograms, whereas weight, being a force, is measured in newtons.

We have looked at buoyancy, elasticity, and gravity. There is a fourth force important in engineering, and that is friction. Friction is a help in some circumstances but a hindrance in others. Let us examine the forces on the box (Fig. 3). Firstly, there is its weight, W, the gravity force, then there is the reaction, R, normal to the plane. R and W have a resultant force trying to pull the box down the slope. It is the friction force, F, acting up the slope, that stops it sliding down.

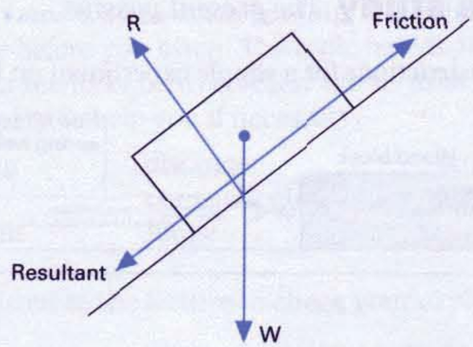


Fig. 3

Reading 2 *Grammar links in texts*

One of the ways in which sentences in a text are held together is by grammar links. In this extract, note how each expression in italics links with an earlier expression.

> Another very important force in engineering is *the one* caused by elasticity. A good example of *this* is a spring. Springs exert more force the more *they* are stretched. *This* property provides a way of measuring force.

Sometimes these links cause problems for readers because they cannot make the right connection between words in different parts of a text.

Study these common grammar links:

1. A repeated noun becomes a pronoun.
   Springs becomes *they*.
2. A word replaces an earlier expression.
   Force in engineering becomes *one*.
3. A word replaces a whole sentence or clause.
   Springs exert more force the more they are stretched becomes *This property*.

Task 4

With which earlier expressions do the words in italics link? Join them as in the example above.

> Friction in machines is destructive and wasteful. *It* causes the moving parts to wear and *it* produces heat where *it* is not wanted. Engineers reduce friction by using very highly polished materials and by lubricating *their* surfaces with oil and grease. *They* also use ball bearings and roller bearings because rolling objects cause less friction than sliding *ones*.
>
> Source: S. Larkin and L. Bernbaum (eds.), The Penguin Book of the Physical World

Language study *The present passive*

Study these instructions for a simple experiment on friction.

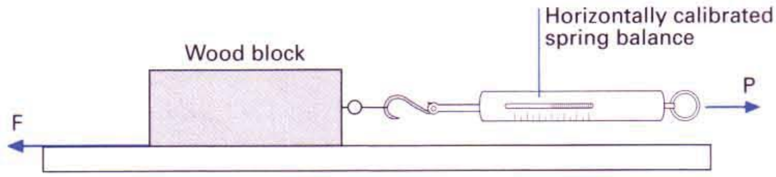


Fig. 4

1 Place a block of wood on a flat surface.
2 Attach a spring balance to one end of the block.
3 Apply a gradually increasing force to the balance.
4 Note the force at which the block just begins to move.
5 Pull the block along so that it moves at a steady speed.
6 Note the force required to maintain movement.
7 Compare the two forces.

When we describe this experiment, we write:

> A block of wood *is placed* on a flat surface. A spring balance *is attached* to one end of the block.

This description uses the present passive. We form the present passive using *is/are* + past participle.

Task 5

Complete this description of the experiment using the present passive.

A block of wood [1] ____________ on a flat surface. A spring balance [2] ____________ to one end of the block. A gradually increasing force [3] ____________ to the balance. The force at which the block just begins to move [4] ____________.

The block [5] ____________ along at a steady speed. The force required to maintain movement [6] ____________. The two forces [7] ____________. It is found that the first force is greater than the second.

What does this experiment show?

Listening *Listening to lectures*

The listening passage you are going to hear is an extract from a typical engineering lecture. Here are some of the features of lectures.

1 Incomplete sentences: Spoken language is not divided neatly into sentences and paragraphs. For example:
Now what I thought I might do today ... What we are going to talk of ...

2 Repetition and rephrasing: Lecturers often say the same thing more than once and in more than one way. For example:
It will turn, revolve.

3 Signpost expressions: Lecturers often use expressions to help the students know what they are going to do next, what is important, etc. For example:
What we are going to talk of is the extension of a force.

Task 6

In the same way as when reading, it is helpful to think about the topic of a lecture before you listen. The topic here is *The Moment of a Force*. Can you explain the links between these words from the lecture and the topic? Use a dictionary to help you if necessary.

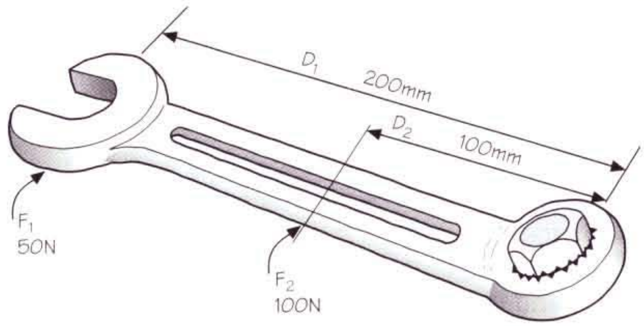
turning	distance	product
pivot	perpendicular	leverage
fulcrum	hinge	

Task 7

Now listen to the lecture to check your explanations.

Task 8

During the lecture, the lecturer drew this diagram on the board. Which of the words in Task 6 can be used to talk about the diagram?



Task 9

Here are some signpost expressions from the lecture. What do you think the lecturer is indicating each time? Select from the labels below, **a** to **e**.

1. We're going to talk about the moment of a force.
2. If you can think of a spanner ...
3. But what you have to remember is ...
4. Something simple to illustrate.
5. I'm thinking of a practical job.
6. Why do we put a handle there on the door?
7. Is that understood? All right?
8. Well that is then a little explanation of how you calculate moments.

a Emphasizing an important point
b Showing that the lecture is over
c Checking that the students can follow him
d Introducing the topic of the lecture
e Giving examples to illustrate the points

Task 10

Listen to the tape again and answer these questions according to the information given by the lecturer.

1. What advantage does a longer spanner offer in loosening a tight nut?
2. What is the formula for calculating the moment of a force?
3. Why is it sometimes difficult to apply a force at right angles in a motor car engine?
4. Why is the handle of a door at the edge?
5. Write down the formulae for calculating force and distance.

6 The electric motor

Tuning-in

Task 1

Working in your group, list as many items as you can in the home which use electric motors. Which room has the most items?

Reading *Skimming*

In Unit 3 you studied scanning – locating specific information quickly. Another useful strategy is reading a text quickly to get a general idea of the kind of information it contains. You can then decide which parts of the text are worth reading in more detail later, depending on your reading purpose. This strategy is called *skimming*.

Task 2

Skim this text and identify the paragraphs which contain information on each of these topics. The first one has been done for you.

a What electric motors are used for *paragraph 1*

b The commutator ____________

c Why the armature turns ____________

d Electromagnets ____________

e Effect of putting magnets together ____________

f The armature ____________

para

**In an electric motor an electric current and magnetic field produce 1
a turning movement. This can drive all sorts of machines, from wrist-watches to trains. The motor shown in Fig. 1 is for a washing machine. It is a universal motor, which can run on direct current or alternating current.**

**An electric current running through a wire produces a magnetic 2
field around the wire. If an electric current flows around a loop of wire with a bar of iron through it, the iron becomes magnetized. It is called an electromagnet; one end becomes a north pole and the other a south pole, depending on which way the current is flowing around the loop.**

▶

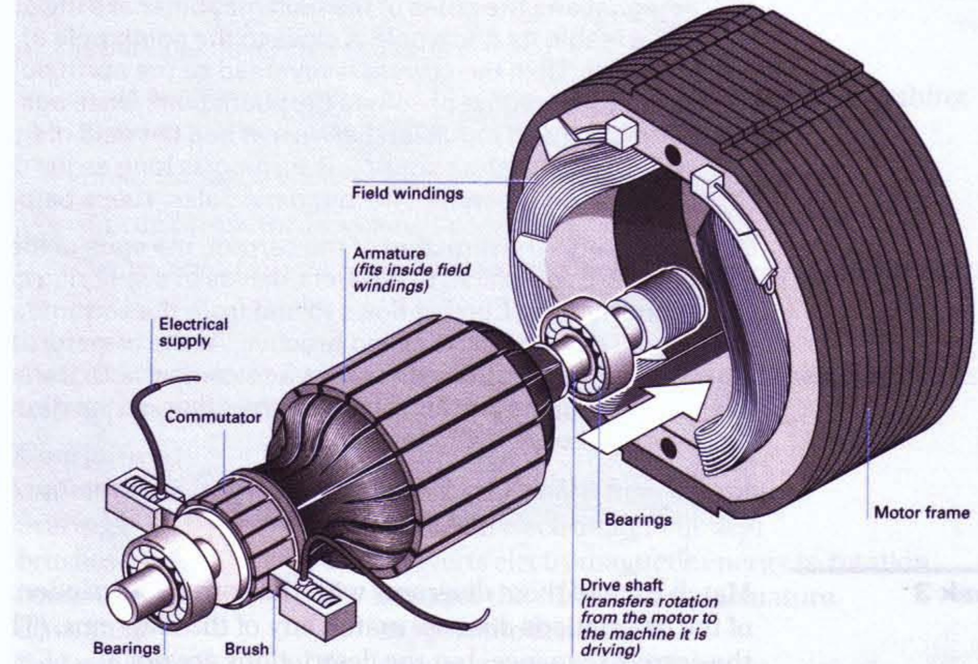


Fig. 1

If you put two magnets close together, like poles – for example, two north poles – repel each other, and unlike poles attract each other. 3

In a simple electric motor, like the one shown in Fig. 2, a piece of iron with loops of wire round it, called an armature, is placed between the north and south poles of a stationary magnet, known as the field magnet. When electricity flows around the armature wire, the iron becomes an electromagnet. 4

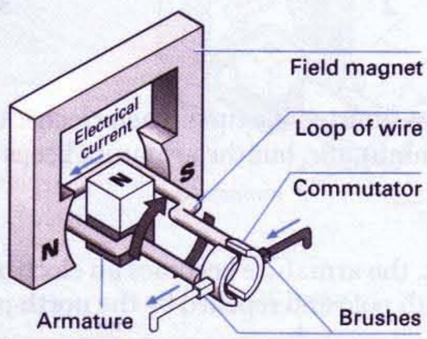


Fig. 2

The attraction and repulsion between the poles of this armature magnet and the poles of the field magnet make the armature turn. As a result, its north pole is close to the south pole of the field magnet. Then the current is reversed so the north pole of the armature magnet becomes the south pole. Once again, the attraction and repulsion between it and the field magnet make it turn. The armature continues turning as long as the direction of the current, and therefore its magnetic poles, keeps being reversed. 5

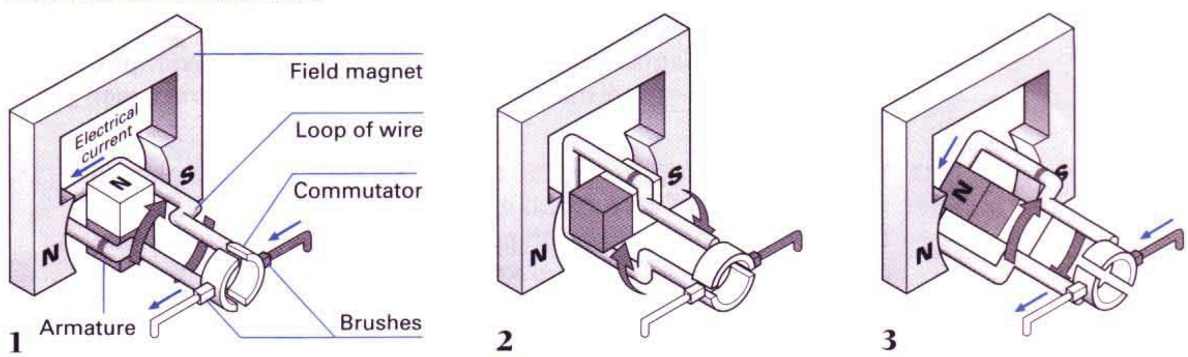
To reverse the direction of the current, the ends of the armature wire are connected to different halves of a split ring called a commutator. Current flows to and from the commutator through small carbon blocks called brushes. As the armature turns, first one half of the commutator comes into contact with the brush delivering the current, and then the other, so the direction of the current keeps being reversed. 6

Source: Adapted from 'Inside out: Electric Motor', *Education Guardian*

Task 3

Match each of these diagrams with the correct description, **A**, **B**, **C**, or **D**. One of the descriptions does *not* match any of the diagrams. (The diagrams are in the correct sequence, but the descriptions are not.)

Motor run on direct current



A
The armature turns a quarter of a turn. Then electric contact is broken because of the gap in the commutator, but the armature keeps turning because there is nothing to stop it.

B
When current flows, the armature becomes an electromagnet. Its north pole is attracted by the south pole and repelled by the north pole of the field magnet.

C
When a universal motor is run on direct current, the magnetic poles in the armature change while those of the field magnet remain constant.

D
When the commutator comes back into contact with the brushes, current flows through the armature in the opposite direction. Its poles are reversed and the turn continues.

Language study *Describing function*

Try to answer this question:

What does an electric motor do?

When we answer a question like this, we describe the function of something. We can describe the function of an electric motor in this way:

An electric motor converts electrical energy to mechanical energy.

We can emphasize the function like this:

The function of an electric motor is to convert electrical energy to mechanical energy.

Task 4

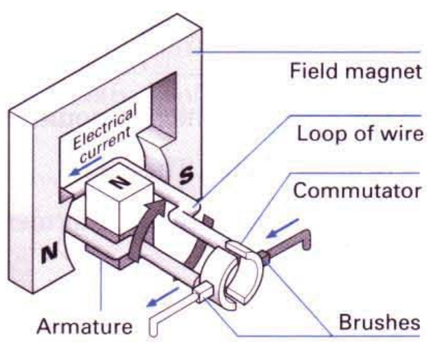
Match each of these motor components to its function, and then describe its function in a sentence.

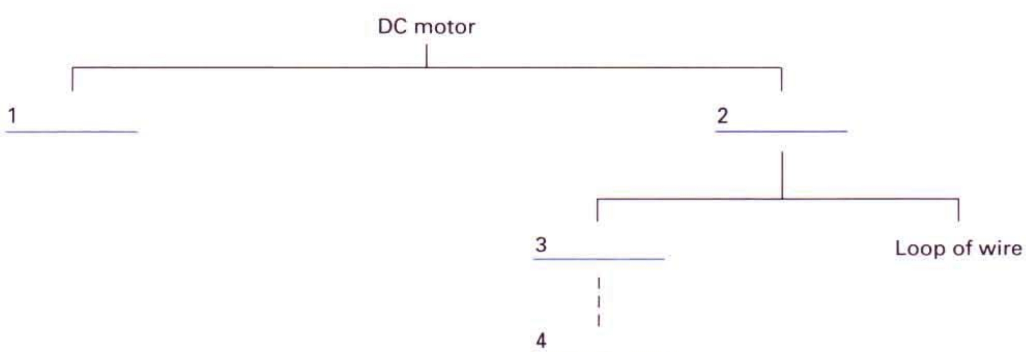
	Component		Function
1	armature	a	transfers rotation from the motor
2	bearings	b	create an electromagnetic field
3	brushes	c	converts electromagnetic energy to rotation
4	commutator	d	reverses the current to the armature
5	drive shaft	e	support the drive shaft
6	field windings	f	supply current to the armature

Writing *Describing components*

Task 5

Dismantle this simple dc motor into its components by completing the labelling of the chart below.





Now study this description of the motor.

A simple dc motor *consists of* a field magnet and an armature. The armature *is placed between* the poles of the magnet. The armature *is made up of* a loop of wire and a split ring *known as* a commutator. The loop *is connected to* the commutator. Current is supplied to the motor through carbon blocks *called* brushes.

To write a description, you need to use language to:

1 dismantle a piece of equipment into its main parts. These expressions will help:

A	*consists of*		X
A	*is made up of*	X and Y	
	is composed of		Y

2 name components:

Carbon blocks	*known as* *called*	brushes.

3 locate components:

The armature *is placed between* the poles.

4 connect components:

The loop *is connected to* the commutator.

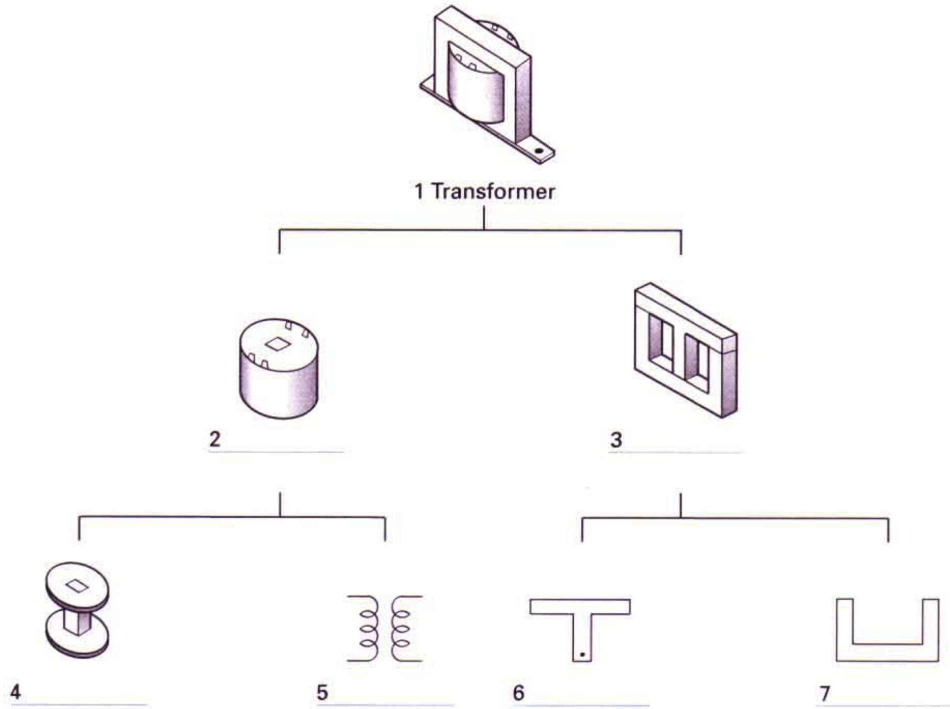
Task 6

Complete the text with the help of the diagram on the next page. Use the following words:

are made up
is placed
is composed
consists

A transformer ____________ of two coils, a primary and a secondary. The coils are wound on a former which is mounted on a core. The coils ____________ of a number of loops of wire. The core ____________ of thin pieces of soft iron. U- and T-shaped pieces are used. The former ____________ on the leg of the T.

Now label the diagram opposite using the completed text.



Word study

Study these expressions for describing how components are connected to each other.

A is bolted to B. = A is connected to B with bolts.
A is welded to B. = A is connected to B by welding.
A is fixed to B. = no specific method given

Task 7

Explain each of these methods of connection.

1 screwed
2 soldered
3 attached
4 wired
5 bonded
6 glued
7 riveted
8 welded
9 brazed
10 nailed

7 An engineering student

Tuning-in

Task 1

List some of the subjects studied by engineering students. Share your list with others in your group.

Task 2

Find out what these terms mean in education. Use a dictionary if necessary.

1 pass
2 resit
3 assessment
4 fail
5 drop out
6 period
7 full-time
8 module

Listening

When listening, it is important to have a clear purpose so that you can concentrate on the parts of the message which best meet your needs. It also helps to think about what you will hear before you listen. The next two tasks will help you to prepare for listening and to have a clear purpose.

Task 3

You are going to hear an interview with David, a student of electrical engineering at a Scottish college of further education. He is a mature student with previous service in the Navy.

Here is David's weekly timetable. Some of the information is missing. Before you listen, try to answer these questions about the timetable.

1 What time does David start each day?
2 When does he finish?
3 How long is a class?
4 How many classes does he have each week?
5 What do the numbers mean after each class, e.g. 150?
6 How often does he have breaks?

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8.45-10.15	Design and make	______	______	Technology	Technology
	150	053		138	051
			Break		
10.30–12.00	Design and make	______	Tutorial	______	______
	150	140	063	406	051
			LUNCH BREAK		
13.00–14.30	______	Maths	Communications	______	Maths
	510	510	606	510	510
			Break		
14.45–16.15	Technology	Principles	Technology	Principles	Self-study
	053	138	039	051	

Task 4

Listen to Parts 1 and 2 of the interview in turn. Answer these questions. Compare your answers with a partner.

Part 1

1 What is the name of David's course?
2 How long is the course?
3 How old is David?
4 How long was he in the Navy?
5 How many types of submarines are there?

Part 2

6 How many weeks of teaching does he have left?
7 How is the course assessed?
8 What happens if you fail the tests once?
9 How many are in his class?
10 What kind of problems has he had?

Task 5 Listen to Part 3 of the interview. Try to complete the information missing from the timetable. Compare your answers with a partner.

Task 6 Listen to the last part of the interview. Answer these questions.

Part 4

11 When does he practise sport?
12 Where can you go for sport?
13 What kind of sports can you practise there?
14 What is he going to do after the Certificate?
15 What does he want to be?

Task 7 Now listen to the whole tape. Answer these more difficult questions.

1 Why did David leave the Navy?
2 Why did students drop out of the class?
3 Why did he dislike school?
4 Why do most students find PSD a bit of a nuisance?
5 Why does he want to know when it's raining?
6 Why does he not have to use the library?
7 Why does he enjoy technology most?

Writing *Comparing and contrasting*

Task 8 Write your own timetable in English.

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY

Task 9 Now complete this table. Note any similarities and differences between David's week and your own.

David's subjects	Hours per week	Your subjects	Hours per week

Task 10

Write a short comparison and contrast of your timetable and David's. These expressions may be useful:

more time/hours/classes/maths than
less time/maths/physics than
fewer hours/classes than
not as much time/maths/physics as
not as many hours/classes as
start/finish earlier/later than

Note that *less* and *much* are used for things which cannot be counted.

8 Central heating

Tuning-in

Task 1

How can you heat a house in cold weather? List the possible ways.

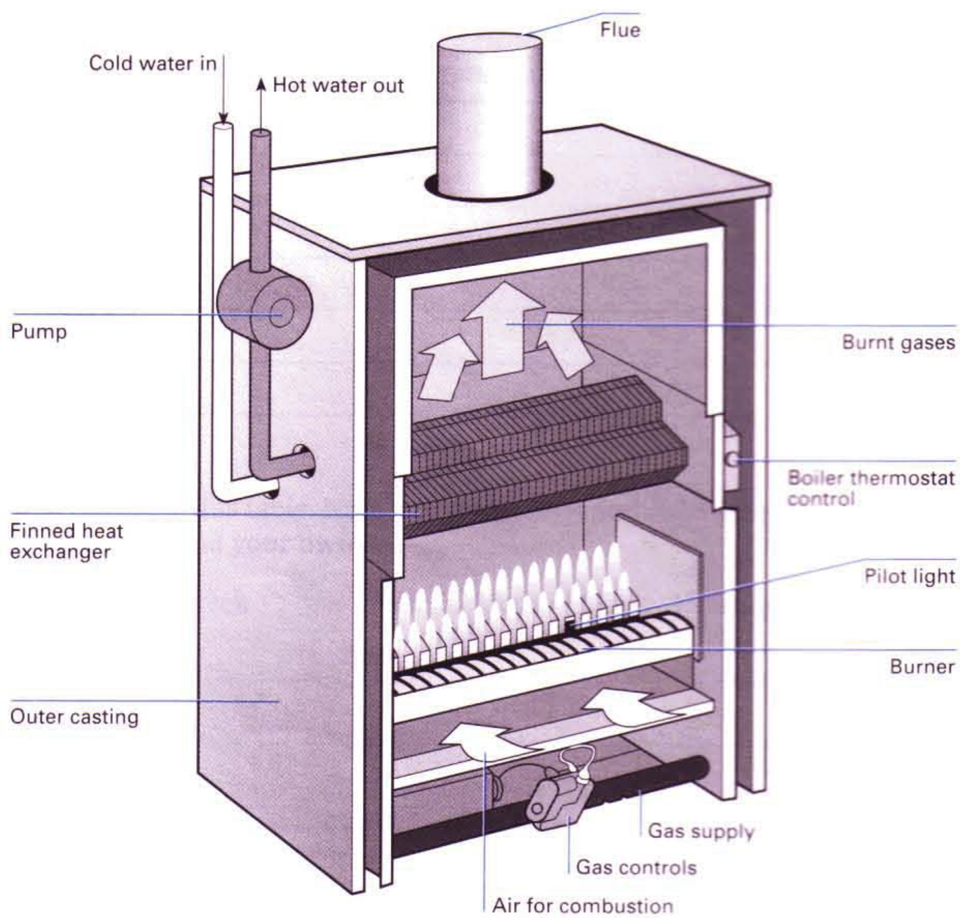
Reading *Predicting*

In Unit 5 we learnt how using the title can help us to predict the contents of a text. Diagrams are also very useful in helping the reader to make the right guesses about what a text will contain. Before you read a text, read the title and look at any diagrams it contains.

Task 2

Using the diagram, try to explain the function of these components:

1 the pilot light
2 the heat exchanger fins
3 the flue
4 the thermostat
5 the pump



Task 3

Scan this text quickly to check the explanations you made in Task 2. You may not find all the information you want.

Gas central heating

Most gas central heating works on the 'wet' system of heat transfer between water flowing through pipes. A typical system includes a boiler, a network of pipes, a feed, and expansion tank, radiators, and a hot water storage system.

In conventional boilers, water is heated by gas burners. It is then pumped around the central heating system and the hot water storage cylinder. The flow of gas to the burner is controlled by a valve (or valves) which can be operated by a time switch or by a boiler thermostat, hot water cylinder thermostat, or by a thermostat located in one of the rooms.

Air is necessary for complete combustion and is supplied to the burners either from inside the house, when adequate ventilation must be ensured, or directly from outside through a balanced flue.

Water is circulated through a heat exchanger above the burner. The heat exchanger is made of tubes of cast iron or copper, which resist corrosion. Both types use fins to increase the surface area in contact with water, which improves the transfer of heat. A thermostat located in the boiler causes the gas control valve to shut off when the water temperature reaches the pre-set level.

After being pumped through a diverter or priority valve, water circulates around either one of two loops of pipework, which act as heat exchangers. One loop passes through the inside of the hot water storage cylinder in a coil arrangement. Heat is transferred to the surrounding water, which can then be drawn off from this cylinder from various hot taps in the house when required. The loop then returns to the boiler for re-heating.

The other loop of the circuit passes to the radiators, which provide room heating. Several radiators are generally connected, where one pipe provides the hot water input and the other carries the cold water back to the boiler. In this way, all radiators receive hot water directly from the boiler.

Source: 'Inside out: Central Heating', *Education Guardian*

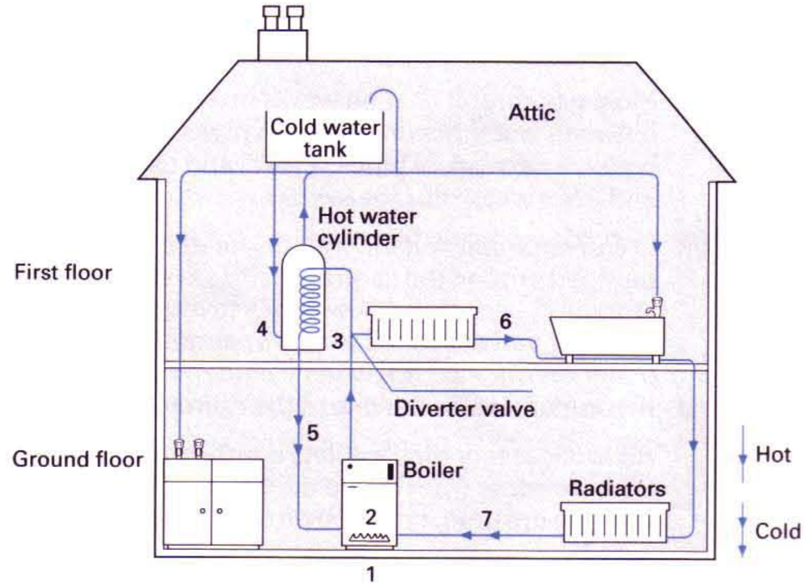
Task 4

Put these statements in the correct sequence. The first and last have been done for you.

a	Water is circulated through a heat exchanger.	*1*
b	The loop returns to the boiler for re-heating.	____
c	One loop passes through the inside of the hot water storage cylinder in a coil of pipes.	____
d	Water is heated by gas burners.	____
e	The hot water is pumped through a diverter valve.	____
f	The other loop of the circuit passes to the radiators.	____
g	Cold water from the radiators returns to the boiler.	*7*

Task 5

Use the statements in Task 4 to label the stages shown in this diagram of a heating system.



Language study *Time clauses*

What is the relationship between these pairs of actions? How can we link each pair to show this relationship?

1 Cold water passes through a heat exchanger.
The water is heated.

2 The water is heated.
It reaches a pre-set temperature.

3 The water is heated.
It is pumped to a diverter valve.

4 The water temperature reaches the right level.
The gas control valve shuts off.

We can show how actions are linked in time by using time clauses.

We can use *as* to link two connected actions happening at the same time. For example:

1 ***As*** *cold water passes through a heat exchanger, the water is heated.*

We can use *until* to link an action and the limit of that action. For example:

2 *The water is heated* ***until*** *it reaches a pre-set temperature.*

Note that *until* normally comes between the stages.

We can use *after* to show that one action is followed by another action. For example:

3 ***After*** *the water is heated, it is pumped to a diverter valve.*

We can use *when* to show that one action happens immediately after another. For example:

4 ***When*** *the water temperature reaches the right level, the gas control valve shuts off.*

Note that when the time word comes first in the sentence, a comma (,) is used after the time clause.

Task 6

Link these sets of actions with appropriate time words.

1 The system is switched on.
Cold water passes through a heat exchanger in the boiler.

2 The water passes through the heat exchanger.
The water becomes hotter and hotter.
The water reaches a pre-set level.

3 The water temperature reaches the pre-set level.
A thermostat causes the gas control valve to shut off.

4 The water is pumped to a diverter valve.
The water goes to the hot water cylinder or the radiators.

5 Hot water passes through the inside of the hot water storage cylinder in a coil arrangement.
Heat is transferred to the surrounding water.

6 The hot water flows through the radiators.
The hot water loses heat.

7 The water passes through the radiators.
The water returns to the boiler.

Word study

Task 7

The words listed in the first column of this table are common in descriptions of technical plant. They describe how substances are moved from one stage of the process to the next. Some of these words can be used for any substance; others are more specific. Write an X under Solids, Liquids, or Gases if the word on the left can be used to talk about them. The first example has been done for you.

	Solids	**Liquids**	**Gases**
carried	*X*	*X*	*X*
circulated			
conveyed			
distributed			
fed			
piped			
pumped			
supplied			

9 Safety at work

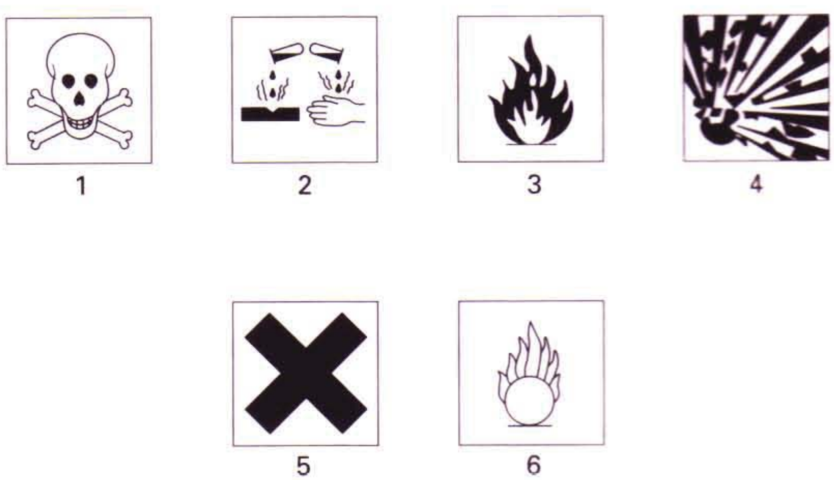
Tuning-in

Task 1

What do these warning labels on chemicals mean? Match each label to the correct warning.

a Highly flammable
b Harmful
c Explosive
d Corrosive
e Oxidizing
f Toxic

MAKE SURE YOU LEARN THE LABELS!
THEY ARE FOR YOUR PROTECTION.



Task 2

List some of the potential dangers in your laboratory, workshop, or place of work. How is the risk of these hazards reduced?

Task 3

Study the safety instructions from a workshop below, and then answer these questions.

a Who are the instructions for?
b Who wrote them?
c What was the writer's purpose?

> 1 Wear protective clothing at all times.
>
> 2 Always wear eye protection when operating lathes, cutters, and grinders and ensure the guard is in place.
>
> 3 Keep your workplace tidy.
>
> 4 The areas between benches and around machines must be kept clear.
>
> 5 Tools should be put away when not in use and any breakages and losses reported.
>
> 6 Machines should be cleaned after use.

Reading *Understanding the writer's purpose*

Knowing what the writer's purpose is, who the writer is, and who the intended readers are can help us to understand a text. The safety instructions in Task 3 are clearly intended to encourage employees to be safety conscious and reduce the risk of accidents. The writer is perhaps a supervisor or the company safety officer, and the intended readers are machine operatives. Knowing these things can help us to work out the meaning of any part of the text we may not understand.

Task 4

Study the company document on safety on the next page, and then answer these questions.

1 Who is this document for?
- **a** machine operatives
- **b** managers
- **c** all employees
- **d** injured employees

2 Who wrote this document?
- **a** trade union representative
- **b** technician
- **c** manager
- **d** medical staff

3 What is the writer's intention?
- **a** to prevent accidents
- **b** to ensure speedy help for injured employees
- **c** to protect the company
- **d** to warn about dangers

Accident investigation

Whenever an accident occurs that results in an injury (medical case), damage of equipment and material, or both, prompt accident investigation by the immediate manager is required. A written preliminary investigation will be completed by the end of the particular shift or business day on which the accident occurred.

In no event should there be a delay of more than 24 hours. Failure to comply with this requirement may subject the immediate manager to disciplinary action up to and including discharge.

Without adequate accident investigation data the Company may be subjected to costs, claims, and legal action for which it has no defence.

As a minimum, the preliminary accident investigation report will include the following:

1 Name, occupation, and sex of injured worker.
2 Place and date / time of accident.
3 Description of how the accident happened.
4 Immediate causes of the accident – unsafe acts and unsafe conditions.
5 Contributing causes – manager safety performance, level of worker training, inadequate job procedure, poor protective maintenance, etc.
6 Witness(es) – name and department.
7 Corrective action taken – when.

The employee who was injured and any employee(s) who witnessed the incident should be separately interviewed as soon as possible. A copy of the report must be submitted to the Manager – Human Resources for review. Another copy of the report is to be retained for a period of not less than the injured employee's length of employment plus five (5) years.

Task 5

Study this brief report of an accident. In which points does it not meet company policy on reporting accidents?

To:	**Name**	**Department & Location**	**Date**
	Manager	Human Resources	17 May
From:	**Name**	**Department & Location**	**Tel.**
	D. Taylor	Mech. Eng. Workshop	6200
Subject	Preliminary Report, Accident, 12 May		

While turning a brass component on Tuesday, last week, Kenneth Oliver, machinist, received an injury to his eye. He was taken to the Eye Hospital where I understand he was operated on. I believe the accident was due to carelessness.

Language study *Making safety rules*

What are the differences in meaning, if any, between these statements?

1 Wear protective clothing.
2 Always wear protective clothing.
3 Protective clothing must be worn.

We can make safety rules in these ways:

1 Using an imperative.

   Wear *protective clothing.*

   Do not wear *loose-fitting clothing.*

2 *Always/never* are used to emphasize that the rule holds in all cases.

   Always *wear protective clothing.*

   Never *wear loose-fitting clothing.*

3 We can use a modal verb for emphasis. → passive.

   Protective clothing ***must*** *be worn.*

   Protective clothing ***should*** *be worn.*

Task 6

Study this list of unsafe environmental conditions (hazards). Write safety rules to limit these hazards using the methods given above. For example:

inadequate lighting

Lighting must be adequate. or
Lighting should be adequate.

1 uneven floors
2 unguarded machinery
3 untidy workbenches
4 untidy workplaces
5 badly maintained machinery
6 carelessly stored dangerous materials
7 inadequate ventilation
8 damaged tools and equipment
9 machinery in poor condition
10 equipment used improperly
11 equipment operated by untrained personnel
12 apprentices working without supervision

Writing *Ways of linking ideas, 2*

In Unit 4 we learnt that to make our writing effective, we have to make sure our readers can follow our ideas. We learnt how to mark reasons, results, and contrasts in our writing.

What are the links between these ideas? What words can we use to mark the links?

1 The accident happened.
2 The operator's carelessness.
3 The supervisor was not present.

Sentence 2 is a *reason* for sentence 1. Sentence 3 is an *additional* reason. We can mark the links between them like this:

> *The accident happened* ***because of*** *the operator's carelessness.* ***In addition/moreover***, *the supervisor was not present.*

We use *because of* to introduce a reason which is a noun or noun phrase. We use *in addition* and *moreover* to introduce an additional reason.

What are the links between these ideas? What words can we use to mark the links?

4 Suitable protection should be worn.
5 Safety helmets should be used where there is a danger of falling objects.

Sentence 5 is an example to illustrate sentence 4. We can mark this in this way:

> *Suitable protection should be worn.* ***For example/For instance***, *safety helmets should be used where there is a danger of falling objects.*

Task 7

Show the links between these sets of ideas using appropriate linking words from this unit and from Unit 4.

1 Many accidents happen.
Workers' carelessness.

2 Education can reduce accidents.
It is important that all workers receive training in basic safety.

3 Eye injuries can be serious.
Goggles must be worn for grinding and cutting.

4 Safety gloves provide protection for the hands.
They prevent burns.
They reduce the danger of cuts.

5 Safety shoes protect the feet against falling objects.
They prevent the feet getting caught in machinery.

6 Respirators should be worn in dusty conditions.
Dust can damage the lungs.

7 Safety gear exists for every danger.
Each year people are injured.
They refuse or forget to wear the right gear.

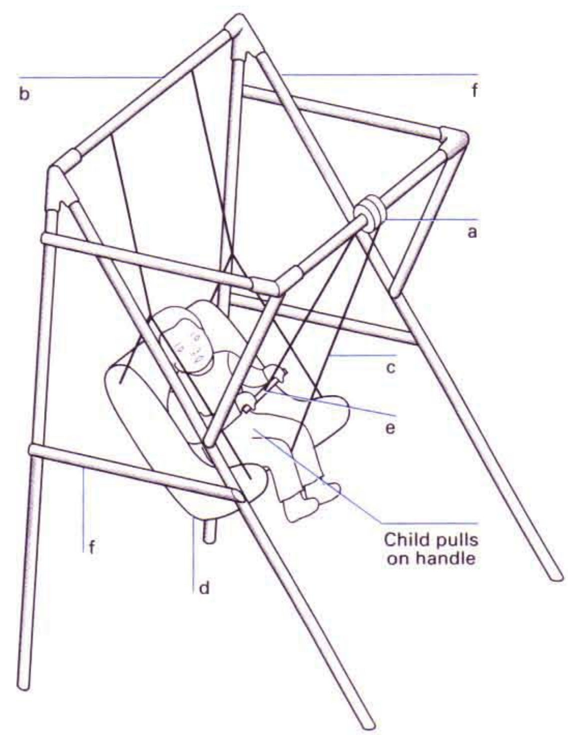
10 Young engineer

Tuning-in

Task 1

Lucy Porter is a recent winner of the *Young Engineer for Britain* award. Study this diagram of her invention. Discuss these questions in your group:

1 What is it?
2 Who is it for?
3 How does it work?



Listening

Task 2 Now listen to Lucy talking about her invention and career plans. As you listen, check your answers to Task 1.

Task 3 Now listen again. Here are some of the things Lucy talks about. Put them in the correct sequence. The first one has been done for you.

- **a** Her career plans. ____
- **b** What happens next with her invention. ____
- **c** How it works. ____
- **d** Why she is planning to study engineering. ____
- **e** Changes in the design. ____
- **f** What her invention is called. *1*
- **g** What materials she used. ____
- **h** Who it is intended for. ____
- **i** How she made the prototype. ____
- **j** How she got the idea. ____
- **k** Her views on engineering as a career for women. ____

Task 4 Now make notes on what Lucy says about the above topics.

Task 5 Label the diagram in Task 1 with these terms:

1. rope
2. handle
3. pulley
4. A-frames
5. cross-piece
6. seat

Task 6 Put these steps in the creation and development of the swing in the correct sequence. The first and last have been done for you.

- **a** problem identified *1*
- **b** prototype built in wood ____
- **c** metal version built ____
- **d** design modified ____
- **e** invention patented ____
- **f** models built to test design ____
- **g** prototype modified ____
- **h** prototype tested ____
- **i** design drawn ____
- **j** manufacturer licensed to produce *10*

Task 7 Now listen again and answer these more detailed questions.

1. How did the invention get its name?
2. What did she use to test designs which seemed viable?
3. Why did she make the first swing from wood?
4. What are the advantages of a metal frame?

Writing *Describing and explaining*

Task 8

You are going to write a brief description and explanation of Lucy's invention. It will consist of two paragraphs.

Paragraph 1

Use the labelled diagram in Task 1 and the information from the tape to write a brief description of Lucy's invention. Your description should answer these questions:

1 What is it called?
2 What is it for?
3 What does it consist of?
4 How are the parts connected?
5 What is it made of?

Use the language of description studied in Unit 6.

Paragraph 2

The following steps explain how the swing works. Put them in the correct sequence. Then use *so* and *when* to link them into a paragraph.

The rope pulls the seat forwards.
Repetition of these actions causes a swinging motion.
The child pulls down on the handle.
The seat swings back under the weight of the child.
The child releases the handle.

Speaking practice

Task 9

Work in pairs, **A** and **B**.

Student A: Play the part of the interviewer. Base your questions on the topics in Task 3, and any other questions you may wish to add. For example:

a Her career plans. → *What are your career plans?*

Student B: Play the part of the swing inventor.

Conduct the interview.

11 Washing machine

Tuning-in

Task 1

Many items found in the home contain control systems. The washing machine is one of the most complex. List some of the factors the control system of a washing machine must handle. This diagram may help you.

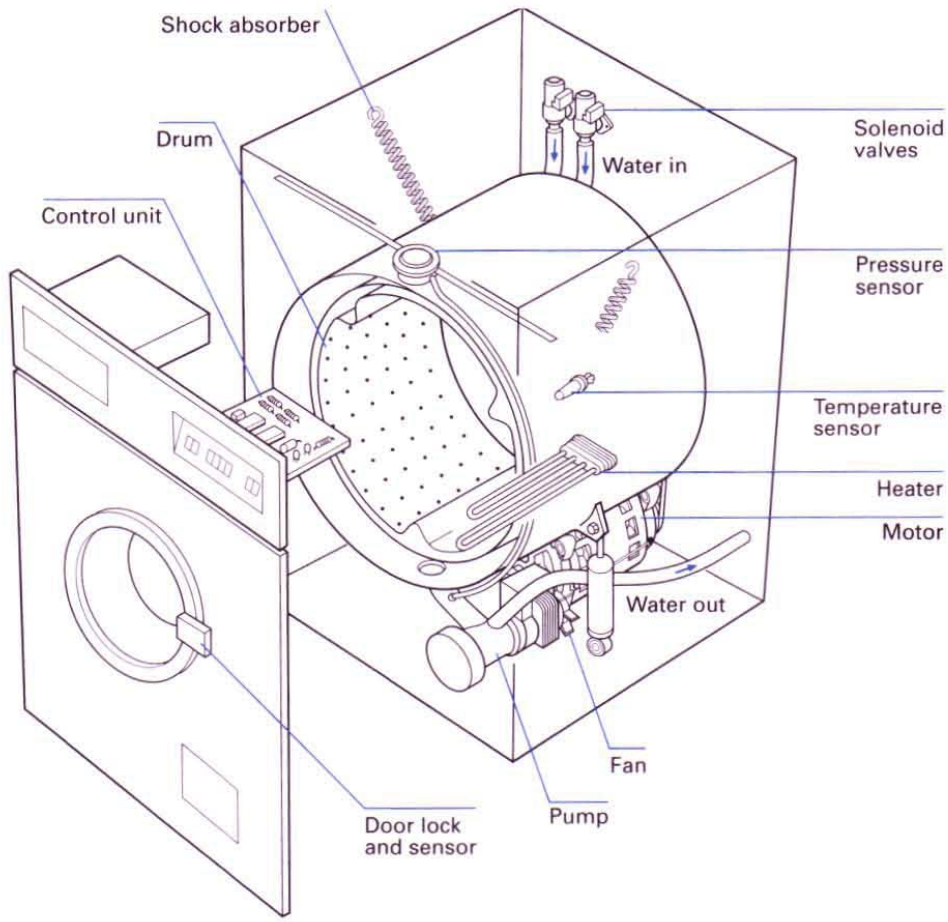


Fig. 1 Cross- section through a washing machine

Reading *Reading diagrams*

In engineering, diagrams carry a great deal of information. They can also help you to understand the accompanying text. For this reason, it is helpful to try to understand any diagram before reading the text.

Task 2

Study the diagram again. Try to explain the function of each of these items.

1 Pump
2 Motor

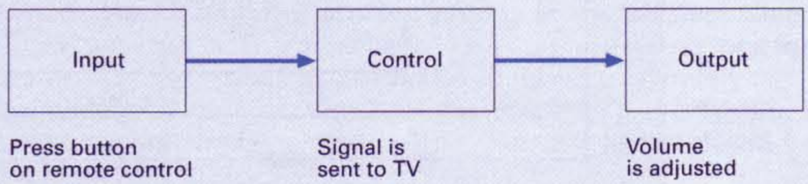
3 Shock absorber
4 Solenoid valves
5 Heater
6 Pressure sensor
7 Door lock and sensor
8 Temperature sensor
9 Fan

Task 3

Read this text to check your answers to Task 1.

Control systems in the home

Most devices in the home have some sort of control. For example, you can control the volume of a TV by using a remote control. The building blocks of a control system are:



The input can be any movement or any change in the environment. For example, a drop in temperature may cause a heating system to come on.

The control may change the size of the output (for example, adjusting the sound of a TV). Often this involves changing one kind of input into a different kind of output. For example, opening a window may set off a burglar alarm.

Outputs can be of many kinds. An alarm system may ring a bell, flash lights, and send a telephone message to the police.

Most control systems are closed loops. That means they incorporate a way of checking that the output is correct. In other words, they have feedback. The thermostat in a central heating system (Fig. 2) provides constant feedback to the control unit.

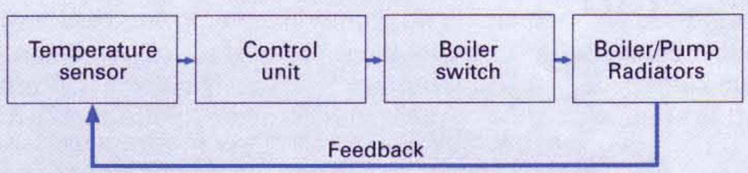


Fig. 2

The control system of a modern washing machine has to take into account several different factors. These are door position, water level, water temperature, wash and spin times, and drum speeds. Most of them are decided when you select which washing program to use.

Fig. 3 shows a block diagram of a washing machine control system. You can see that this is quite a complex closed loop system using feedback to keep a check on water level, water temperature, and drum speeds.

▶

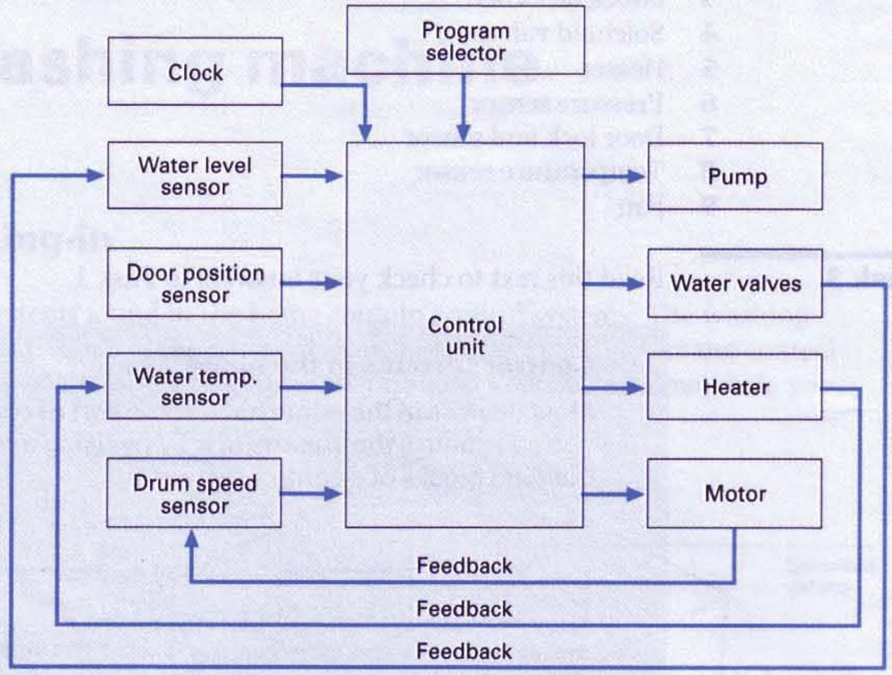


Fig. 3

The control unit is the heart of the system. It receives and sends out signals which control all the activities of the machine. It is also capable of diagnosing faults which may occur, stopping the program, and informing the service engineer what is wrong. It is a small, dedicated computer which, like other computers, uses the language of logic.

Source: P. Fowler and M. Horsley, 'Control systems in the home', *CDT: Technology*

Task 4

Read the following text to find the answers to these questions:

1 What device is used to lock the door?
2 What provides feedback to the control unit about the door position?

Text 1

Door position

The machine will not start any program unless the door is fully closed and locked. When the door is closed, it completes an electrical circuit which heats up a heat-sensitive pellet. This expands as it gets hot, pushing a mechanical lock into place and closing a switch. The switch signals the control unit that the door is closed and locked. Only when it has received this signal will the control unit start the wash program.

Now work in pairs, **A** and **B**.

Student A: Read Texts 2 and 3.
Student B: Read Texts 4 and 5.

Complete your section of the table opposite. Then exchange information with your partner to complete the whole table.

	Control factor	Operating device	Feedback by
1	Door position	heat-sensitive pellet	switch
2	Water level		
3	Water temperature		
4	Wash and spin times		—
5	Drum speeds		

Text 2

Water level

When a wash program first starts it has to open the valves which allow the water in. There are usually two of these valves, one for hot water and one for cold. Each must be controlled separately depending on the water temperature needed for that program. The valves are solenoid operated, i.e. they are opened and closed electrically.

The rising water level is checked by the water level sensor. This is a pressure sensor. The pressure of the air in the plastic tube rises as it is compressed by the rising water. The pressure sensor keeps the control unit informed as to the pressure reached and the control unit uses the information to decide when to close the water inlet valves.

Text 3

Water temperature

The temperature sensor, a type of thermometer which fits inside the washer drum, measures the water temperature and signals it to the control unit. The control unit compares it with the temperature needed for the program being used. If the water temperature is too low, the control unit will switch on the heater. The temperature sensor continues to check the temperature and keep the control unit informed. Once the correct temperature is reached, the control unit switches off the heater and moves on to the next stage of the program.

Text 4

Clock

The control unit includes a memory which tells it how long each stage of a program should last. The times may be different for each program. The electronic clock built into the control unit keeps the memory of the control unit informed so that each stage of each program is timed correctly.

Text 5

Drum speed

During the washing and spinning cycles of the program, the drum has to spin at various speeds. Most machines use three different speeds: 53 rpm for washing; 83 rpm for distributing the load before spinning; 100 rpm for spinning.

The control unit signals the motor to produce these speeds. The motor starts up slowly, then gradually increases speed. The speed sensor, a tachogenerator, keeps the control unit informed as to the speed that has been reached. The control unit uses the information to control the power to the motor and so controls the speed of the drum at all times.

Language study *If/Unless sentences*

Task 5

Fill in the blanks in this table using the information in Fig. 3 and the texts in Task 4.

Sensor	Condition	Control unit action
Water	level low	open inlet valves
	level high enough	______
Water temperature	______	switch on heater
	high enough	______
Drum speed	______	______
	______	decrease motor speed

The conditions which the sensors report determine the action of the control unit. We can link each condition and action like this:

> ***If*** *the water level is low, the inlet valves are opened.*

Task 6

Write similar sentences for the other five conditions given.

Now study this example:

Sensor	Condition	Control unit action
Door	Door open	Machine cannot start
	Door closed	Machine can start

We can link these conditions and actions as follows:

1 ***If*** *the door is open, the machine cannot start.*

2 ***If*** *the door is closed, the machine can start.*

3 ***Unless*** *the door is closed, the machine cannot start.*

We use *unless* when an action cannot or will not happen if a prior condition is not true. In example 3, *Unless* means *If ... not*. We can rewrite 3 as:

> ***If*** *the door is* ***not*** *closed, the machine cannot start.*

Task 7

Complete these sentences using *Unless* and your knowledge of engineering.

1 Unless the ignition is switched on, a car cannot ______________.

2 Unless the pilot light is on, gas central heating will not ______________.

3 Unless the diverter valve is switched to central heating, the radiators will not ______________.

4 Unless there is current flowing in the primary coil of a transformer, there will be no current in the ______________ coil.

5 Unless there is ______________ in the cylinders, a petrol engine will not start.

6 Unless the doors are ______________, a lift will not operate.

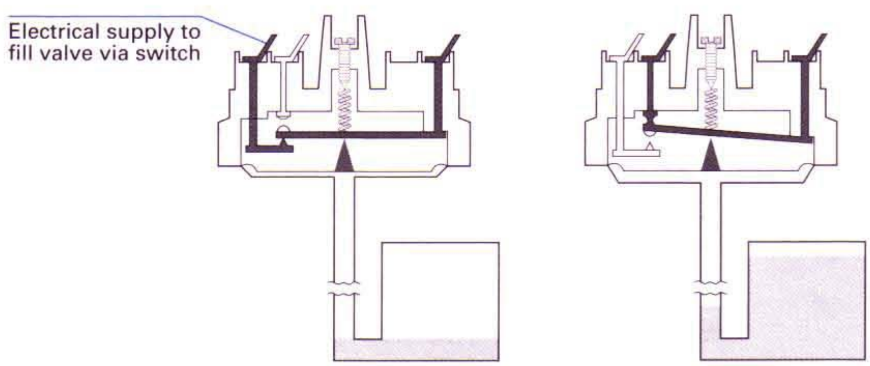
7 Unless mild steel is painted, it will ______________.

8 Unless electrical equipment is earthed, it may be ______________.

Writing *Explaining a diagram*

Task 8

Study this diagram of a pressure sensor. Explain how it works by linking each pair of actions with appropriate time words.



1 A wash programme first starts.
It opens the valves to allow the water in.
2 The water level in the drum rises.
The air in the plastic tube is compressed.
3 The pressure rises.
The diaphragm moves upwards.
4 This continues.
The switch contacts are separated.
5 This happens.
The fill valves are closed.

Task 9

Join the following groups of statements to make longer sentences. Use the words printed in *italics* above each group. You may omit words and make whatever changes you think are necessary in the word order and punctuation of the sentences. Join the sentences to make a paragraph.

1 *which*
The temperature sensor measures the water temperature.
The temperature sensor is a type of thermometer.

2 *and*
The temperature sensor fits inside the washer drum.
The temperature sensor signals the water temperature to the control unit.

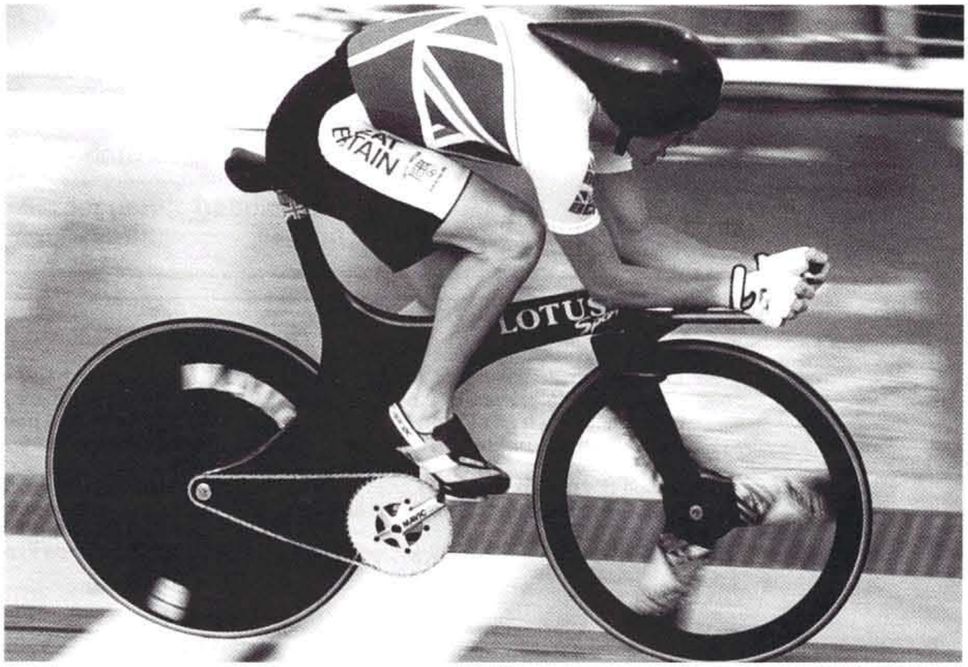
3 *which*
The control unit compares the water temperature with the temperature.
The temperature is needed for the programme being used.

4 *If*
The water temperature is too low.
The control unit will switch on the heater.

5 *and*
The temperature sensor continues to check the temperature.
The temperature sensor keeps the control unit informed.

6 *When ... and*
The correct temperature is reached.
The control unit switches off the heater.
The control unit moves on to the next stage of the programme.

12 Racing bicycle



Chris Boardman in the 1992 Olympics.

Tuning-in

Task 1

Label this diagram of a bicycle with these terms.

pedals	chain	chain-wheel
seat	gears	brakes
handlebars	frame	toe-clips

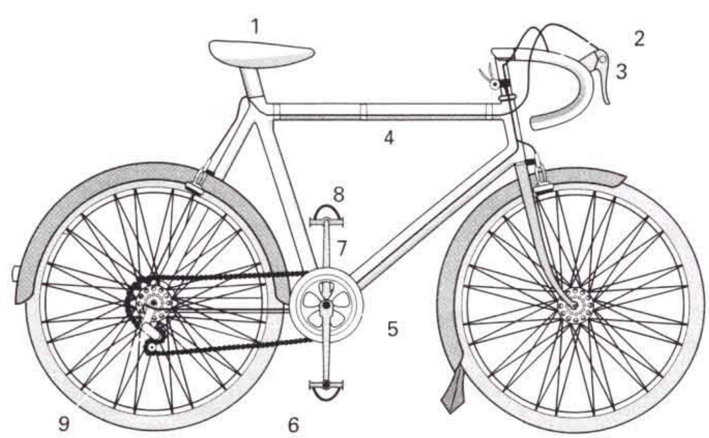


Fig. 1

Task 2 Check your answers by listening to this description.

Task 3

Compare Fig. 2 (below) with the bicycle shown in Fig. 1 and Task 2. What differences can you note? Write your answers in this table.

Conventional (Fig. 1)	**Improvement** (Fig. 2)
Spoked wheels	
Gear lever on the frame	
Tubular aluminium-alloy frame	
Pedals with toe-clips	
Steel gears	
Ordinary handlebars	

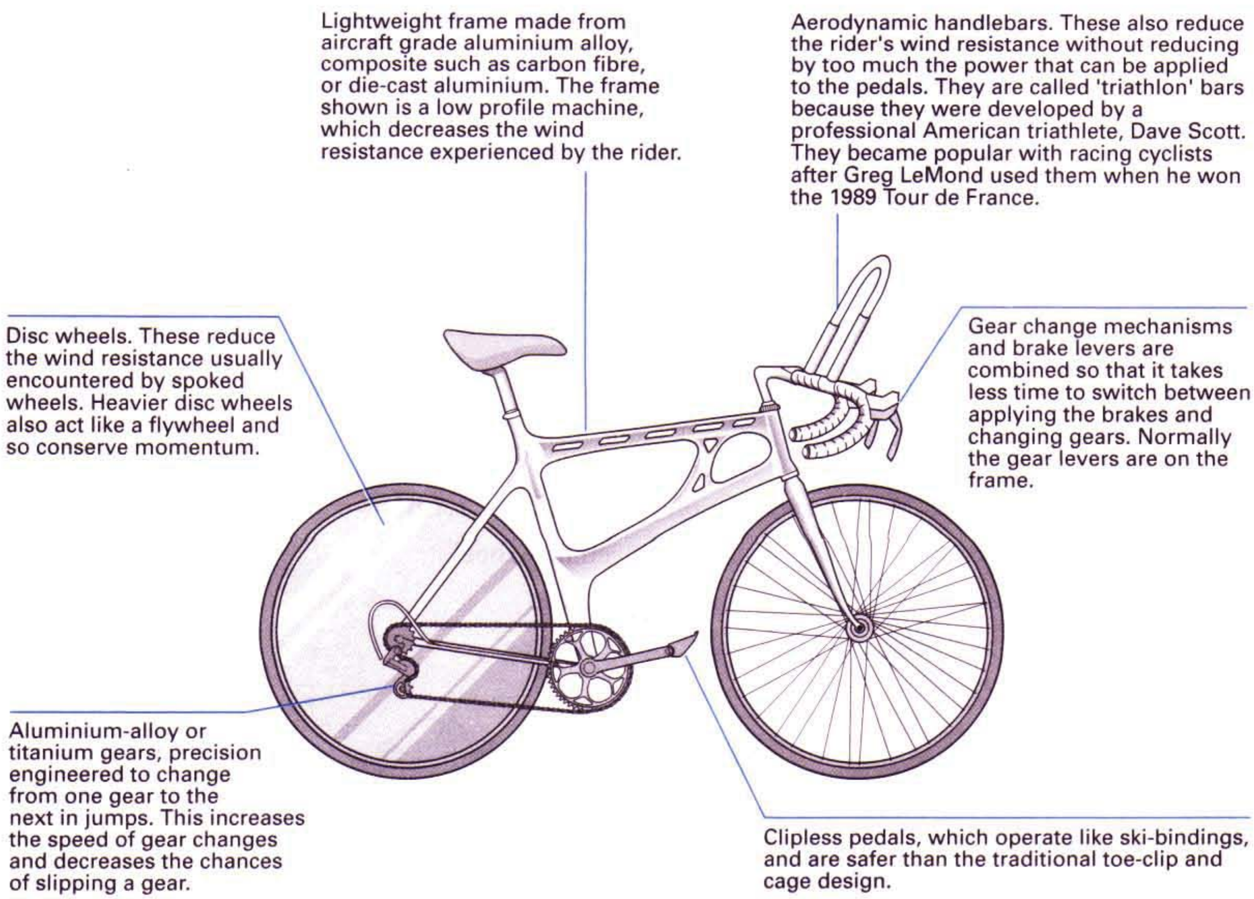


Fig. 2

Task 4

Check your answers to Task 3 in column 1 opposite. Then study Fig. 2 again to find reasons for each improvement.

Improvement	Reason
Disc wheels	______
Combined gear change and brake levers	______
Carbon fibre frame	______
Clipless pedals	______
Precision-engineered aluminium-alloy or titanium gears	______
Aerodynamic handlebars	______

Reading *Prediction*

Task 5

Study this extract from the text you are going to read.

> Bicycles, and especially racing bicycles, have much in common with aircraft:

What similarities between racing bicycles and aircraft do you think the text will cover? Note your predictions.

Task 6

Read this text to check your answers to Task 5.

Racing bicycle

The standard design of the bicycle has been in existence for about 100 years. But in the past 10 years there have been more changes than during any other decade.

Bicycles, and especially racing bicycles, have much in common with aircraft: both are designed to minimize wind resistance, maximize energy efficiency, respond instantly to the demands placed on them, yet weigh very little without losing strength. So, much of the technology used in aerospace has found its way into racing bicycles.

The heart of the bicycle is its frame. It must be strong, light, flexible enough to absorb bumps, but not so much that it wastes the energy the rider transmits by pedalling.

Bicycle frame designers share many aims with aircraft engineers, who must design wings which are strong, light, aerodynamic, and efficient at converting engine power into lift. Yet the wings must be flexible enough to absorb turbulence without wasting the engine's thrust. Therefore, the modern bicycle frame and aircraft wing share both materials and design features. Many racing bicycle frames which consist of tubes joined together are made from aluminium alloys similar to those used in aviation. The French company, Vitus, ▶

glues the tubes together using the same techniques as those used for connecting aircraft components.

In recent years, aircraft manufacturers such as Boeing have been experimenting with composite materials like Cheval and carbon fibres. It is no surprise that some racing bicycle frames are now manufactured from the same materials.

Perhaps the most innovative frame to date is constructed from die-cast magnesium alloy. Its designer, Frank Kirk, formerly worked in aerospace.

Components which fit on bicycle frames have also benefited from aerospace engineering. Many components, such as gears, brakes, handlebars, and wheels, are both aerodynamic and often made from aluminium alloys or titanium – another light, strong metal used in aircraft.

Language study *Describing reasons*

We can describe the reasons for an improvement or design change in a number of ways. Study this example:

Improvement/Design change	**Reason**
Disc wheels	Reduce wind resistance.

How many ways do you know to link an improvement and the reason for it? Try to complete this sentence by adding the reason given.

New racing bicycles have disc wheels ____________.

Using *to* + verb is the easiest way to link improvement and reason. For example:

New racing bicycles have disc wheels ***to*** *reduce wind resistance.*

Another simple way is to use a linking word. You studied this in Unit 5. For example:

New racing bicycles have disc wheels ***because/since/as*** *this reduces wind resistance.*

A more difficult way is to use *so that* which must be followed by a clause. For example:

New racing bicycles have disc wheels ***so that*** *wind resistance is reduced.*

Task 7

Link each improvement and reason in Task 4 using the methods given above.

Writing *Describing contrast*

In engineering, it is often necessary to compare and contrast different proposals, solutions to problems, and developments. In this unit we will focus on contrast – describing differences.

We can show differences in a table like this:

Conventional	Improved bicycle
Spoked wheels	Disc wheels
Gear lever on the frame	Combined gear change and brake levers
Tubular aluminium-alloy frame	Carbon fibre frame
Pedals with toe-clips	Clipless pedals
Steel gears	Precision-engineered titanium gears
Ordinary handlebars	Aerodynamic handlebars

We can describe differences using:

1 the comparative form of the adjective or adverb. For example:

The new bicycle ***is lighter than*** *the old.*
The new bicycle ***is more aerodynamic than*** *the old.*
Titanium gears can be changed ***more easily****.*

2 the connecting words *but/whereas, in contrast*. For example:

On new bicycles the gear and brake lever are combined, ***whereas*** *on old ones, the gear lever is on the frame.*
Old bicycles have spoked wheels. ***In contrast****, the new bicycle has disc wheels.*

3 using expressions such as *unlike/different from*. For example:

Unlike *the conventional bicycle, the new bicycle has a carbon fibre frame.*
The new bicycle is ***different from*** *the conventional one in that the gears are made of titanium.*

Note that these expressions assume that the reader is familiar with the materials used in the conventional bicycle, which are not mentioned.

Task 8

Describe the differences between a conventional and an improved bicycle using the information in the table above and appropriate expressions from the list provided.

Word study *Properties of materials*

Study these examples of adjective and noun pairs for describing the properties of materials.

Adjective	Noun
flexible	flexibility
light	lightness
strong	strength

Task 9

Now fill in the gaps in this table with the missing adjectives and nouns.

Adjective	Noun
	wind resistance
elastic	
	plasticity
tough	
soft	
rigid	
wear-resistant	
	brittleness
hard	

Speaking practice

Task 10

Work in pairs, **A** and **B**.

Student A: Your task is to explain to your partner how to adjust the distance between the saddle and the handlebars of a racing bicycle. Use the text and diagrams on pages 177/8 to help you.

Student B: Your task is to explain to your partner how to adjust the height and tilt of the handlebars of a racing bicycle. Use the text and diagrams on pages 181/2 to help you.

Technical reading *Gear systems*

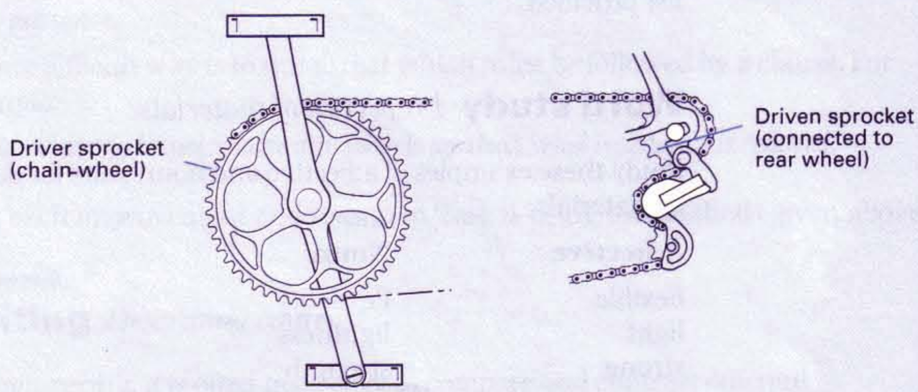


Fig. 3

Bicycles use a chain and sprocket system to transmit rotary motion from the driver shaft to the driven shaft because of its strength and because it will not slip. When it comes to working out speed changes, you use the number of teeth on the sprockets. For example, looking at the system in Fig. 3:

Driver sprocket has 60 teeth.

Driven sprocket has 15 teeth.

$$\text{Gear speed ratio} = \text{Number of teeth on driven sprocket} \div \text{Number of teeth on driver sprocket}$$

$$= \frac{15}{60} \text{ or } 1{:}4$$

Task 11

Calculate the gear ratios of a bicycle with the system shown in Fig. 4 below. It has a double chain-wheel and five driven sprockets on the rear wheel but only the combinations shown below are recommended. You may need a calculator.

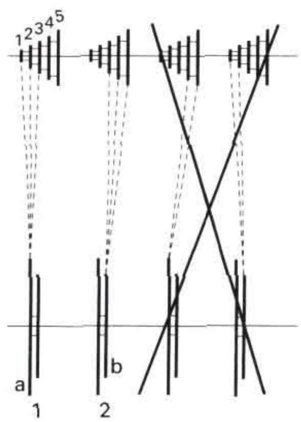


Fig. 4

Chain-wheel	teeth	Sprocket	teeth	Ratio
a	51	1	15	1:3.4
		2	17	
		3	21	
b	42	3	21	
		4	24	
		5	28	

13 Lasers

Tuning-in

Task 1

What are lasers? List any applications you know for lasers.

Reading

Task 2

Read this text to check your answers to Task 1.

Lasers (Light Amplification by Stimulated Emission of Radiation) are devices which amplify light and produce beams of light which are very intense, directional, and pure in colour. They can be solid state, gas, semiconductor, or liquid.

When lasers were invented in 1960, some people thought they could be used as 'death rays'. In the 1980s, the United States experimented with lasers as a defence against nuclear missiles. Nowadays, they are used to identify targets. But apart from military uses, they have many applications in engineering, communications, medicine, and the arts.

In engineering, powerful laser beams can be focused on a small area. These beams can heat, melt, or vaporize material in a very precise way. They can be used for drilling diamonds, cutting complex shapes in materials from plastics to steel, for spot welding and for surfacing techniques, such as hardening aircraft engine turbine blades. Laser beams can also be used to measure and align structures.

Lasers are ideal for communications in space. Laser light can carry many more information channels than microwaves because of its high frequency. In addition, it can travel long distances without losing signal strength. Lasers can also be used for information recording and reading. Compact discs are read by lasers.

In medicine, laser beams can treat damaged tissue in a fraction of a second without harming healthy tissue. They can be used in very precise eye operations.

In the arts, lasers can provide fantastic displays of light. Pop concerts are often accompanied by laser displays.

Task 3

Complete this table of laser applications using information from the text opposite. You may also add any applications you know of which are not included in the text.

Military	Engineering	Communications	Medicine	Arts
______	drilling diamonds	______	treating damaged tissue	______
	cutting complex shapes	information recording and reading	______	
	______			
	______			
	______			
	______			

Language study *used to/for*

Study these examples of laser applications:

1. Laser beams can be *used to measure* and align structures.
2. They can be *used for drilling* diamonds.
3. They can be *used for* light displays.

We can describe applications with *used to* + infinitive or *used for* + *-ing* or noun.

Task 4

Describe the applications of lasers using the information in your table in Task 3 and the structures given above.

Word study *Noun + noun compounds*

We can use adjectives to describe an object in greater detail. For example:

light	*electric light*
a motor	*an electric motor*
steel	*stainless steel*
gears	*helical gears*

We can also use nouns. For example:

light	*laser light*
a motor	*an air motor*
steel	*carbon steel*
gears	*titanium gears*

Many relationships are possible in noun compounds. For example:

an air motor	a motor which uses air
carbon steel	steel which contains carbon
titanium gears	gears made of titanium

Task 5

Put each of these examples in the correct column.

carbon blocks
aluminium alloy
carbon fibre
a gas burner
roller bearings
a circuit board
a plastic pipe
magnesium alloy
a power tool
a ball bearing
a concrete beam
a diesel boat
a spring balance
a plastic tube
steel sheets

uses	is made of	contains

Task 6

What new relationships can you find in the examples below? Rewrite each compound to show the relationship. For example:

a foot pump	*a pump which is operated by foot*
a ribbon cable	*a cable which is like a ribbon*
a gear lever	*a lever for operating gears*

1 chain wheel
2 disc wheel
3 foot brake
4 a hand throttle
5 strain gauge
6 college lecturer
7 toe-clip
8 boiler thermostat
9 safety helmet
10 aircraft engineer

Writing *Describing a process, 1: sequence*

When we write about a process, we have to:

1. Sequence the stages
2. Locate the stages
3. Describe what happens at each stage
4. Explain what happens at each stage

In this unit, we will study how to sequence the stages.

Consider these stages in the operation of a washing machine.

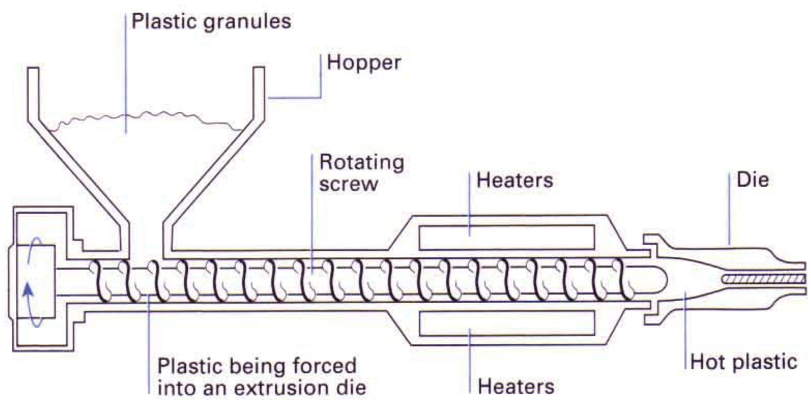
1 The drum is filled with water.
2 The water is heated to the right temperature.
3 Soap is added.
4 The drum is rotated slowly.
5 The dirty water is pumped out.
6 Clean water is added.
7 The drum is rotated much faster and the water pumped out.
8 The clean clothes are removed.

Instead of numbers, we can show the correct order using sequence words.

First the drum is filled with water.
Then the water is heated to the right temperature.
Next soap is added.
After that, the drum is rotated slowly.
Next the dirty water is pumped out.
Then clean water is added.
After that, the drum is rotated much faster and the water pumped out.
Finally, the clean clothes are removed.

Task 7

Study this diagram. It shows an extruder for forming plastic pipes. Describe the extruder.



Task 8

Now put these stages in the process in the correct sequence.

a The hot plastic is forced through the die to form a continuous length of pipe.
b The rotating screw forces the plastic past heaters.
c The plastic granules are mixed and placed in the hopper.
d The pipe is cooled and cut to suitable lengths.
e The plastic melts.

Task 9

Describe the correct order using sequence words. Add to your description of the process your description of the extruder from Task 7. Form your text into a paragraph.

Technical reading *Laser cutting*

Task 10

Engineers have to read sales literature describing the products and services of companies. Read the following sales literature to answer these questions:

1. Who is this text for?
2. What service does the company provide?
3. What are the design benefits of laser cutting?
4. Can lasers cut non-metals?
5. What limitations are there on the service they provide?
6. How does the service cut lead time?

DESIGN ENGINEERS – DEVELOPMENT ENGINEERS – BUYERS – STOCK CONTROLLERS

Frustrated?

By having to restrict designs to suit manufacturing processes?
By the difficulty and high cost of producing accurate prototypes?
By the high cost and lengthy lead times associated with press tools?
By the high stock levels necessitated by minimum batch sizes?

If your answer to any of the above is yes ...

WE HAVE THE SOLUTION!

OUR NEW 1500 WATT CNC-CONTROLLED LASER CUTTER IS AT YOUR DISPOSAL.

■ The Process

Laser technology is not new, but it is only recently that the full benefits have become available to manufacturers.

Taking light and passing it through a series of lenses makes the light source so great that its power density is several million times that of the sun – this laser energy is then used to cut almost any material.

The light is directed down towards a CNC-controlled table making it very easy to produce accurate complicated shapes without distortion, giving burr-free, smooth, and perfectly square edges.

■ The Materials

The laser is suitable for cutting:

- All types of steel including stainless and spring steel.
- Most non-ferrous metals.
- Plastics, wood, fibreglass, and almost any other material you care to mention!

■ The Capacity

Carbon Steel – up to 13 mm
Stainless Steel – up to 10 mm
Plastics – up to 40 mm
Wood – up to 40 mm
Rubber – up to 40 mm

Table movement 1650 mm x 1250 mm

■ The Advantages

Short lead time
No tooling costs
Low set-up costs
Extremely accurate
Highest quality
Minimal heat affected zones
Design flexibility

Source: Eraba Limited

14 Automation technician

Tuning-in

Task 1

You are going to hear an interview with Alistair, a technician with an American company based in the United Kingdom. His company produces cellular communication equipment. Try to list some of the products his company might make.

Listening

Task 2

Listen to Part 1 of the interview. Check your answers to Task 1 and answer these questions.

1 What is his job title?
2 What does his section build?
3 What type of machines are they?
4 What does a Fuji robot do?
5 What do his machines do?
6 What three types of sensors does a robot have?

Task 3 Listen to Part 2 of the interview and answer these questions.

1 How long has he been with the company?
2 How many technicians are in his section?
3 When does he start work?
4 What does he do first when he gets to work?
5 Name one thing he might do after that.
6 Why does he visit plants in Europe?
7 Where has he been?
8 What does he dislike about travelling?

Task 4 Listen to Part 3 of the interview and answer these questions.

1 What did the company he previously worked for make?
2 Name one thing he feels was good about working for his old company.
3 What qualification does he have?
4 How long did it take to get this qualification?
5 During his work placement, what did he do a lot of?
6 What kind of companies did he do installations in?
7 What was one of the perks of the job?

Task 5 Listen to the interview again and complete the gaps in this record of Alistair's work experience.

Period	Type of company	Product	Job title
2 years	________	________	Automation technician
______ years	________	Telephone exchange	________
______ months	Instrument makers	________	Student placement

Speaking practice *Talking about specifications*

Task 6 Work in pairs, **A** and **B**. Some of the design specifications for your drawing are missing. Complete them with help from your partner.

Before you start, make sure you know how to say these abbreviations and expressions in full:

1 max. maximum
2 min. minimum
3 dia. diameter
4 cm centimetre
5 kg kilogram
6 1.42 one point four two
7 0.55 zero point five five
8 ± plus or minus

You may look at each other's drawings after you have exchanged information.

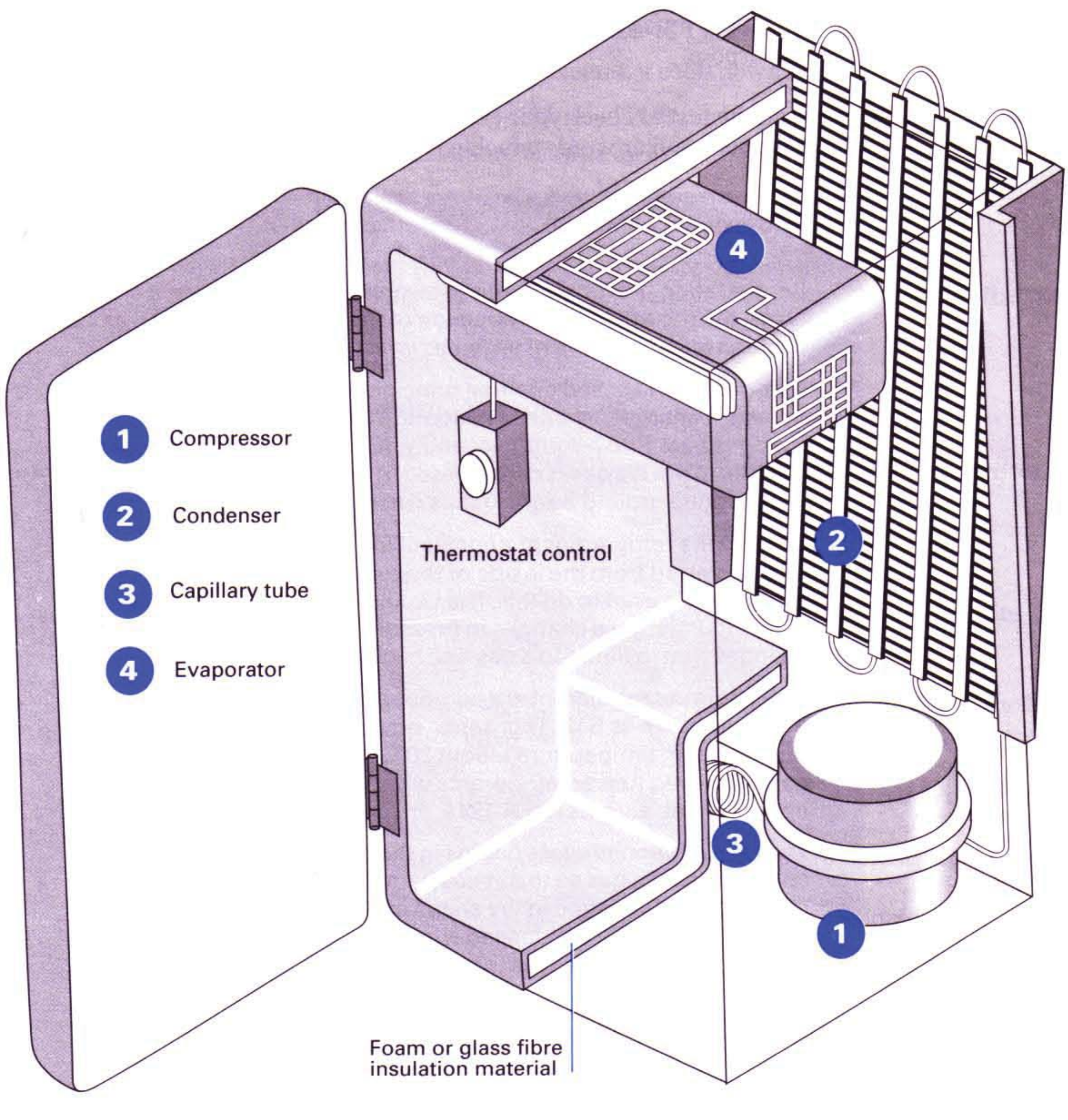
Student A: Your specifications are on page 178.
Student B: Your specifications are on page 182.

15 Refrigerator

Tuning-in

Task 1

Study this diagram. It explains how a refrigerator works. In your group try to work out the function of each of the numbered components using the information in the diagram.



Reading *Dealing with unfamiliar words, 1*

You are going to read a text about refrigerators. Your purpose is to find out how they operate. Read the first paragraph of the text below. Underline any words which are unfamiliar to you.

> Refrigeration preserves food by lowering its temperature. It slows down the growth and reproduction of micro-organisms such as bacteria and the action of enzymes which cause food to rot.

You may have underlined words like *micro-organisms*, *bacteria*, or *enzymes*. These are words which are uncommon in engineering. Before you look them up in a dictionary or try to find translations in your own language, think! Do you need to know the meaning of these words to understand how refrigerators operate?

You can ignore unfamiliar words which do not help you to achieve your reading purpose.

Task 2

Now read the text to check your explanation of how a refrigerator works. Ignore any unfamiliar words which will not help you to achieve this purpose.

Fridge

para

Refrigeration preserves food by lowering its temperature. It slows *1*
down the growth and reproduction of micro-organisms such as bacteria and the action of enzymes which cause food to rot.

Refrigeration is based on three principles. Firstly, if a liquid is *2*
heated, it changes to a gas or vapour. When this gas is cooled, it changes back into a liquid. Secondly, if a gas is allowed to expand, it cools down. If a gas is compressed, it heats up. Thirdly, lowering the pressure around a liquid helps it to boil.

To keep the refrigerator at a constant low temperature, heat must *3*
be transferred from the inside of the cabinet to the outside. A refrigerant is used to do this. It is circulated around the fridge, where it undergoes changes in pressure and temperature and changes from a liquid to a gas and back again.

One common refrigerant is a compound of carbon, chlorine, and *4*
fluorine known as R12. This has a very low boiling point: –29°C. At normal room temperature (about 20°C) the liquid quickly turns into gas. However, newer refrigerants which are less harmful to the environment, such as KLEA 134a, are gradually replacing R12.

The refrigeration process begins in the compressor. This *5*
compresses the gas so that it heats up. It then pumps the gas into a condenser, a long tube in the shape of a zigzag. As the warm gas passes through the condenser, it heats the surroundings and cools down. By the time it leaves the condenser, it has condensed back into a liquid.

Liquid leaving the condenser has to flow down a very narrow tube *6*
(a capillary tube). This prevents liquid from leaving the condenser too quickly, and keeps it at a high pressure.

►

As the liquid passes from the narrow capillary tube to the larger tubes of the evaporator, the pressure quickly drops. The liquid turns to vapour, which expands and cools. The cold vapour absorbs heat from the fridge. It is then sucked back into the compressor and the process begins again. 7

The compressor is switched on and off by a thermostat, a device that regulates temperature, so that the food is not over-frozen. 8

Source: 'Inside out: Fridge', *Education Guardian*

Language study *Principles and laws*

Study these extracts from the text above. What kind of statements are they?

1 If a liquid is heated, it changes to a gas or vapour.

2 If a gas is allowed to expand, it cools down.

3 If a gas is compressed, it heats up.

Each consists of an action followed by a result. For example:

Action	*Result*
a liquid is heated	it changes to a gas or vapour

These statements are principles. They describe things in science and engineering which are always true. The action is always followed by the same result.

Principles have this form:

If/When (action – present tense), (result – present tense).

Task 3

Link each action in column **A** with a result from column **B** to describe an important engineering principle.

A Action

1 a liquid is heated
2 a gas is cooled
3 a gas expands
4 a gas is compressed
5 a force is applied to a body
6 a current passes through a wire
7 a wire cuts a magnetic field
8 pressure is applied to the surface of an enclosed fluid
9 a force is applied to a spring fixed at one end

B Result

a it heats up
b there is an equal and opposite reaction
c it changes to a gas
d it extends in proportion to the force
e it is transmitted equally throughout the fluid
f a current is induced in the wire
g it cools down
h it sets up a magnetic field around the wire
i it changes to a liquid

Word study *Verbs and related nouns*

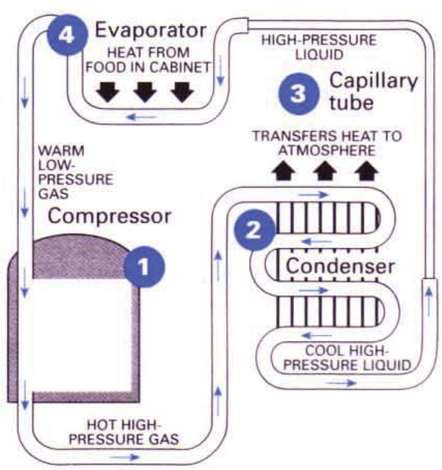
Task 4

Each of the verbs in column **A** has a related noun ending in *-er* or *-or* in column **B**. Complete the blanks. You have studied these words in this and earlier units. Use a dictionary to check any spellings which you are not certain about.

	A Verbs	**B Nouns**
	For example: refrigerate	refrigerator
1	condense	________
2	________	evaporator
3	compress	________
4	resist	________
5	________	charger
6	generate	________
7	conduct	________
8	________	exchanger
9	radiate	________
10	control	________

Writing *Describing a process, 2: location*

Study this diagram. It describes the refrigeration process.



In Unit 13 we learnt that when we write about a process, we have to:

1. Sequence the stages
2. Locate the stages
3. Describe what happens at each stage
4. Explain what happens at each stage

For example:

sequence location *description*
The refrigeration process begins in the compressor. This compresses the gas
explanation
so that it heats up.

In this unit we will study ways to locate the stages.

Task 5

Put these stages in the refrigeration process in the correct sequence with the help of the diagram above. The first one has been done for you.

a The liquid enters the evaporator. ____

b The gas condenses back into a liquid. ____

c The vapour is sucked back into the compressor. ____

d The gas is compressed. *1*

e The liquid turns into a vapour. ____

f The gas passes through the condenser. ____

g The liquid passes through a capillary tube. ____

h The high pressure is maintained. ____

There are two ways to locate a stage in a process.

1 Using a preposition + noun phrase. For example:

The liquid turns to vapour ***in the evaporator***.
The gas cools down ***in the condenser***.

2 Using a *where*-clause, a relative clause with *where* rather than *which* or *who*, to link a stage, its location and what happens there. For example:

The warm gas passes through the condenser, ***where it heats the surroundings and cools down***.
The refrigerant circulates around the fridge, ***where it undergoes changes in pressure and temperature***.

Task 6

Complete each of these statements.

1 The gas passes through the compressor, where ____________.

2 It passes through the condenser, where ____________.

3 The liquid passes through a capillary tube, where ____________.

4 The liquid enters the evaporator, where ____________.

5 The cold vapour is sucked back into the compressor, where ____________.

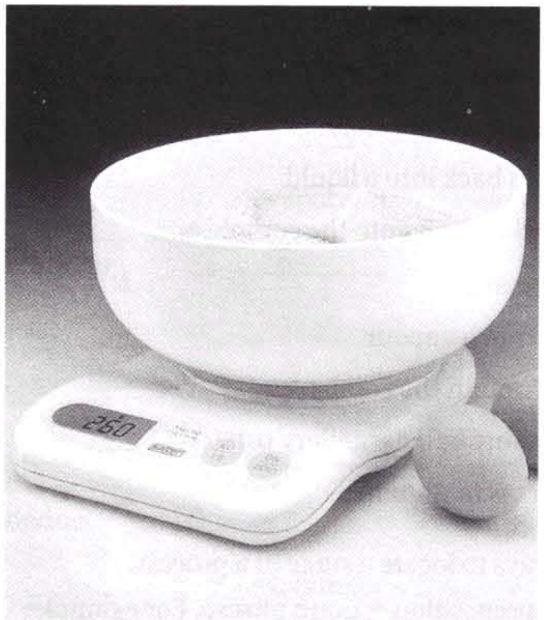
Task 7

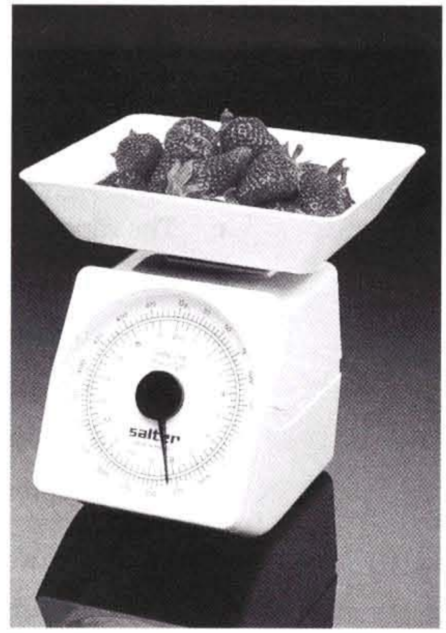
Add sequence expressions to your statements to show the correct order of events. For example:

First the gas passes through the condenser ...

Make your statements into a paragraph adding extra information from the text in Task 2 if you wish. Then compare your paragraph with paragraphs 6, 7, and 8 from the text.

16 Scales





Tuning-in

Task 1

Complete this table of common quantities and forces to be measured in engineering, the units in which they are measured, and the instruments you use to measure them.

	Quantity/Force	Unit	Instrument
1	Current	______	Ammeter
2	______	Newton	Force gauge
3	Velocity	km/hr	______
4	______	°C	Thermometer
5	Thickness	______	Micrometer
6	______	Ohm	Ohmmeter
7	Voltage	______	______
8	Pressure	______	Manometer

Task 2

How can you measure weight accurately? What alternatives are there? If you cannot name the instruments, draw them.

Task 3

What do you think are the advantages of electronic scales over mechanical scales?

Reading 1 *Meaning from context*

Task 4

Read the first two paragraphs of this text and try to fill in the missing words. More than one answer is possible for some of the blanks. Then check your answer to Task 3 using the completed text.

Electronic scales

para

The electronic kitchen scale [1] __________ takes a larger load and is [2] __________ accurate than its mechanical counterpart. Whereas a [3] __________ scale may have a capacity of about 3kg, broken [4] __________ 25g units, the electronic scale can [5] __________ a load of [6] __________ to 5kg broken into units of 5g or even 2g. *1*

The scale [7] __________ by converting the load increase on its platform [8] __________ weighing area into a weight reading [9] __________ the liquid crystal display (LCD). It is controlled [10] __________ a microprocessor and can therefore [11] __________ from ounces to grams at the touch of a button. The compact internal components also make it small and [12] __________ to store. *2*

Reading 2 *Comparing sources*

When we read, we may wish to look at more than one source of information on a topic to:

1. get extra information
2. find a text we can understand
3. check points where texts disagree

In the tasks which follow, we will compare information from a diagram and a text.

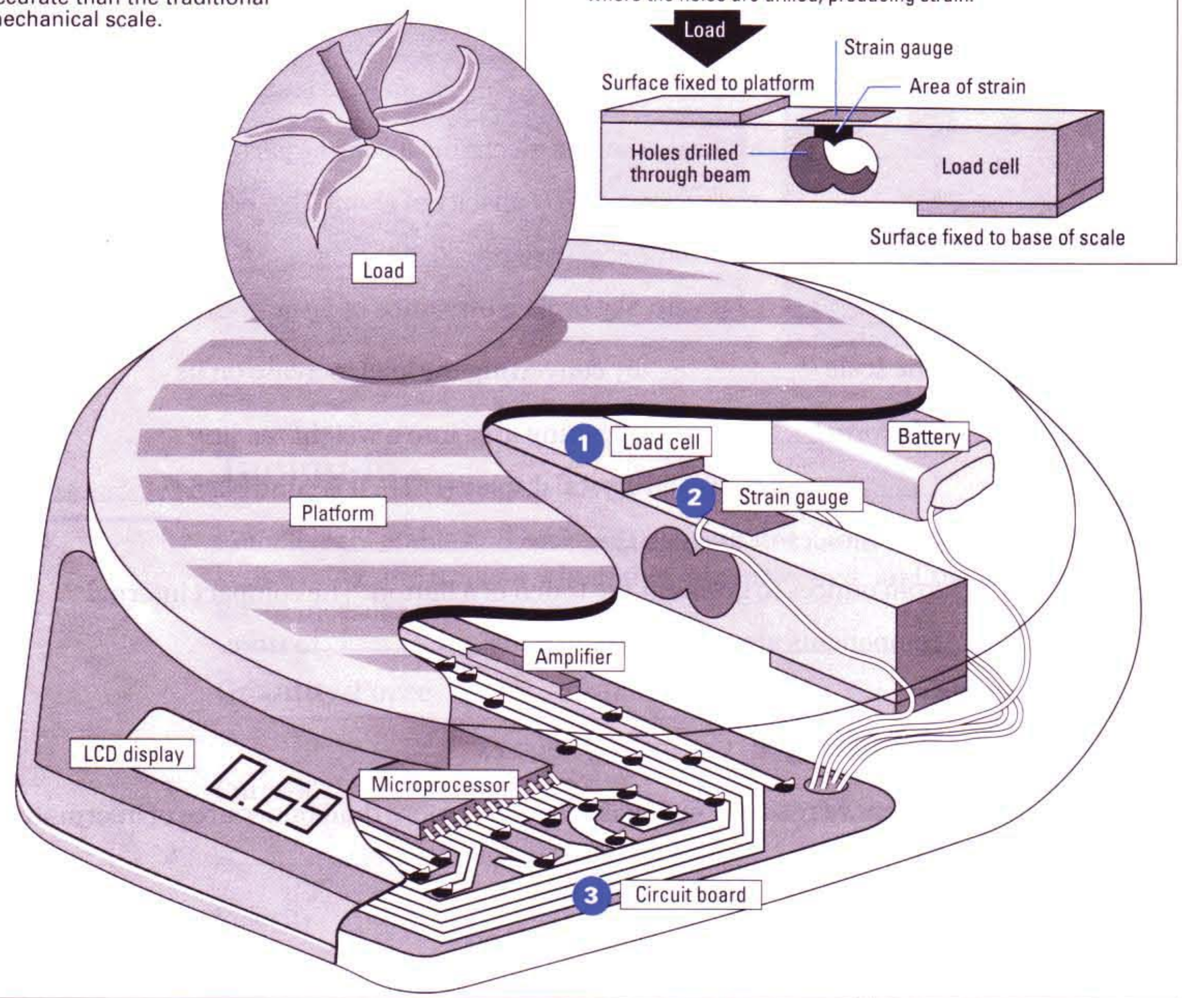
Task 5

Study this diagram of electronic scales and complete the notes below.

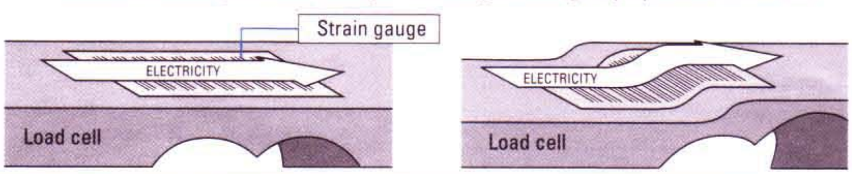
	1 *Load cell*	2 *Strain gauge*	3 *Circuit board*	
Material	______	______	Converter function	______
Position	between the platform and base	______	Microprocessor function	______
Operation	______	bends with the load cell, stretching the wires, voltage falls in proportion to load		

The electronic kitchen scale uses microchip technology. It is small, convenient to store, and more accurate than the traditional mechanical scale.

1 **The load cell** is an aluminium alloy beam. When a load is placed on the platform, it causes the beam to bend very slightly in the middle where the holes are drilled, producing strain.



2 **The strain gauge** consists of small wires through which a voltage flows. It is bonded to the load cell. When the load cell bends, the strain gauge bends with it. The heavier the load, the more it bends and the harder it is for the electricity to travel through the wires (for they are stretched), resulting in a lower voltage. The change in voltage is proportional to the load.



3 **The circuit board** contains two important components: an analogue to digital converter which amplifies the voltage from the strain gauge and converts it into digital information, and the microprocessor. This changes the digital information into weight which is displayed on the LCD.

Task 6

Scan this text to find information on the load cell, the strain gauge, and the circuit board. Note any information in the text which is new, i.e. additional or different to the information obtained from the diagram.

para

Electronic scales use a weighing device called a load cell underneath the platform. The load cell, an aluminium alloy beam, eliminates the need for springs, cogs, or other moving parts which can wear, break, or cause inaccuracy in mechanical scales. *3*

A strain gauge is bonded on the load cell. The strain gauge consists of a small piece of metal foil which detects any bending of the beam. A controlled input voltage is supplied to the strain gauge from a battery-powered circuit. *4*

When a load is placed on the platform, it causes the load cell to bend very slightly. This, in turn, causes a change in strain, which triggers a change in the electrical resistance of the strain gauge. *5*

As the resistance changes, so does the output voltage from the strain gauge. In short, the change in voltage across the strain gauge is proportional to the load on the platform. *6*

The voltage from the gauge is small and has to be amplified and then converted into a digital signal. This signal is fed to a specially programmed microprocessor, which converts it into a weight reading. This is displayed on the LCD. The display will automatically switch off a few minutes after weighing is finished, thereby saving battery power. *7*

Source: 'Inside out: Electronic scales', *Education Guardian*

Language study *Cause and effect, 1*

Study these actions. What is the relationship between them?

1 A load is placed on the platform.
2 The load cell bends very slightly.
3 The strain gauge is stretched.
4 The electrical resistance increases.

In each case, the first action is the cause and the second action is the effect. We can link a cause and effect like this:

1+2 *A load is placed on the platform, which* ***causes*** *the load cell* ***to*** *bend very slightly.*

3+4 *The strain gauge is stretched, which* ***causes*** *the electrical resistance* ***to*** *increase.*

In these examples, both the cause and the effect are clauses – they contain a subject and a verb. Study this example:

Cause: *The strain gauge is stretched.*
Effect: *An increase in electrical resistance.*

The effect is a noun phrase. We can link cause and effect like this:

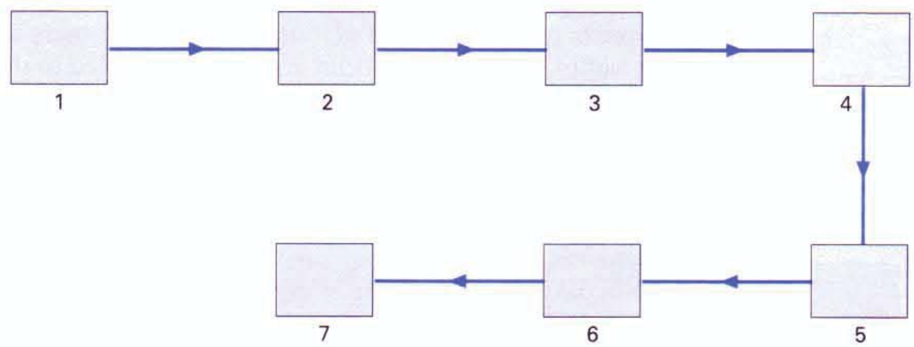
The strain gauge is stretched, which ***causes*** *an increase in electrical resistance.*

In Unit 22 we will study other ways to link a cause and an effect.

Task 7

The diagram below is a cause and effect chain which explains how a strain gauge works. Each arrow shows a cause and effect link. Match these actions with the correct boxes in the diagram.

- **a** An increase in resistance.
- **b** A load is placed on the scale.
- **c** A drop in voltage across the gauge.
- **d** The load cell bends very slightly.
- **e** They become longer and thinner.
- **f** The strain gauge conductors stretch.
- **g** The strain gauge bends.



Now practise linking each pair of actions, i.e. 1+2, 2+3, and so on.

Technical reading *Strain gauges*

Task 8

Read the text below to find the answers to these questions.

1. What principle do strain gauges operate on?
2. Why is it an advantage to have a long length of conductor formed into many rows in a strain gauge?
3. If you want to measure strain in a member, how do you position the strain gauge?
4. Why is an amplifier necessary?
5. Why is a dummy gauge included in the circuit?
6. What is the function of VR2?
7. Why would you adjust the output to exactly zero?
8. In the circuit shown, how is the amplifier output displayed?

Strain gauges

Strain gauges measure the amount of strain in a member. They work on the principle that the electrical resistance of a wire changes as it is stretched, becoming longer and thinner. The more it is stretched, the greater its resistance. Mathematically, this is written as:

$$\text{Resistance} \propto \frac{\text{Length}}{\text{Area}} \text{ or } R \propto \frac{L}{A}$$

By arranging the wire in tightly packed rows, quite long lengths can be fitted on to a small pad (Fig. 1). Modern strain gauges are made not of wire, but by etching a pattern into metal foil which is stuck to a polyester backing (Fig. 2). ▶

In use, a gauge is stuck on to the surface of the member being tested. Its active axis is fixed along the direction in which you want to measure the strain. Movements on the passive axis will have no real effect on it. The gauge must then be connected to an electronic circuit. Fig. 3 shows a block diagram of the complete circuit. The resistance of the gauge is compared with the resistance of fixed value resistors in the circuit. Any differences in resistance are converted into voltage differences. These very small changes in voltage are amplified before being displayed.

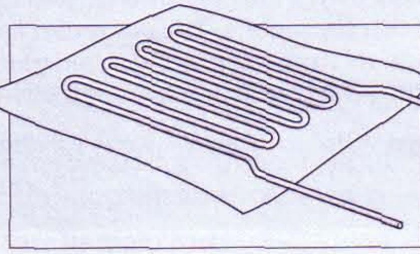


Fig. 1 strain gauge

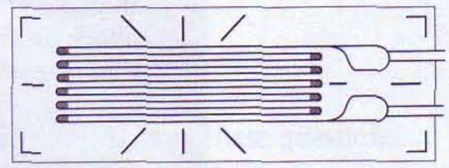


Fig. 2 modern strain gauge

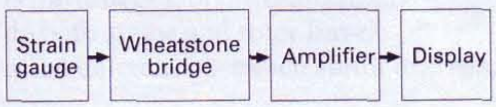


Fig. 3 block diagram of the complete circuit

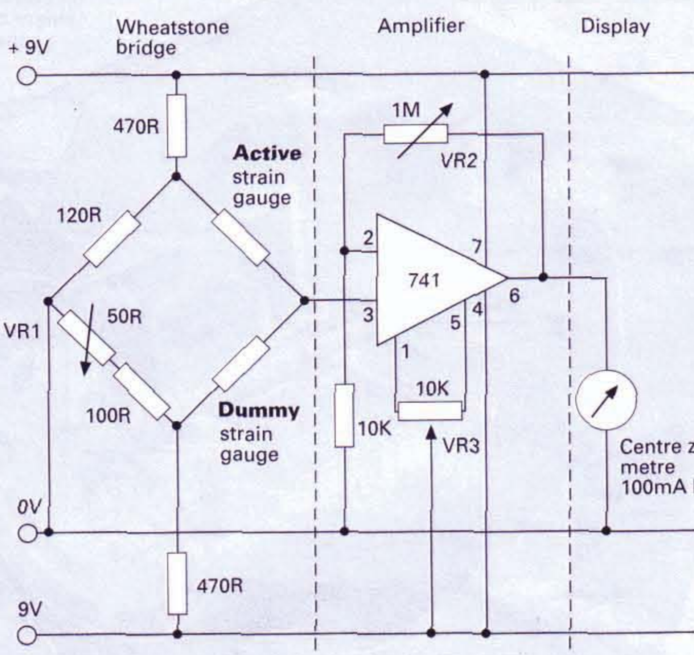


Fig. 4 strain gauge in circuit

The final circuit, shown in Fig. 4, includes a dummy gauge. This compensates for any changes in the resistance of the active gauge caused by temperature changes. The active and dummy gauges form part of the Wheatstone bridge. With no forces applied to the active gauge the output from this part of the circuit should be zero. When forces are applied, the resistance of the active gauge changes so the output voltage to the amplifier changes. The ►

amplifier magnifies that change so that it can be clearly seen on the meter. The three variable resistors in the circuit each allow different adjustments to be made. VR1 allows you to 'balance' the bridge, getting the resistances exactly equal. VR2 allows you to adjust the 'gain' of the amplifier, in other words, how much the voltage is amplified. By adjusting VR3 the output can be adjusted to exactly zero before a load is applied to the member being tested.

In practice, strain gauges tend to be used in pairs or groups, often measuring the strain in various parts of a structure at the same time. When used like this they are often linked to a computer rather than a series of display meters. The computer keeps a constant check on the outputs from each of the strain gauges, making sure that no part of the structure is being loaded beyond normal limits.

Source: P. Fowler and M. Horsley, 'Control Systems in the Home', *CDT: Technology*