Series Editor: Terry Phillips

Roger H. C. Smith

English for ELECTRICAL ENGINEERING in Higher Education Studies

Course Book

esap
English for Specific Academic Purposes

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Introduction

English for Electrical Engineering is designed for students who plan to take an Electrical Engineering course entirely or partly in English. The principal aim of *English for Electrical Engineering* is to teach students to cope with input texts, i.e., listening and reading, in the discipline. However, students will be expected to produce output texts in speech and writing throughout the course.

The syllabus focuses on key vocabulary for the discipline and on words and phrases commonly used in academic English. It covers key facts and concepts from the discipline, thereby giving students a flying start for when they meet the same points again in their faculty work. It also focuses on the skills that will enable students to get the most out of lectures and written texts. Finally, it presents the skills required to take part in seminars and tutorials and to produce essay assignments.

English for Electrical Engineering comprises:

- this student Course Book including audio transcripts and wordlist
- the Teacher's Book, which provides detailed guidance on each lesson, full answer keys, audio transcripts and extra photocopiable resources
- audio CDs with lecture and seminar excerpts

English for Electrical Engineering has 12 units, each of which is based on a different aspect of electrical engineering. Odd-numbered units are based on listening (lecture/seminar extracts). Even-numbered units are based on reading.

Each unit is divided into four lessons:

Lesson 1: vocabulary for the discipline; vocabulary skills such as word-building, use of affixes, use of synonyms for paraphrasing

Lesson 2: reading or listening text and skills development

Lesson 3: reading or listening skills extension. In addition, in later units, students are introduced to a writing assignment which is further developed in Lesson 4; in later listening units, students are introduced to a spoken language point (e.g., making an oral presentation at a seminar) which is further developed in Lesson 4

Lesson 4: a parallel listening or reading text to that presented in Lesson 2, in which students have to use their new skills (Lesson 3) to decode; in addition, written or spoken work is further practised

The last two pages of each unit, *Vocabulary bank* and *Skills bank*, are a useful summary of the unit content.

Each unit provides between four and six hours of classroom activity with the possibility of a further two to four hours on the suggested extra activities. The course will be suitable, therefore, as the core component of a faculty-specific pre-sessional or foundation course of between 50 and 80 hours.

It is assumed that prior to using this book students will already have completed a general EAP (English for Academic Purposes) course such as *Skills in English* (Garnet Publishing, up to the end at least of Level 3), and will have achieved an IELTS level of at least 5.

For a list of other titles in this series, see www.garneteducation.com

Book map

Unit	Topics
1 What is electrical engineering? Listening · Speaking	• what is included in the subject of Electrical Engineering • different branches of electrical engineering: computing and electric power • different aspects of electrical engineering e.g., definitions of some basic electrical terms, measuring devices
2 The history of electrical and electronic engineering Reading · Writing	• the history of electrical engineering from the 19th century to modern days • key figures in the discipline: their main achievements and inventions • the more recent history of electronic engineering: solid-state electronics
3 Electric and magnetic circuits Listening · Speaking	• Ohm's law • the applications of Ohm's law to simple electric circuits • the limitations of Ohm's law for circuit elements that do not have a constant resistance • how Ohm's law can be applied to magnetic circuits
4 The computer Reading · Writing	• the development of the computer • the invention of the integrated circuit, or microchip: its advantages and its impact on society • the use of computers in education • a guide to a more efficient use of the Internet and computers in research
5 The television – from CRT to LCD and 3D Listening · Speaking	• small electrical items: the technology behind different types of television set and screen • some examples of television technology and devices • 3D televisions: two types of lens used in 3D technology: passive and active
6 Control systems Reading · Writing	• control system design • a common feedback loop controller: *PID* • examples of control systems: setting the temperature of a domestic oven, cruise control for cars
7 Electric power generation, transmission and distribution Listening · Speaking	• how electric power is generated in various kinds of power station, such as wind turbines • how it is transmitted across long distances • how it is delivered to customers • issues involved in the power transmission process: energy loss, voltage choices, transformers
8 Telecommunications Reading · Writing	• the history of telecommunication: the main inventions and developments • the processes involved in telecommunication: key stages, elements and related devices • examples of the main applications of telecommunication: radio broadcasting, the mobile phone • the influence that telecommunication has had on the world
9 Signal processing Listening · Speaking	• analogue and digital signal processing • different types of signal and how and why they are processed • filters and processors for both analogue and digital signals • applications of signal processing: active noise control and speech recognition technologies
10 Electric cars Reading · Writing	• the reasons why electric cars have become popular, their advantages and disadvantages • the problems that electric cars pose for electrical engineers: the need to balance issues of efficiency, weight and environmental concerns
11 Microelectromechanical systems Listening · Speaking	• MEMS and NEMS (micro- and nanoelectromechanical systems): how they are manufactured • applications: examples of devices using MEMS and NEMS • potential future developments
12 Lighting engineering Reading · Writing	• the main lighting devices: incandescent light bulbs, fluorescent lamps and LEDs • how these devices work, their applications, and their advantages and disadvantages • technical report writing in the field of simple circuits with LEDs

Vocabulary focus	Skills focus		Unit
• words from general English with a special meaning in electrical engineering • prefixes and suffixes	Listening	• preparing for a lecture • predicting lecture content from the introduction • understanding lecture organization • choosing an appropriate form of notes • making lecture notes	1
	Speaking	• speaking from notes	
• English–English dictionaries: headwords · definitions · parts of speech · phonemes · stress markers · countable/uncountable · transitive/intransitive	Reading	• using research questions to focus on relevant information in a text • using topic sentences to get an overview of the text	2
	Writing	• writing topic sentences • summarizing a text	
• stress patterns in multi-syllable words • prefixes	Listening	• preparing for a lecture • predicting lecture content • making lecture notes • using different information sources	3
	Speaking	• reporting research findings • formulating questions	
• computer jargon • abbreviations and acronyms • discourse and stance markers • verb and noun suffixes	Reading	• identifying topic development within a paragraph • using the Internet effectively • evaluating Internet search results	4
	Writing	• reporting research findings	
• word sets: synonyms, antonyms, etc. • the language of trends • common lecture language	Listening	• understanding 'signpost language' in lectures • using symbols and abbreviations in note-taking	5
	Speaking	• making effective contributions to a seminar	
• synonyms, replacement subjects, etc. for sentence-level paraphrasing	Reading	• locating key information in complex sentences	6
	Writing	• reporting findings from other sources: paraphrasing • writing complex sentences	
• compound nouns • fixed phrases from electrical engineering • fixed phrases from academic English • common lecture language	Listening	• understanding speaker emphasis	7
	Speaking	• asking for clarification • responding to queries and requests for clarification	
• synonyms • nouns from verbs • definitions • common 'direction' verbs in essay titles (discuss, analyze, evaluate, etc.)	Reading	• understanding dependent clauses with passives	8
	Writing	• paraphrasing • expanding notes into complex sentences • recognizing different essay types/structures: descriptive · analytical · comparison/evaluation · argument • writing essay plans and writing essays	
• fixed phrases from electrical engineering • fixed phrases from academic English	Listening	• using the Cornell note-taking system • recognizing digressions in lectures	9
	Speaking	• making effective contributions to a seminar • referring to other people's ideas in a seminar	
• 'neutral' and 'marked' words • fixed phrases from electrical engineering • fixed phrases from academic English	Reading	• recognizing the writer's stance and level of confidence or tentativeness • inferring implicit ideas	10
	Writing	• writing situation–problem–solution–evaluation essays • using direct quotations • compiling a bibliography/reference list	
• words/phrases used to link ideas (*moreover, as a result*, etc.) • stress patterns in noun phrases and compounds • fixed phrases from academic English • words/phrases related to research	Listening	• recognizing the speaker's stance • writing up notes in full	11
	Speaking	• building an argument in a seminar • agreeing/disagreeing	
• verbs used to introduce ideas from other sources (*X contends/suggests/asserts that …*) • linking words/phrases conveying contrast (*whereas*), result (*consequently*), reasons (*due to*), etc. • words for quantities (*a significant minority*)	Reading	• understanding how ideas in a text are linked	12
	Writing	• deciding whether to use direct quotation or paraphrase • incorporating quotations • writing research reports • writing effective introductions/conclusions	

1 WHAT IS ELECTRICAL ENGINEERING?

1.1 Vocabulary

guessing words in context • prefixes and suffixes

A Read the text. The red words are probably familiar to you in general English. But can you think of a different meaning for each word in English for electrical engineering? Change the form if necessary.

> One evening, I was feeling hungry so I crossed the field next to my house and went to a local restaurant. It's on a busy junction, so there was a lot of noise from the traffic. There was also a band playing inside so it was impossible to talk. I waved to a friend on the other side of the restaurant. The menu was written on a board above the bar, and I ordered my favourite dish. The waiter came loaded with plates, and when he reached my table they all fell to the ground and smashed! When the bill came, he charged me less because he wanted to apologize.

B Read these sentences from engineering texts. Complete each sentence with one of the red words from Exercise A. Change the form if necessary (e.g., change a noun into a verb).

1 Light is transmitted in the form of a ______________.
2 I can receive a lot more television channels now I've installed a ______________.
3 The electrical ______________ is very weak.
4 This radio can receive a wide ______________ of frequencies.
5 The electrical components are positioned on the printed circuit ______________.
6 It is important that the wiring in a ______________ box is not loose.
7 The original transmitted signal is distorted by a lot of ______________.
8 We need a ______________ connection to make this system safe.
9 The ______________ on this circuit is too high – turn it off!
10 This electrode has a strong negative ______________.

C Study the words in box a.

1 What is the connection between all the words?
2 What is the base word in each case?
3 What do we call the extra letters?
4 What is the meaning of each prefix?
5 Can you think of another word with each prefix?

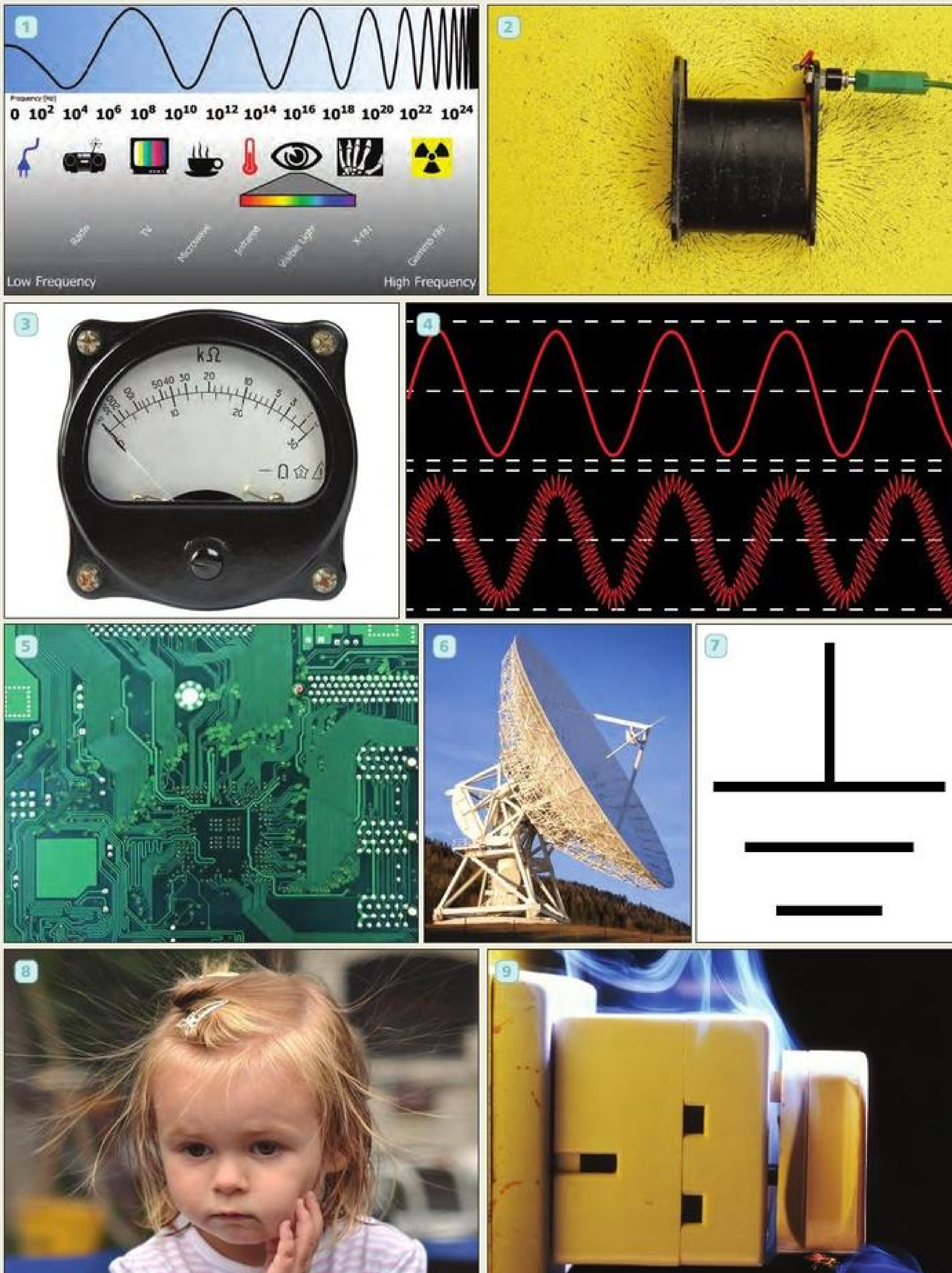
a		
electromagnet	infrared	
kilowatt	megawatt	microwave
overload	thermoplastic	
transmission	ultrasonic	untuned

D Study the words in box b.

1 What is the connection between all the words?
2 What is the base word in each case?
3 What do we call the extra letters?
4 What effect do the extra letters have on the base word?
5 Can you think of another word with each suffix?

b			
electricity	inductance	leakage	
magnetic	ohmmeter	radiation	
resistor	thermal	voltaic	wiring

E Use words from this page to discuss the pictures on the opposite page.


1
0 10^2 10^4 10^6 10^8 10^10 10^12 10^14 10^16 10^18 10^20 10^22 10^24
Radio
TV
Microwave
Infrared
Visible Light
X-ray
Gamma ray
Low Frequency
High Frequency
2
3
kΩ
4
5
6
7
8
9

1.2 Listening

preparing for a lecture • predicting lecture content • making notes

A You are a student in the Electrical Engineering Faculty of Hadford University. The title of your first lecture is *What are the branches of Electrical Engineering?*

1 Think of the branches of Electrical Engineering that you know.

2 What other ideas will be in this lecture? Make some notes.
See *Skills bank*

B Listen to Part 1 of the talk. What does the lecturer say about the branches of Electrical Engineering? Tick the best choice.

1 There are only a few important branches of Electrical Engineering. ___

2 The branches are completely separate from each other. ___

3 Electronics is not part of Electrical Engineering. ___

4 Electrical Engineering has many branches covering a wide area. ___

C In Part 2 of the talk, the lecturer describes several important branches of Electrical Engineering and some applications and devices.

1 How many applications and devices do you know?

2 Listen and check your ideas.

3 What will the lecturer talk about next?

D In Part 3 of the talk, the lecturer talks about key *subjects* that electrical engineers need to know, specific *theories* they may use in their work, and typical *tasks* they do.

1 Which subjects, theories and tasks will be mentioned, do you think?

2 Listen and check your ideas.

E In the final part of the talk, the lecturer looks at the difference between Electrical Engineering and Electronic Engineering. Listen and mark each word in the box with A or B if it is connected with electrical engineering (A) or electronic engineering (B).

computers ___	integrated circuits ___
large-scale electrical systems ___	motor control ___
power transmission ___	small-scale electrical systems ___
transmit energy ___	transmit information ___

F Write a definition of:

1 *Electrical* Engineering (as used in Europe). Use words from Exercise E.

2 *Electronic* Engineering (as used in Europe). Use words from Exercise E.

G Look back at your notes from Exercise A. Did you predict:

- the main ideas?
- most of the special vocabulary?

1.3 Extending skills

lecture organization • choosing the best form of notes

A What can an electrical engineer …

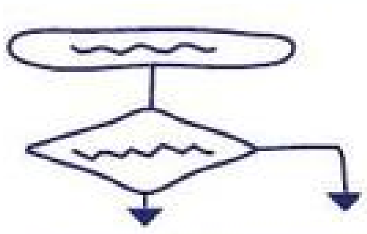
1 invent?	**4** read?	**7** specialize in?
2 measure?	**5** use?	**8** write?
3 study?	**6** become?	**9** design?

B How can you organize information in a lecture? Match the beginnings and endings.

1 question and [i]	**a** contrast
2 problem and ☐	**b** definition
3 classification and ☐	**c** disadvantages
4 advantages and ☐	**d** effect
5 comparison and ☐	**e** events
6 cause and ☐	**f** supporting information
7 sequence of ☐	**g** process
8 stages of a ☐	**h** solution
9 theories or opinions then ☐	**i** answer

C How can you record information during a lecture? Match the illustrations with the words and phrases in the box.

tree diagram flowchart headings and notes spidergram table timeline two columns

1


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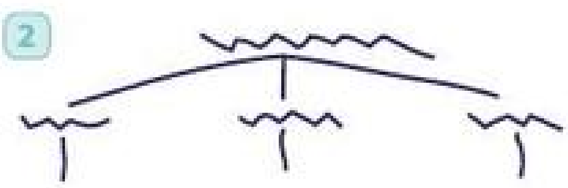

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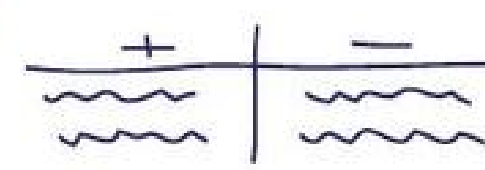

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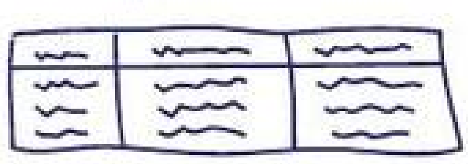

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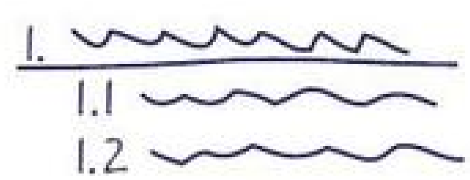

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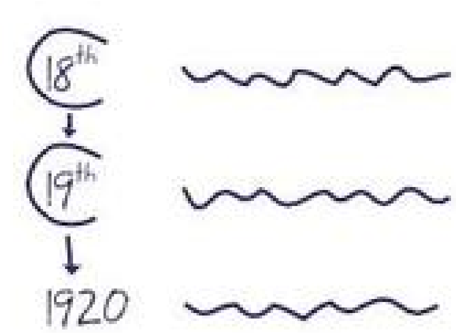


7

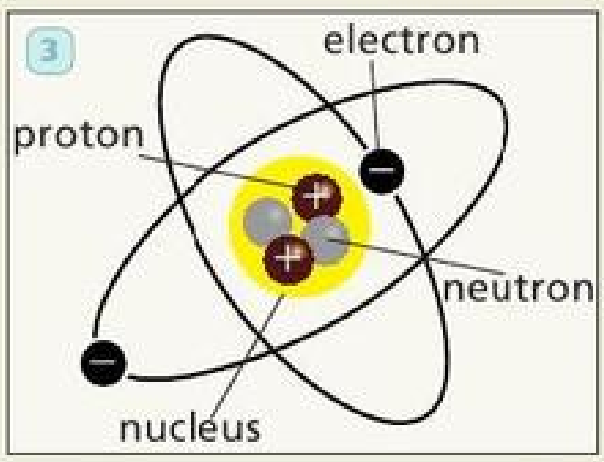

D Match each organization of information in Exercise B with a method of note-taking from Exercise C. You can use one method for different types of organization.

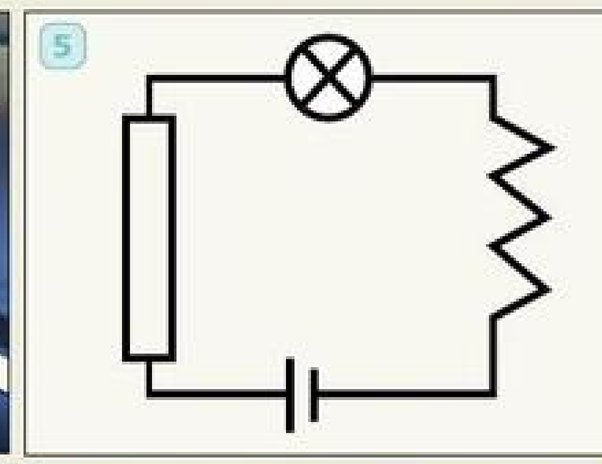
E Listen to five lecture introductions. Choose a possible way to take notes from Exercise C in each case.

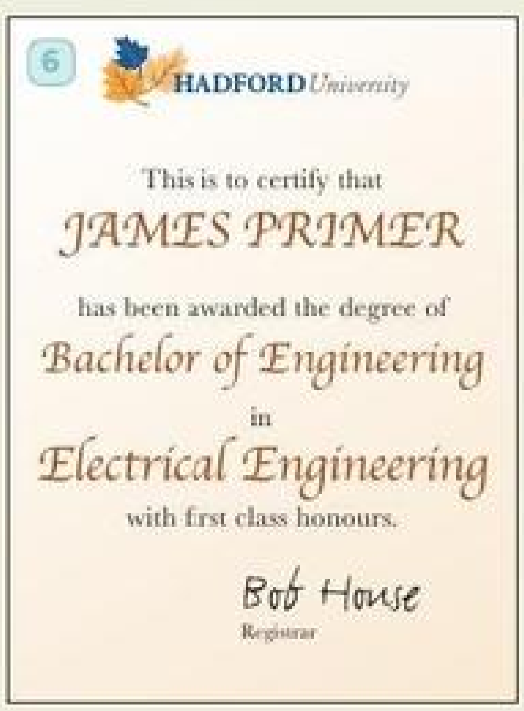
Example:

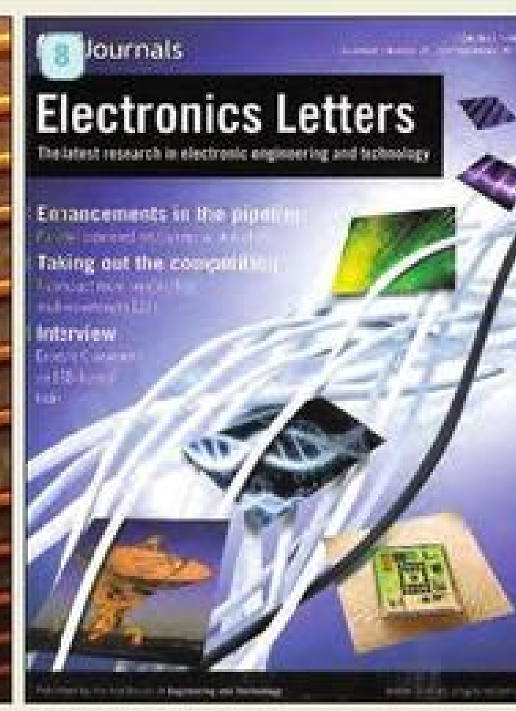
You hear: *Hello, everyone. Today I'm going to talk about the different electrical engineering systems that you can find in a standard modern car. What electrical systems does it contain and what are they for?*

You choose: *heading and notes*









A Study the pictures. What do pictures 1–8 show? Use words from the box.

ammeter	atomic particles	car radio	closed circuit
degree certificate	inductor coil	journal	pen drive

B 🎧 Cover the opposite page. Listen to the lecture introductions from Lesson 1.3 again. Make an outline on a separate sheet of paper for each introduction.

C Look at your outline for each lecture. What do you expect the lecturer to talk about in the lecture? In what order?

D 🎧 Listen to the next part of each lecture. Complete your notes.

E Uncover the opposite page. Check your notes with the model notes. Are yours the same or different?

F Work in pairs.

1 Use the notes on the opposite page. Reconstruct one lecture.

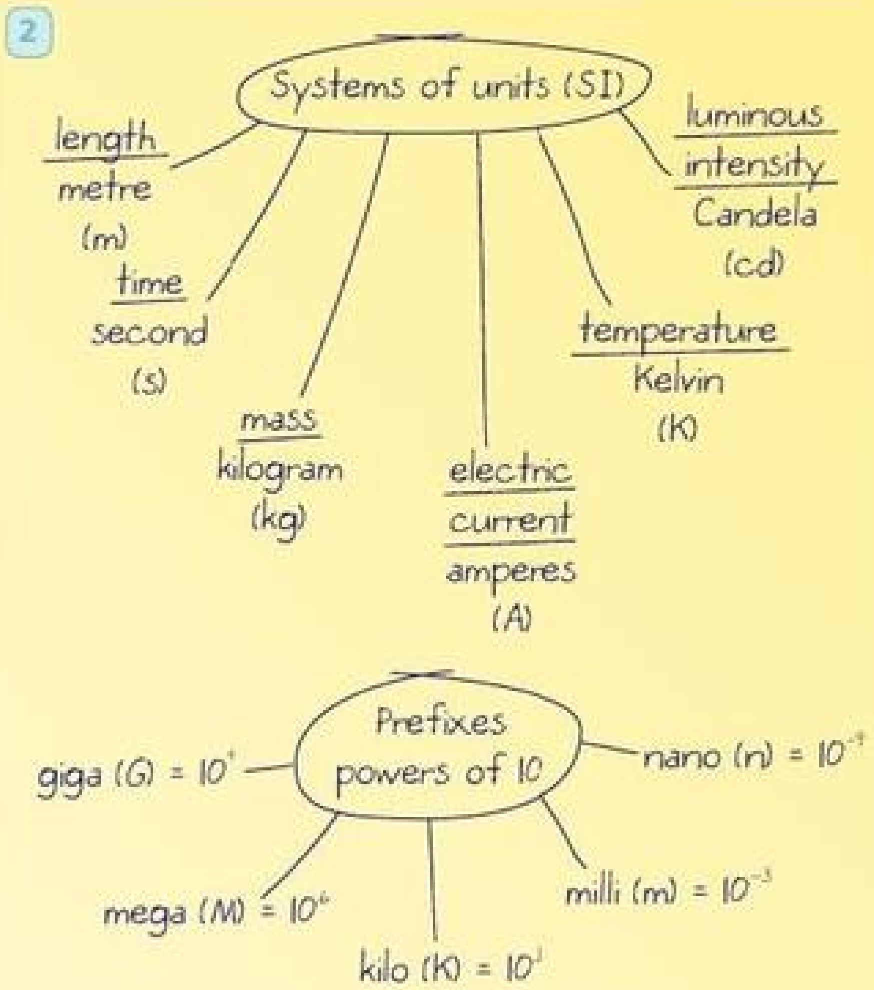
2 Give the lecture to another pair.

1

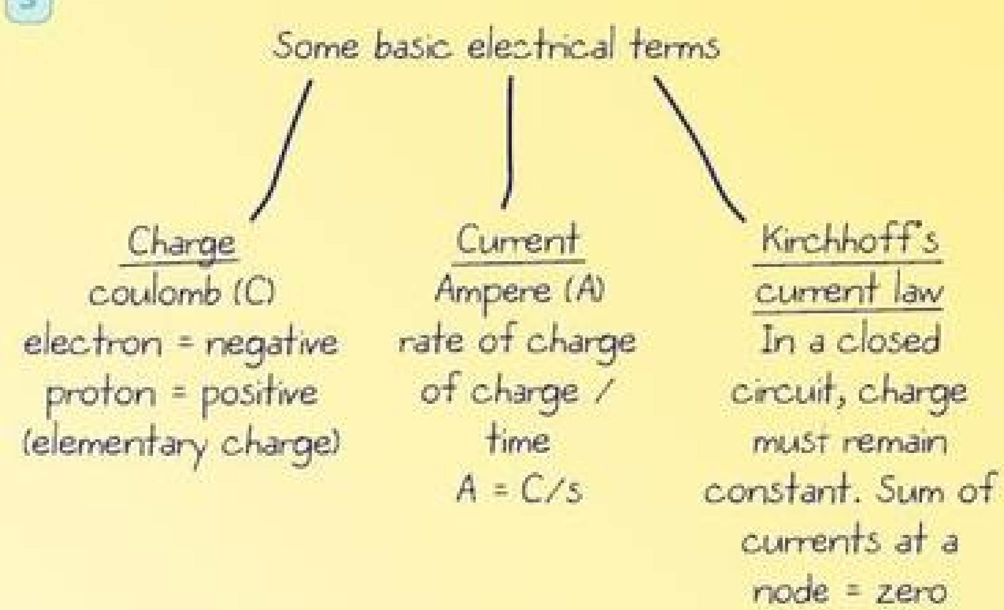
Electrical engineering systems in a car

- electrical ignition system: nduction coil → spark → igniter fuel. (old)
- transistor electronic ignition (new)
- battery + alternator charging system
- radio – antenna receiver signal
- computer systems – control exhaust emissions
  - suspension
  - cruise control
  - antilock braking
- future: fibre-optic networks?

2



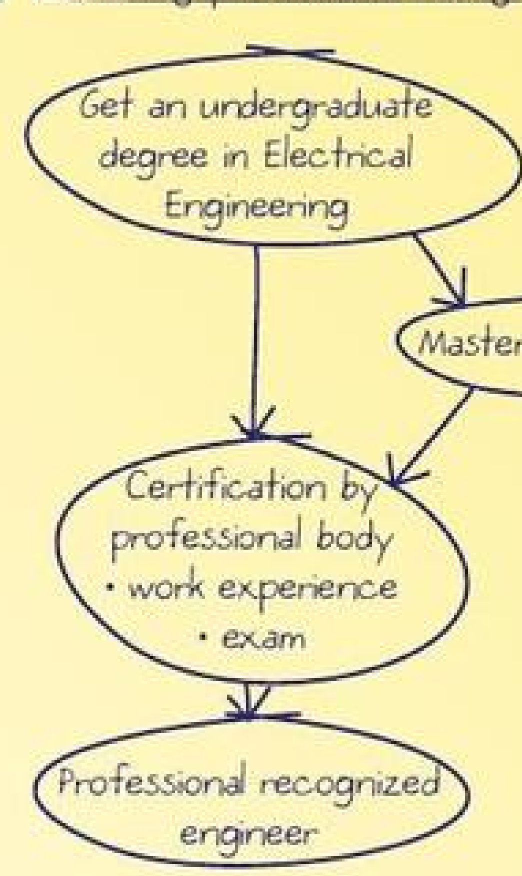
3



4

device	characteristics	how it is used
ohmmeter	measures resistance	connected across circuit element (disconnected)
ammeter	measures current	in series with element zero resistance (ideally)
voltmeter	measures voltage	connected across circuit element infinite resistance (ideally)

5 Becoming professional recognized engineers



Vocabulary bank

Guessing words in context

Using related words

Sometimes a word in general English has a special meaning in electrical engineering.

Examples:
dish, wave, charge

If you recognize a word but don't understand it in context, think:
What is the basic meaning of the word? Does that help me understand the special meaning?

Example:
*A **dish** is something you eat from – it is circular and has a curved shape.*

*A satellite **dish** has the same shape.*

Removing prefixes

A **prefix** = letters at the **start of a word**.

A prefix changes the meaning of a word.

Examples:
non-repairable – cannot be repaired
microwave – a very small wave

If you don't recognize a word, think: *Is there a prefix?* Remove it. Do you recognize the word now? What does that prefix mean? Add it to the meaning of the word.

Removing suffixes

A **suffix** = letters at the **end of a word**.

A suffix sometimes changes the part of speech of the word.

Examples:
magnet ➔ *magnetic* = noun ➔ adjective
resist ➔ *resistor* = verb ➔ noun

A suffix sometimes changes the meaning **in a predictable way**.

Examples:
induct + *ance* – the act or fact of (inducting)
noise + *less* – without (noise)
switch + *ing* – action involving (a switch)

If you don't recognize a word, think:
Is there a suffix? Remove it. Do you recognize the word now?
What does that suffix mean? Add it to the meaning of the word.

Skills bank

Making the most of lectures

Before a lecture ...

Plan
- Find out the topic of the lecture.
- Research the topic.
- Check the pronunciation of names and key words in English.

Prepare
- Get to the lecture room early.
- Sit where you can see and hear clearly.
- Bring any equipment you may need.
- Write the date, topic and name of the lecturer at the top of a sheet of paper.

During a lecture ...

Predict
- Listen carefully to the introduction. Think: *What kind of lecture is this?*
- Write an outline. Leave space for notes.
- Think of possible answers/solutions/effects, etc., while the lecturer is speaking.

Produce
- Write notes/copy from the board.
- Record sources – books/websites/names.
- At the end, ask the lecturer/other students for missing information.

Making perfect lecture notes

Choose the best way to record information from a lecture.

advantages and disadvantages	→	two-column table
cause and effect	→	spidergram
classification and definition	→	tree diagram/spidergram
comparison and contrast	→	table
problem and solution	→	headings and notes/two-column table
sequence of events	→	timeline/flowchart
stages of a process	→	flowchart
question and answer	→	headings and notes

Speaking from notes

Sometimes you have to give a short talk in a seminar on research you have done.
- Prepare the listeners with an introduction.
- Match the introduction to the type of information/notes.

2 THE HISTORY OF ELECTRICAL AND ELECTRONIC ENGINEERING

2.1 Vocabulary

using an English–English dictionary

A How can an English–English dictionary help you understand and produce spoken and written English?

B Study the extract from an Electrical Engineering dictionary on the opposite page.

1. Why are the two words (top left and top right) important?
2. How many meanings does *element* have?
3. What is the name of the elementary negative charge?
4. Where is the main stress on *electron*? What about *electronic*?
5. What is the difference between *electric* and *electrical*?
6. What is the pronunciation of *y* in each bold word in this extract?
7. What is the pronunciation of *e* in each bold word in this extract?
8. What part of speech is *electrostatic*?
9. Are both of these correct? *There is some energy. / There are some energies.*
10. Can we write: *The electrolysis are finished.* Why (not)?

C Look at the bold words in the dictionary extract on the opposite page.

1. What order are they in?
2. Write the words in box a in the same order.

switch wave conductor amplify
signal insulated
technique development distribution
application integrated microprocessor

D Look at the top of this double page from an English–English dictionary.

1. Which word from the blue box will appear on these pages?
2. Think of words before and after some of the other words in the blue box.


sensor speaker

E Look up the red words in the blue box.

1. How many meanings can you find for each word?
2. What word(s) can be nouns or verbs?
3. How are the words used in electrical engineering?

F Look up the green words in the blue box.

1. Where is the stress in each word?
2. What is the sound of the underlined letter(s) in each word?
3. How are the words used in electrical engineering?

G Test each other on the words from Exercises E and F. Give the dictionary definition of one of the words. Can your partner guess which word you are defining?

H Discuss the pictures on the opposite page using words from this lesson.

electric — **equivalent resistance**

electric /ɪ'lektrɪk/ *adj* worked by or charged with electricity: *electric current, electric field*
n [U] the supply of electricity to a building

electrical /ɪ'lektrɪkl/ *adj* 1. operating by electricity 2. concerned with the nature of electricity: *electrical charge, electrical power system*

electrode /ɪ'lektrəʊd/ *n* [C] a terminal where electricity passes from one medium to another, e.g., in an electrical cell

electrolysis /ɪlek'trɒləsɪs/ *n* [U] a chemical process of changing the composition of a material by passing an electric current through it

electrolyte /ɪ'lektrəlaɪt/ *n* [C] a dissolved substance, forming a liquid or a paste, that can conduct electricity

electromagnet /ɪ'lektrəʊmægnət/ *n* [C] a magnet which has been electrically excited and is capable of performing mechanical work

electromagnetic /ɪlektrəʊmæg'netɪk/ *adj* having electrical and magnetic properties: *electromagnetic induction, electromagnetic radiation*

electron /ɪ'lektrɒn/ *n* [C] the elementary negative charge revolving around the nucleus of an atom

electronic /ɪlek'trɒnɪk/ *adj* 1. having many small parts that direct and control an electric current: *an electronic switch* 2. concerned with electronic equipment: *an electronic engineer*

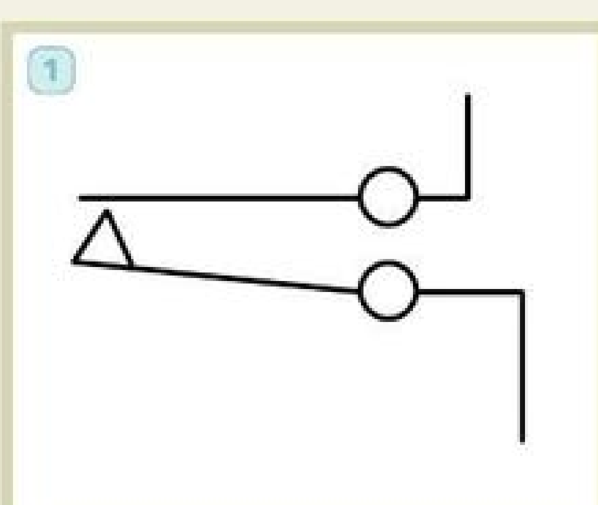
electrostatic /ɪlektrəʊ'stætɪk/ *adj* concerning electricity at rest, e.g., charges on an object

element /'elɪmənt/ *n* [C] 1. a chemical substance that cannot be divided into simpler substances 2. part of a device that contributes directly to its operation, e.g., a capacitor, diode, transistor, etc. 3. the part of an antenna that is a radiator, either parasitic or active

encoder /ɪn'kəʊdə(r)/ *n* [C] an electric or electronic device used to change a signal or character into a code

energy /'enədʒiː/ *n* [U] the capacity or ability to do work

equivalent resistance /ɪ'kwɪvələnt rɪ'zɪstəns/ *n* [C] a resistance representing the total value of ohms across two terminals of a circuit

1


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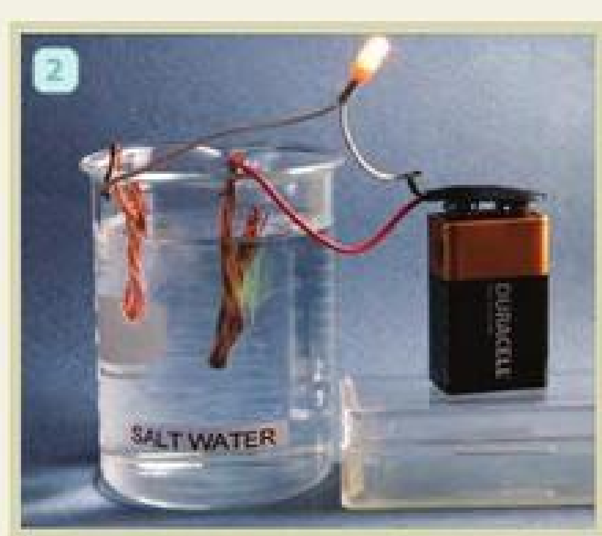

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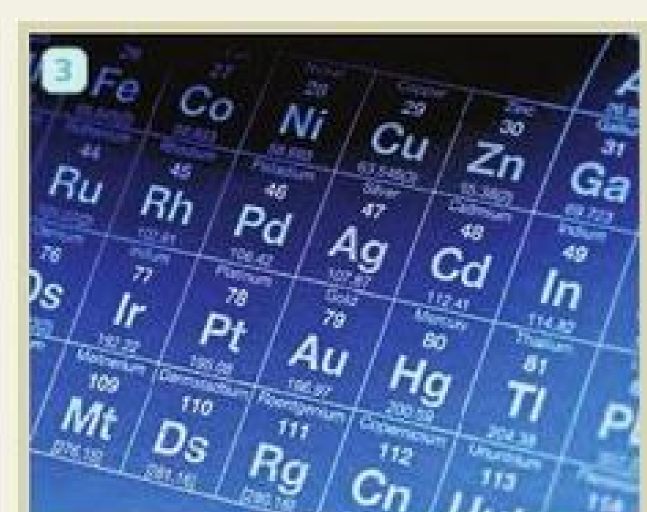

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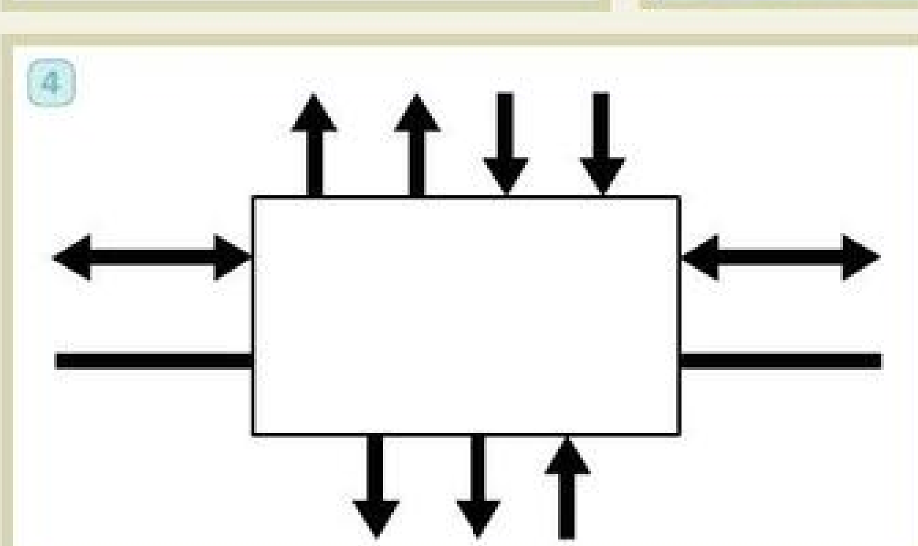

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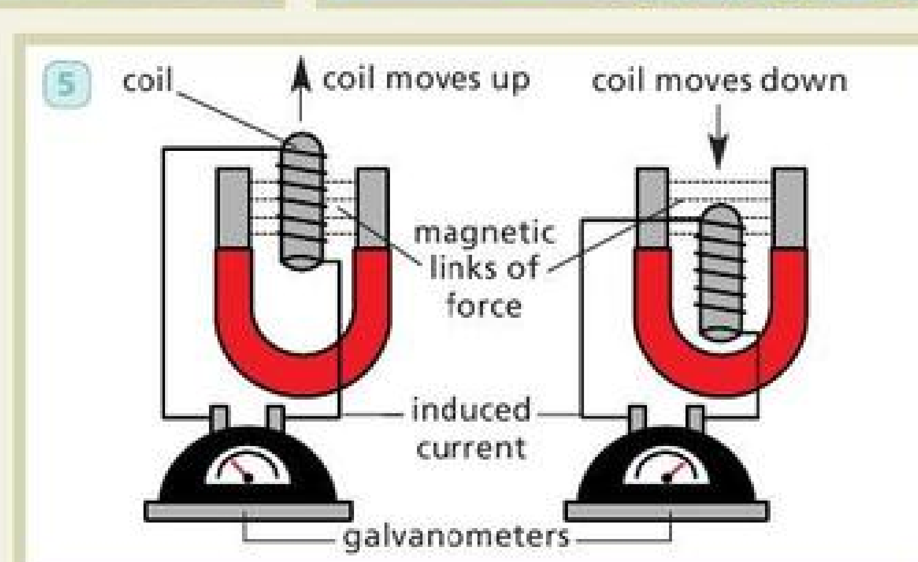


2.2 Reading
using research questions

A Which are the most important electrical inventions in the history of Electrical Engineering?

B Look at the list of inventions on the right.

1. Define each invention.
2. Do you know who invented them?

C You are going to read a text. What should you do before you read a text in detail? **See *Skills bank***

D This text is about the history of electrical engineering up to 1950.

1. What do you know about: The Edison effect? Electron theory? Alternating current?
2. Think of some research questions before you read.
3. Compare your questions with those in the Hadford University assignment on this page.

E Study these topic sentences from the text and answer the questions below.

> Electrical phenomena occupied European thinkers as early as the 17th century, but the first notable developments in this field were made in the first half of the 19th century.

> However, many people believe that Electrical Engineering can only be said to have emerged as a discipline in the second half of the 19th century.

> As a result of the discoveries in electricity, there was a dramatic increase in work in the area.

> The rivalry between AC and DC systems helped advance electrical engineering.

> The discovery of the Edison effect and electron theory laid the foundations of radio engineering.

> In 1930, the term *electronics* was introduced to include radio and the industrial applications of electron tubes.

> The Second World War saw tremendous advances in the field of electronics.

1. Were you right about who invented these things and when?
2. Where might you find the answer to each question in the university assignment? Write 1, 2 or 3 next to the topic sentence.
3. What do you expect to find in the other paragraphs?

F Read the text on the opposite page and check your ideas. **See *Skills bank***

Great Advances in Electrical Engineering

- The generator
- The telegraph
- The telephone
- The incandescent lamp
- Induction motors
- The stock ticker
- Vacuum tubes
- Radio
- Television
- Radar
- The magnetron

HADFORD *University*

Faculty: Electrical Engineering

Assignment

Do some research into the main inventions in the history of electrical engineering. Make notes to answer these questions:

1. When did the first discoveries in electricity take place?
2. When did Electrical Engineering start as a subject in its own right?
3. What were the key discoveries and inventions in the field of Electrical Engineering?

The history of Electrical Engineering up to 1950


Thomas Edison

Electrical phenomena occupied European thinkers as early as the 17th century, but the first notable developments in this field were made in the first half of the 19th century. Ohm quantified the relationship between electric current and potential difference for a conductor, and constructed an early electrostatic machine in the 1830s. Also around this time, Faraday discovered electromagnetic induction and developed the homopolar generator. The first practical application of electromagnetism was the telegraph, invented by Henry, and exploited commercially by Morse in 1837.

However, many people believe that Electrical Engineering can only be said to have emerged as a discipline in the second half of the 19th century. This happened when it was associated with the tools of modern research techniques. The Scottish physicist Maxwell summarized the basic laws of electricity in mathematical form in 1864. He predicted that radiation of electromagnetic energy would occur. The radiation later became known as *radio waves*.

As a result of the discoveries in electricity, there was a dramatic increase in work in the area. Bell invented the telephone in 1876, and Edison invented the incandescent lamp in 1878. Edison provided the world's first large-scale electrical supply network with *direct current* (DC), while Tesla offered a rival form of power distribution known as *alternating current* (AC). AC eventually replaced DC for generation and power distribution, which allowed for the expansion of the electric power industry throughout the world, improving the safety and efficiency of power distribution.

The rivalry between AC and DC systems helped advance electrical engineering. Tesla's work on induction motors influenced the field for years to come, while Edison's work on telegraphy and the stock ticker helped his company expand. It eventually became General Electric. All these applications meant an increased demand for people trained to work with electricity.

The discovery of the Edison effect and electron theory laid the foundations of radio engineering. The Edison effect is the name given to the phenomenon of a hot metal cathode emitting electrons and is the principle behind vacuum tubes. Many scientists and inventors were involved in the radio technology that followed as a result of experiments in the Edison effect and electron theory. Hertz transmitted and detected radio waves using electrical equipment in 1888. Tesla, in 1895, was able to detect signals from transmissions at a distance of over 80 km. In 1896, Popov made wireless transmissions over a distance of 60 m, and Marconi, around the same time, made a transmission across 2.4 km. By the end of 1906, Fessenden had sent the first radio broadcast.

In 1930, the term *electronics* was introduced to include radio and the industrial applications of electron tubes. However, prior to the Second World War, the subject was still commonly known as *radio engineering* and was mainly restricted to aspects of communications, commercial radio and early television. At this time, the study of radio engineering at universities could only be undertaken as part of a physics degree.

The Second World War saw tremendous advances in the field of electronics. Key advances were made in radar, as well as in the magnetron developed by Randall and Boot in Birmingham in 1940. Radio location, radio communication and radio guidance of aircraft were all developed in Britain at this time. An early electronic computing device, Colossus, was built by Flowers to decipher German coded messages. Advanced hidden radio transmitters and receivers for use by secret agents were also developed at this time. All these developments ensured that electrical engineering had come of age, and was at the forefront of modern scientific advancement.

2.3 Extending skills

paragraph structure • topic sentences • summarizing

A Study the words in box a. They are all from the text in Lesson 2.2.

1 Look back at the text on page 17. Find the words which go together with the words in the box.

2 Are the words in the box used as nouns or verbs?

3 What is the meaning of each phrase? Look at the context and check with your dictionary if necessary.

a
relationship induction
techniques network safety
demand foundations signals
broadcast radio

B Study the words in box b. They are all from the text in Lesson 2.2.

1 What is the base word in each case? What part of speech is the base word?

2 Does the prefix/suffix change the part of speech?

3 How does the prefix/suffix change the meaning of the base word?

b
conductor electromagnetism
distribution efficiency
applications wireless
guidance electronic

C Look back at the text on page 17. After each topic sentence, how does the writer continue the paragraph? The following list may be helpful:

- (an) example(s)
- restatement of the topic sentence
- a list of points
- more detailed information
- concluding

D Write a summary of the text on page 17. Paraphrase the topic sentences. Add extra information and examples. **See *Skills bank***

2.4 Extending skills

using research questions • writing topic sentences • summarizing

A Discuss these questions.

1 Which inventions were discussed in Lesson 2.2?

2 Which inventions led directly to others?

3 Which period was the most eventful in the history of electrical engineering?

B The lecturer has asked you to do some research into the history of electronic engineering.

1 What are the key inventions in electronic engineering?

2 Think of good research questions before you read the text on the opposite page.

3 Look quickly at the text on the opposite page. What is the best way to record information while you are reading?

C Study the text on the opposite page.

1 Highlight the topic sentences.

2 Read each topic sentence. What will you find in the rest of the paragraph?

3 Which paragraph(s) will probably answer each research question? Read those paragraphs and make notes.

4 Have you got all the information you need? If not, read other paragraphs.

D Use the Internet to find out about different household appliances that use microprocessors. Explain what functions the microprocessors perform in these appliances.

1 Make notes.

2 Write a series of topic sentences which summarize your findings.

3 Prepare to report back to the other students in the next lesson.

The history of electronic engineering

The discovery of the electron in 1897 emerged from Edison's work on the electric light bulb and marked the beginning of electronics. In his experiments, Faraday noticed that a small metal plate placed in front of one of his experimental bulbs picked up an electric current that had crossed the bulb's vacuum from the hot filament. The current passing through the vacuum always travelled in the same direction, from the filament to the plate, even when the filament carried an alternating current. The existence of microscopic particles – electrons – was proposed. The theory was that these particles were moving through the vacuum at high speed.

A series of experiments led to the invention of the triode. Within the vacuum tube, a grid-like wire was inserted between the filament and the plate. This functioned as an amplifier, meaning that changes in a very small voltage applied to the grid produced corresponding changes in the flow of the much larger current between the other two elements. This three-element tube – or triode – had many applications, including long-distance telephony, record players, radio and television.

Triodes can also work as a switch by using the grid voltage to turn a current on or off. Rapid switching between on and off positions was identified as a way of carrying out complex calculations using the binary numbering system, with different arrangements of switches sufficient to perform any mathematical or logical operation. Vacuum tubes were therefore quickly enlisted for the new computing machines. But, because a very large number of switches are required, the first models of computers were extremely large and expensive to run.

By the middle of the 20th century, scientists were searching for an alternative to vacuum tubes. Crystalline materials known as *semiconductors*, in which current flows in only one direction, were investigated. It was known that the presence of certain impurities, such as phosphorus, strongly affected the electrical behaviour of semiconductors. The impurities provided a surplus of electrons that were free to contribute to a current. Some researchers were convinced that semiconductors could have the properties of a triode. In 1947, that goal was met in the form of a three-layer semiconductor sandwich, known as a *transistor*. An impurity was added to the outer layers to supply extra electrons, and the middle portion of the sandwich functioned like the grid in a triode, controlling a sizable current flow between the outer layers. This was the beginning of solid-state electronics.

There were pros and cons to the first transistors. They used much less power than vacuum tubes, did not need to warm up, and were compact. However, their main ingredient was germanium: an expensive, hard-to-handle element, with performance limitations. A turning point came in early 1954, when a transistor was made from silicon, an element of sand. The Silicon Age had arrived. Silicon transistors led to the creation of integrated circuits. An integrated circuit is an assemblage of different components that are wired together and work as a unit. In 1958, it was discovered that a wafer of silicon could be given all the elements necessary to function as a circuit. The design of the wafer was developed and it became better protected and insulated. It also became much easier to connect the circuit elements together. By the mid-1990s, some chips the size of a fingernail contained 20 million components.

Today, transistors are much cheaper and are often organized in circuits that can perform complex functions or tasks. They can provide electronic memory and carry out particular tasks, such as manipulating audio signals or graphic images. Other uses are in general-purpose computing devices called *microprocessors*, which are not designed to do one specific task. Instead, they can follow software instructions to perform a range of tasks.

The first microprocessor was produced in 1971. Faster versions soon followed, and prices dropped. Microprocessors are now everywhere, operating in every household appliance and in every mode of communication and transportation. This rate of development shows no sign of slowing. Computing power will continue its incredible expansion and change our future in ways which we cannot imagine at present.

Using your English–English dictionary

This kind of dictionary helps you actually **learn** English.

Using headwords and parts of speech

1 Find the correct **headword**.
These **bold** words in a dictionary are in alphabetical order. Look at the words on the top left and top right of the double page. Find a word which comes just before and after your word.

2 Find the correct **meaning**.
If there are different meanings of the word, they appear in a numbered list. Look at all the meanings before you choose the correct one in context.

3 Find the correct **part of speech**.
Sometimes the same headword appears more than once, followed by a small number. This means the word has more than one part of speech, e.g., *n* and *v*. Work out the part of speech before you look up a word. Clues:

- Nouns often come after articles (*a/an/the*) or adjectives.
- Verbs come after nouns or pronouns.

Learning to pronounce words

The symbols after the headword show you how to pronounce the word. Learn these symbols (the key is usually at the front or the back of the dictionary).

The little line in the symbols shows you how to stress the word.

Example:
Compare the stress in the words

electric /ɪ'lektrɪk/ but *electricity* /ɪlek'trɪsɪtɪ/

Learning to use words correctly in context

Nouns can be **countable** or **uncountable**. This information is important for using articles and verb forms (e.g., *is/are*) correctly. Look for the symbol [**C**] or [**U**].

Some verbs need an object. They are **transitive**. Some verbs don't need an object. They are **intransitive**. This information is important for making good sentences. Look for the symbol [**T**] or [**I**].

Some words can be spelt in **British** English (e.g., *colour, centre*) or **American** English (e.g., *color, center*). Choose the correct spelling for the text you are working on.

Skills bank

Doing reading research

Before you start reading ...

- Think of research questions. In other words, ask yourself: *What must I find out from my research?*
- Look at headings, sub-headings, illustrations. Look for patterns or variations in presentation, e.g., a series of dates; words in **bold** or *italic* script. Think: *What information do they give me?*
- Decide how to record information from your reading. Choose one or more methods of note-taking. **See Unit 1 *Skills bank***

While you are reading ...

- Highlight the topic sentences.
- Think: *Which paragraph(s) will probably give me the answer to my research questions?*
- Read these paragraph(s) first.
- Make notes.

After reading ...

- Think: *Did the text answer all my research questions?*
- If the answer is no, look at other paragraphs to see if the information is there.

Using topic sentences to summarize

The topic sentences of a text normally make a good basis for a summary. Follow this procedure:

- Locate the topic sentences.
- Paraphrase them – in other words, rewrite them in your own words so that the meaning is the same. Do not simply copy them. (This is a form of plagiarism.)
- Add supporting information – once again, in your own words.

Example:

Topic sentence	There were pros and cons to the first transistors.
Paraphrase of topic sentence	The first transistors had advantages and disadvantages.
Supporting information and examples (summarized)	They were smaller and cheaper to run than vacuum tubes, but they were made of a material that was expensive and difficult to use.

- Check your summary. Check that the ideas flow logically. Check spelling and grammar. If your summary is short, it may be just one paragraph. For a longer summary, divide it into paragraphs.

3 ELECTRIC AND MAGNETIC CIRCUITS

3.1 Vocabulary

stress within words • prefixes

A Discuss these questions.

1 What is an *electric circuit*?

2 What circuit elements do you know?

3 Draw an example of a simple circuit, showing the different elements.

a

battery calculations circuit
conductor current equation
measurement multiplication
potential proportional
resistance terminals

B Study the pictures on the opposite page.

1 What does each picture show? Talk about each picture using a word from box a.

2 Which of the pictures show examples of electric circuits? Which show elements of circuits? Can any of the other words be used in connection with electric circuits?

C Look at the words in box a.

1 Underline the stressed syllable in each word.

2 Which word has the same stress pattern as *engineering*?

3 Sort the other words into groups according to their stress patterns.

D Complete each sentence with a word from box a. Change the form if necessary.

1 Copper is a very good ______________ of electricity.

2 The straight line on the graph shows the ______________ relationship between the two quantities.

3 ______________ flows around the circuit.

4 *3 + x = 5* is an example of an algebraic ______________.

5 The sign for ______________ is 'x', as in *3* x *4 = 12*.

6 Electrical engineers make a lot of ______________ as part of their work.

7 Instruments that make ______________ include the ohmmeter and the voltmeter.

8 Electric ______________ is the energy required to move a unit electric charge to a particular place in a static electric field.

E Study the words in box b. Find the prefix and try to work out the meaning in each case.

b

photovoltaic	non-linear	multimeter	reproduction	degeneration
photodiode	non-repairable	multielement	regeneration	demagnetize
phototransistor	non-resonant	multiloop	recur	deconstruct

F Complete each sentence with a word from box b. Change the form if necessary.

1 The graph doesn't show a proportional relationship so it is ______________.

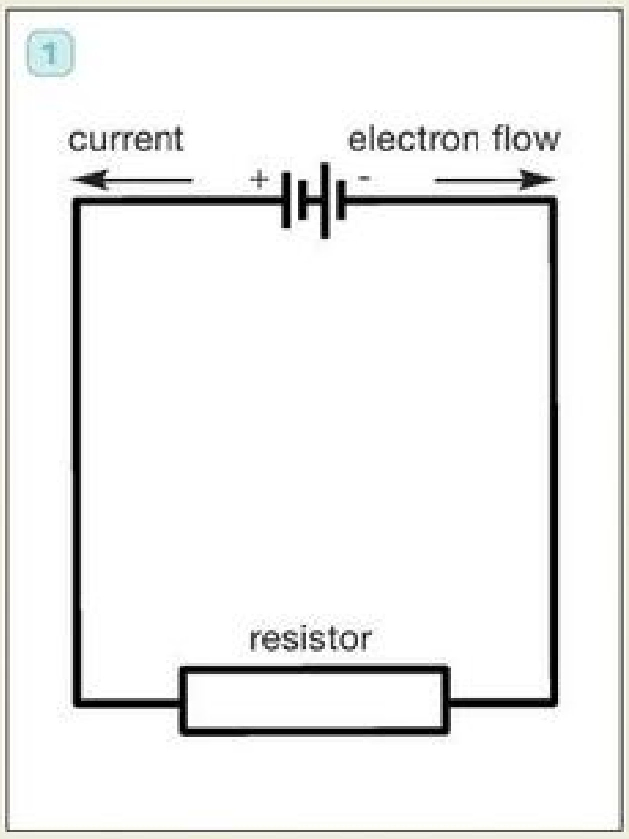
2 The experiment used a ______________ to measure voltage, current and resistance.

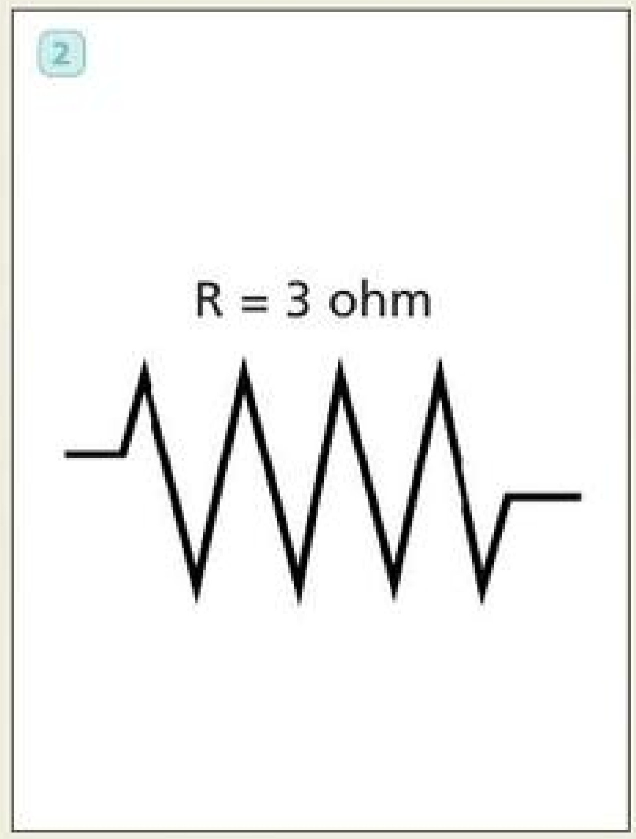
3 The quality of the ______________ of music on an mp3 player can depend on the earphones you use.

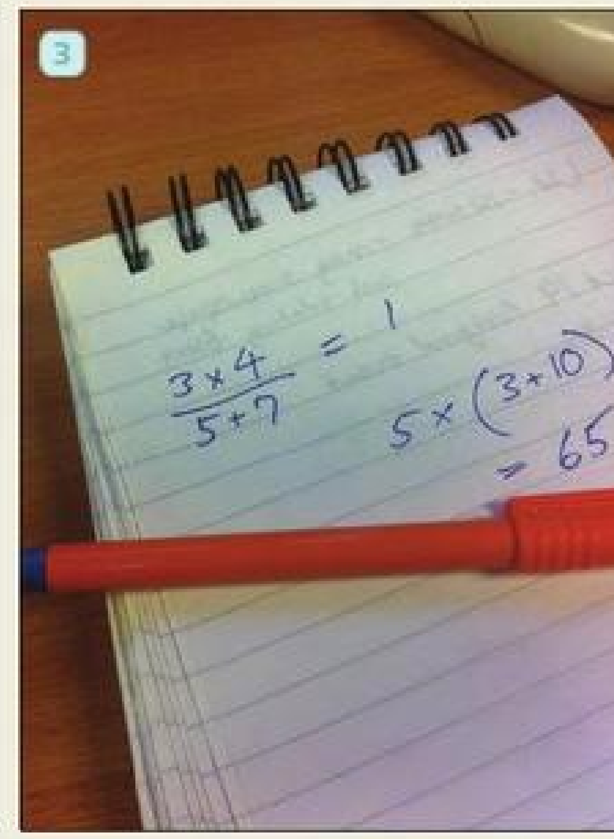
4 If you drop a magnet, you may ______________ it.

5 Solar panels use ______________ cells to generate electrical energy.

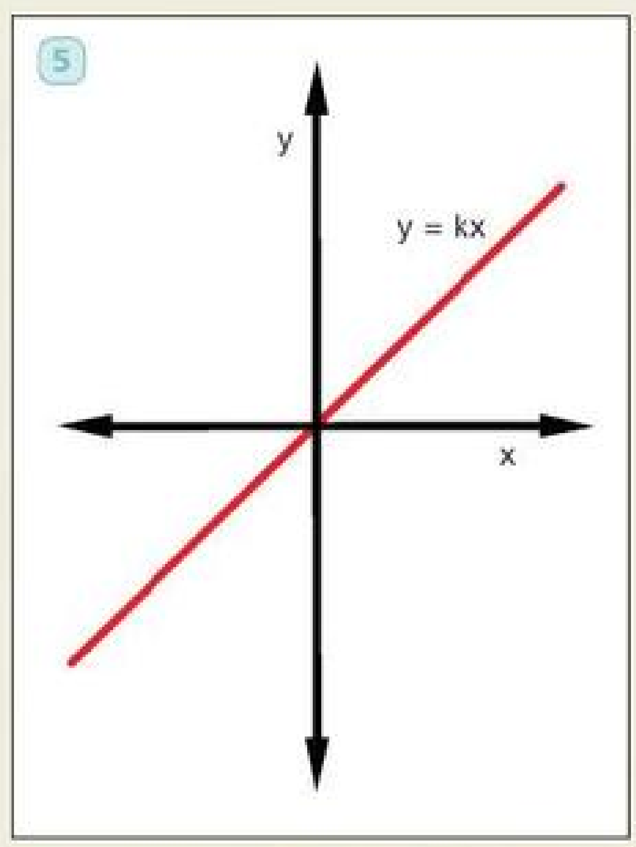
6 An old microwave oven is an example of a ______________ system – if it doesn't work, throw it away and buy a new one.

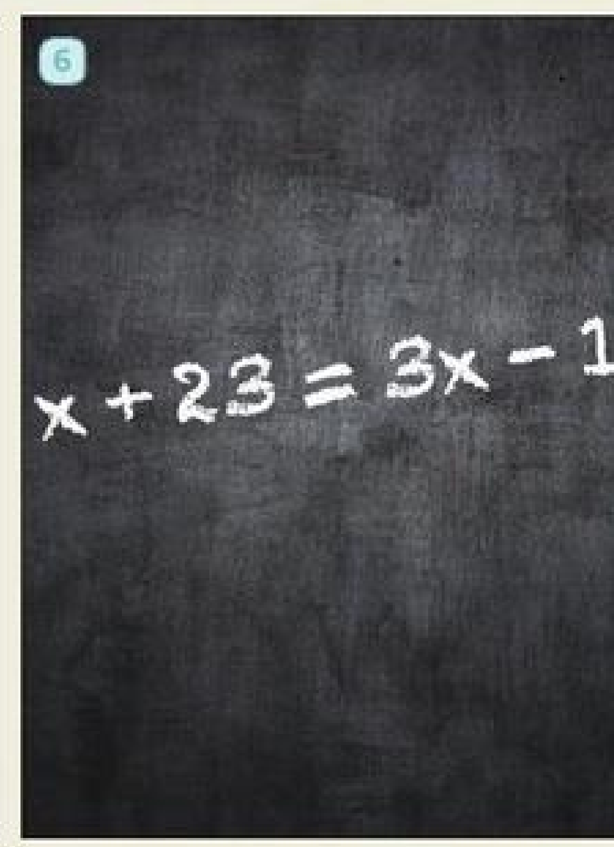

1
current
electron flow
+
-
resistor


2
R = 3 ohm


3
3×4 / 5+7 = 1
5×(3+10)
= 65


4
400 mA
10A
FUSE


5
y
y = kx
x


6
x + 23 = 3x − 1


7


8


9

A Study the slides from a lecture about electric circuits.

1 What do you expect to learn in this lecture? Make a list of points.

2 Write down key words you expect to hear.

3 How are you going to prepare for this lecture?

B Listen to Part 1 of the lecture.

1 What exactly is the lecturer going to talk about today? Tick the topic(s) you heard.
- Ohm's law and simple electric circuits ____
- Ohm's law and complicated electric circuits ____
- Exceptions to Ohm's law ____

2 What reason does the lecturer give for talking about this topic?

3 What is the best way to organize notes for this lecture?

C Listen to Part 2 of the lecture.

1 What does the lecturer say about the history behind Ohm's law?

2 What is Ohm's law?

3 What analogy does the lecturer use to illustrate the law?

4 What do you expect to hear in the next part of the lecture?

D Listen to Part 3 of the lecture.

1 How could you write notes for this part?

2 What is the quantity discussed and how is it defined?

E Listen to Part 4 of the lecture.

1 Check your definition of the quantity discussed.

2 What is the research task?

F Listen and say whether these sentences are true or false according to the lecture.

1 ____ 2 ____ 3 ____

4 ____ 5 ____

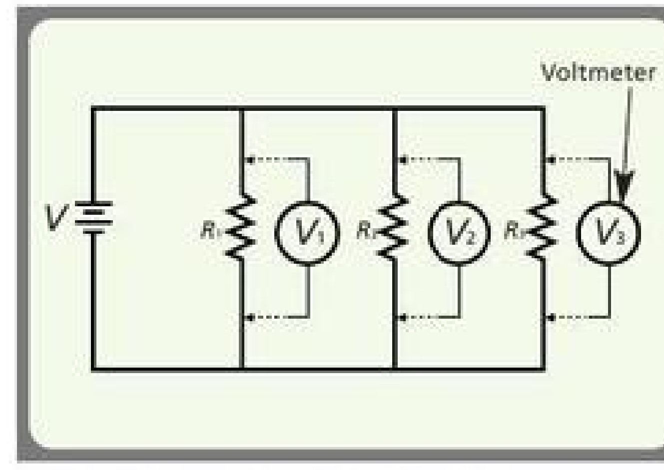
G What does Slide 5 show? Discuss:

1 the missing units and symbols

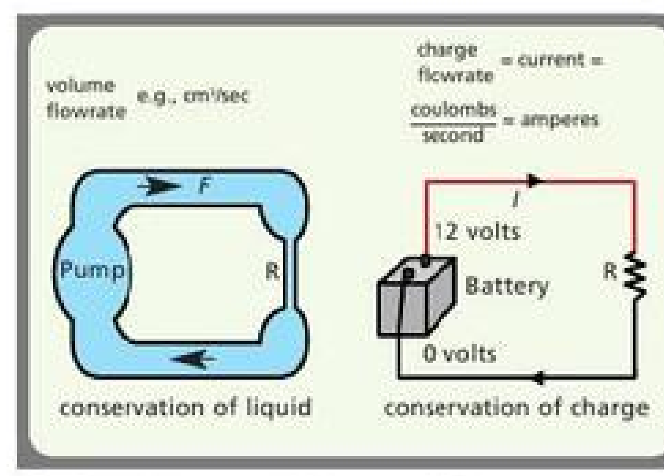
2 the missing numbers for the quantities (assuming they are from a circuit that obeys Ohm's law)

$$V = I \times R$$

Slide 1: Ohm's law



Slide 2: An electrical circuit



Slide 3: Current law and flow rate

$$P = V \times I = \frac{V^2}{R}$$

Slide 4: Joule's law

Quantity	Voltage	Current	Resistance	Power
Symbol				
Unit				
Unit symbol				
Circuit 1		3	1	
Circuit 2	6	3		
Circuit 3	4		2	

Slide 5: Quantities, units symbols and examples of Ohm's law and Joule's law

3.3 Extending skills

stress within words • using information sources • reporting research findings

A Listen to some stressed syllables. Identify the word below in each case. Number each word.

Example:

You hear: 1 *com* /kʌm/ You write:

application	___	filament	___	relationship	___
circuit	___	incandescent	___	resistor	___
compass	1	increase	___	supply	___
constant	___	linear	___	temperature	___
electromagnetic	___	magnet	___	terminal	___
empirical	___	polarity	___	zero	___

B Where is the stress in each multi-syllable word in Exercise A?

1 Mark the main stress.

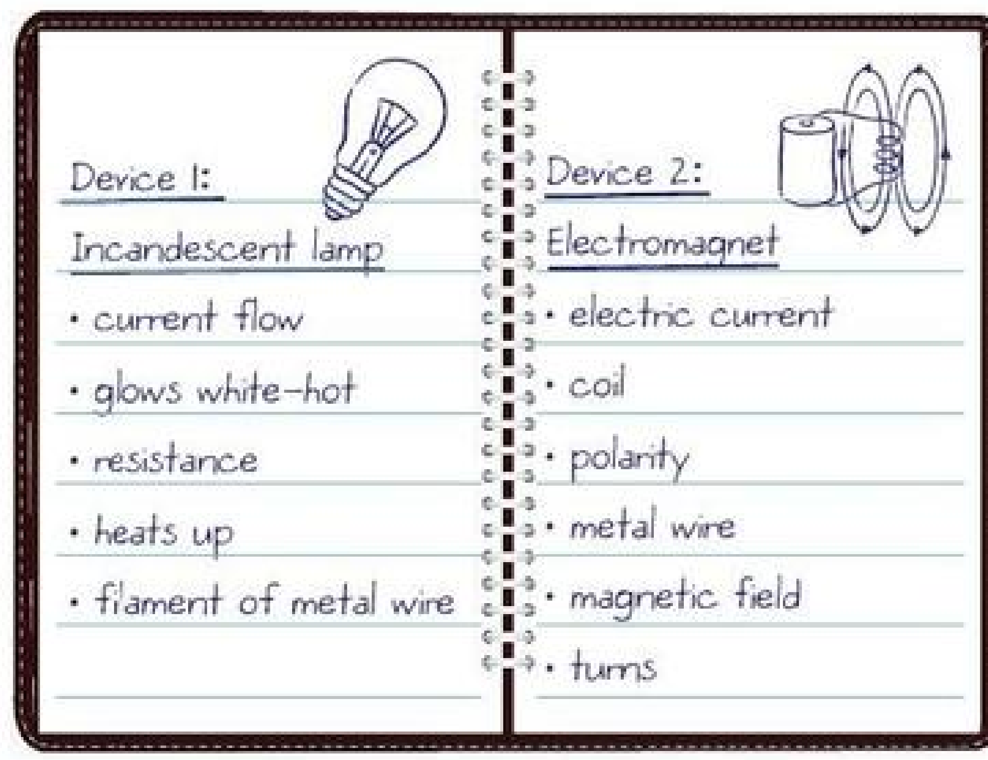
2 Practise saying each word.

C Work in pairs or groups. Define one of the words in Exercise A. The other student(s) must find and say the correct word.

D Look at the notes on the two devices on the right.

1 Describe each device and how it works using the items in the lists. Use a flow diagram if possible.

2 Do you know any other types of simple electrical device?



E Before you attend a lecture you should do some research.

1 How could you research the lecture topics on the right?

2 What information should you record?

3 How could you record the information?

HADFORD University

Faculty: Electrical Engineering

1 The resistance of different metals and different types of wire used in circuits.

2 Different types of electric lamp.

3 The unwanted effects of temperature rise in wires of a circuit.

4 How to maximize the magnetic field of an electromagnet.

F You are going to do some research on a particular lecture topic. You must find:

1 a dictionary definition

2 an encyclopedia explanation

3 a useful Internet site

Student A

- Do some research on **the resistance of different metals and different types of wire used in circuits**.
- Be prepared to tell your partner about your findings in Lesson 3.4.

Student B

- Do some research on **the unwanted effects of temperature rise in wires in a circuit**.
- Be prepared to tell your partner about your findings in Lesson 3.4.

3.4 Extending skills

asking for information • reporting information

A You are going to listen to a continuation of the lecture in Lesson 3.2.

1. Make a list of points from that lecture.
2. What is the lecturer going to talk about today? (Clue: Lesson 3.2 research task.)
3. Listen to Part 4 of the last lecture again and check your ideas.
4. Report your findings from the research task in Lesson 3.3 (Exercise F).

B Look at the slides and handout for today's lecture on the opposite page.

1. What is shown on Slide 1?
2. What is shown on Slide 2?
3. What is shown on Slide 3?

C Listen to Part 1 of today's lecture.

1. The lecturer will define something. What is it?
2. What is the definition?
3. What is a good way to make notes from this lecture? Prepare a page in your notebook.

D Listen to Part 2 of the lecture. Make notes. If necessary, ask other students for information.

E How will the lecturer finish the lecture?

1. Listen to the beginning of Part 3 and check your ideas.
2. Now listen to the rest of the lecture. Make notes. If necessary, ask other students for information.

F Match the verbs and definitions/synonyms.

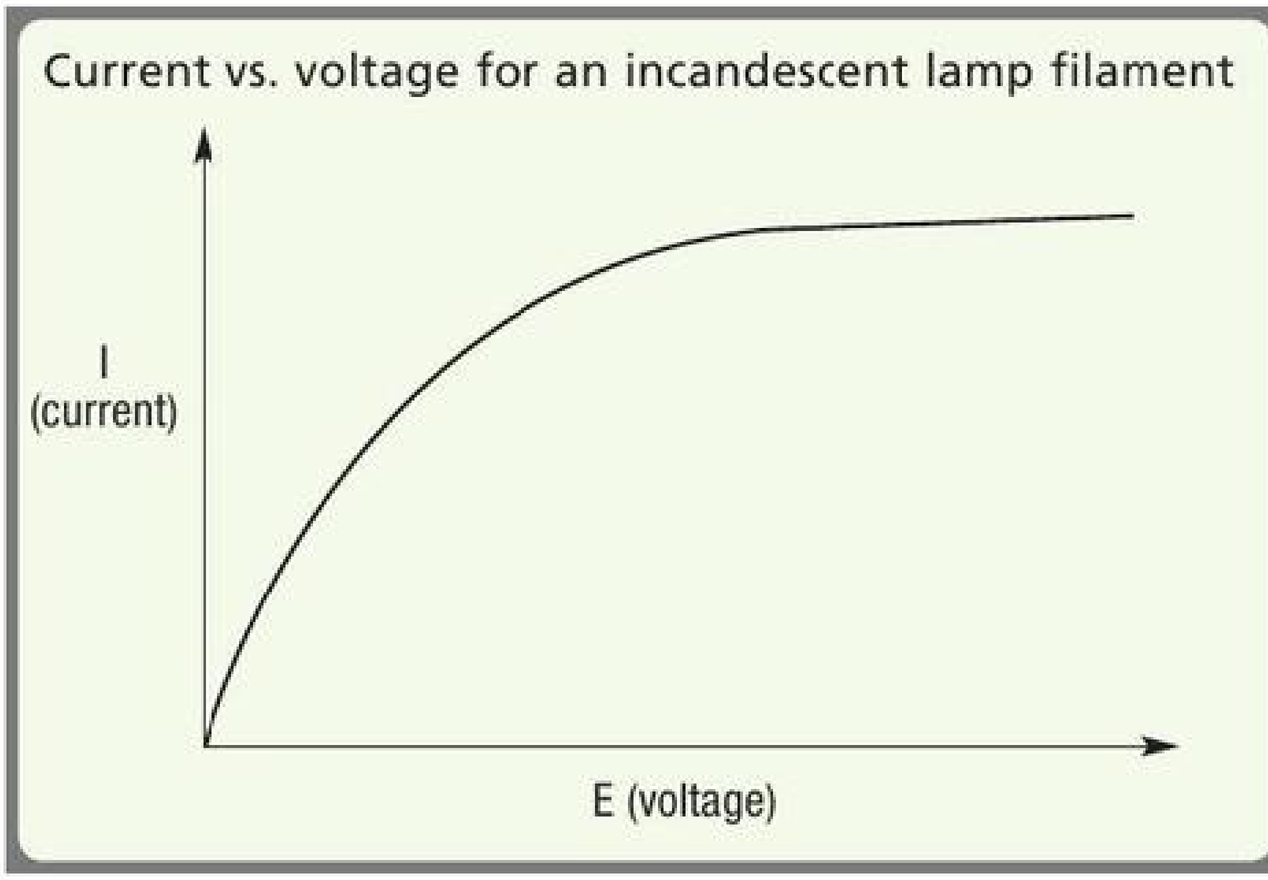
1 multiply ☐	**a** join together
2 connect ☐	**b** -
3 divide ☐	**c** take no notice of
4 generate ☐	**d** x
5 subtract ☐	**e** become bigger in number, level or amount
6 increase ☐	**f** ÷ or /
7 add ☐	**g** produce
8 ignore ☐	**h** +

How do we say these calculations verbally?

3 x 4   6 ÷ 3   3 + 4   3 – 1

G Work with a partner but do not show your partner your drawings.

1. Draw a diagram of a simple electric circuit with a battery and two or three resistors. Put the resistors either in parallel or in series. Choose the voltage and the value of the resistors.
2. Draw an electromagnet. Decide on the current and the number of turns in the coil.
3. Work with a partner. Your partner will ask you questions to find out about your electric circuit and your electromagnet, and try to draw them from this information.



Slide 1

Quantity	Symbol	Definition
Field force	mmf	The quantity of magnetic field force or 'push'
Field flux	Φ	The quantity of total field effect or 'substance' of the field
Field intensity	H	The amount of field force (mmf) distributed over the length of the electromagnet (also known as magnetizing force)
Flux density	B	The amount of magnetic field flux concentrated in a given area
Reluctance	$\Re$	The opposition to magnetic field flux through a given volume of material or space

Slide 2

Ohm's law for electric circuits

$$V = IR$$

Ohm's law for magnetic circuits

$$\text{mmf} = \Phi\Re$$

Slide 3

Vocabulary bank

Stress within words

Nouns, **verbs**, **adjectives** and **adverbs** are called **content words** because they carry the meaning.

One-syllable words

Some content words have **one syllable** or sound. This is always stressed.

Examples: *'key, 'need, 'trust, 'aim*

Two-syllable words

Some content words have **two syllables**. Two-syllable nouns and adjectives are often stressed on the first syllable. Two-syllable verbs are often stressed on the second syllable.

Examples:

Nouns	*'factor, 'shelter, 'impact*
Adjectives	*'basic, 'crucial, 'rigid*
Verbs	*en'sure, re'act, com'bine*

Exceptions:

Nouns	*re'ward, e'ffect, ma'chine*
Adjectives	*un'ique, se'cure*
Verbs	*'challenge*

Multi-syllable words

Some content words have **three or more syllables**. Multi-syllable words are normally stressed three syllables from the end.

Example:
O o o   o O o o   o o O o o

This is true for most words ending in:

~ize/~ise	*'magnetize*
~sis	*a'nalysis, elec'trolysis*
~ate	*co'mmunicate, 'deviate*
~ify	*'classify, 'satisfy*
~ical	*'physical, el'ectrical*
~ity	*elec'tricity, po'larity*
~ular	*par'ticular, 'regular*
~al	*ma'terial, em'pirical*
~ology	*tech'nology*
~cy	*e'fficiency*

Exceptions:
Multi-syllable words ending in the following letters are normally stressed two syllables from the end.

~ic	*el'ectric, spe'cific, in'trinsic*
~ion	*con'dition, multipli'cation, reso'lution*
~ent	*incan'descent, e'fficient*
~tial	*po'tential, influ'ential*

Stress sometimes moves to fit the patterns above when you add a suffix.

Skills bank

Getting information from other people

From the lecturer

We can sometimes ask a lecturer questions at the end of a lecture. Introduce each question in a polite or tentative way.

Examples:
Could you go over the bit about *reluctance* ***again?***
I didn't quite understand what you said about *the filament of the lamp.*
I wonder if you could repeat *the name of resistors that follow Ohm's law.*
Would you mind giving *the name of that symbol* ***again?***

From other students

It is a good idea to ask other students after a lecture for information to complete your notes.

Examples:
What did the lecturer say about *the direction of the magnetic field?*
Why did she talk about *water pipes?*
When did she say that *Ohm did his experiments?*
I didn't get the bit about *turns in the coil.*

Be polite!

It sometimes sounds impolite to ask people a direct question. We often add a polite introduction.

Examples:
Does a resistor make the flow of current easier or more difficult?
→ (polite) ***Do you know if*** *a resistor makes the flow of current easier or more difficult?*

What does 'ohmic' mean?
→ (polite) ***Can you remember what*** *'ohmic' means?*

What's the relationship between Ohm's law and electromagnetics?
→ (polite) ***Could you tell me something about*** *the relationship between Ohm's law and electromagnetics?*

Reporting information to other people

We often have to report research findings to a tutor or other students in a seminar. Make sure you can give:

- sources – books, articles, writers, publication dates
- quotes – in the writer's own words
- summary findings – in your own words

4 THE COMPUTER

4.1 Vocabulary

computer jargon • abbreviations and acronyms • verb and noun suffixes

A Study the words and phrases in box a.

1. Which words or phrases relate to computers and the Internet? Which relate to books and libraries? Find two groups of words.
2. Find pairs of words and phrases with similar meanings, one from each group.
3. Check your ideas with the first part of *The Computer Jargon Buster* on the opposite page.

a

books browse/search catalogue close cross-reference database electronic resources exit/log off hyperlink index library log in/log on look up menu open page search engine table of contents web page world wide web

B Complete the instructions for using the Learning Resource Centre with words or phrases from box a.

HADFORD *University*

Learning Resource Centre

Instructions for use:

If you want to access web pages on the ____________, you must first ____________ to the university Intranet with your username and password. You can use any ____________ but the default is Google. ____________ for web pages by typing one or more keywords* in the search box and clicking on ***Search***, or pressing ***Enter***. When the results appear, click on a ____________ (highlighted in blue) to go to the web page. Click on ***Back*** to return to the results listing.

You can also use the university ____________ of learning resources. Click on ***Resources*** on the main ____________ .

*A 'keyword' is different from a 'key word', which means a word that tells you about the main idea or subject of something.

C Study the abbreviations and acronyms in box b.

1. How do you say each one?
2. Divide them into two groups:
   - abbreviations
   - acronyms

See *Vocabulary bank*

b

CAD CAL CAM DVD HTML HTTP ISP LCD PIN ROM URL USB WAN WWW

D Test each other on the items in Exercise C.

1. What do the letters stand for in each case?
2. What do they mean?
3. Check your ideas with the second part of *The Computer Jargon Buster* on the opposite page.

E Study the nouns in box c.

1. Make a verb from each noun.
2. Make another noun from the verb.

c

class computer digit identify machine

The Computer Jargon Buster

There are many common words used about books and libraries which are translated into jargon words when we talk about using computers and the Internet for similar functions.

books	electronic resources
index	search engine
cross-reference	hyperlink
catalogue	database
library	world wide web
table of contents	menu
look up	browse/search
page	web page
open	log in/log on
close	exit/log off

There are many abbreviations and acronyms in computing. Learn some useful ones.

Abbr./Acr.	What it stands for	What it means
CAL	**computer-assisted learning**	using computers to help you learn
DVD	**digital versatile disk**	a disk for storing data, including sound and pictures
HTML	**hypertext markup language**	a way to write documents so they can be displayed on a website
HTTP	**hypertext transfer protocol**	a set of rules for transferring files on the www, usually included at the beginning of a website address (e.g., http://www. …)
ISP	**Internet service provider**	a company that enables access to the Internet
JPEG	**joint photographic experts group**	the usual format for photos and other images
LCD	**liquid crystal display**	the kind of screen you get on many laptops
PIN	**personal identification number**	a collection of numbers or letters which are used like a password to identify someone.
RAM	**random-access memory**	the memory you can use to store your own information
ROM	**read-only memory**	a type of permanent computer or disk memory that stores information that can be read or used but not changed
URL	**uniform resource locator**	a website address, e.g., http://www.garneteducation.com
USB	**universal serial bus**	a standard way to connect things like printers and scanners to a computer
WAN	**wide area network**	a way of connecting computers in different places, often very far apart
WWW	**world wide web**	a huge collection of documents that are connected by hypertext links and can be accessed through the Internet

A Discuss these questions.

1 When was the first computer invented?

2 What inventions and discoveries were important to the development of the computer?

B Look at the title of the text on the opposite page.

1 What will the text be about?

2 The article talks about three 'generations' of computers. What do you think they are?

3 Write some questions that you would like the text to answer.

C Work in pairs. Look at pictures 1, 2 and 3.

1 Choose a picture. Describe it. Can your partner guess which one it is?

2 What are the objects in the pictures?

D One student wrote some ideas about the development of the computer before reading the text on the opposite page. Write **T** (this is true), **F** (this is false) or **?** (I'm not sure) next to the statements.

E Look carefully at the topic sentences in the text on the opposite page.

1 Identify the topic and the comment about the topic. **See *Skills bank***

2 What do you think each paragraph will be about?

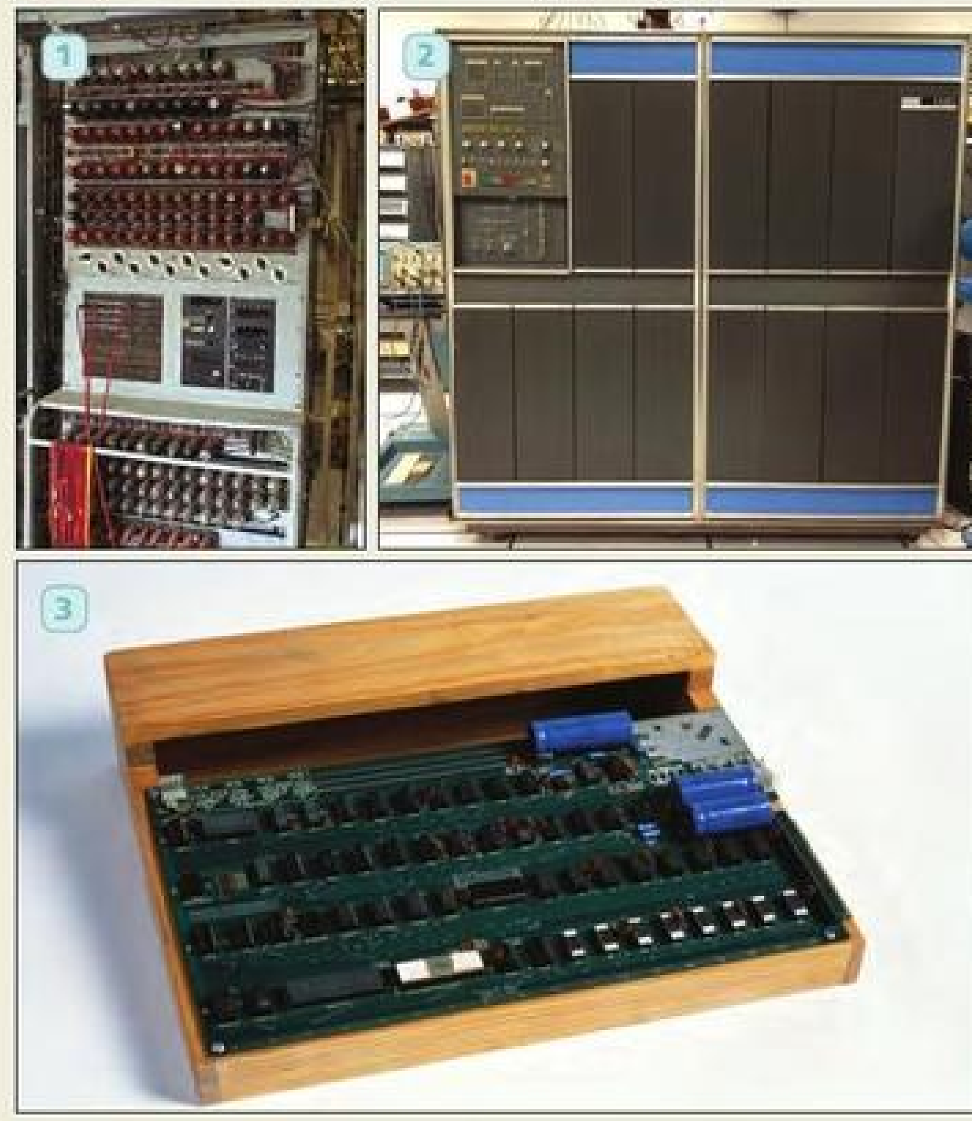
F Read the text carefully. Were your questions from Exercise B answered?

G According to the writer of the text, are the statements in Exercise D true or false? Which ideas are not mentioned?

H Study the notes a student made in the margin of the text on the opposite page.

1 What ideas are in the other paragraphs? Write some key words.

2 Which words introduce new ideas in each paragraph? **See *Skills bank***



The development of the computer

Computers have had a big influence on the field of Electrical Engineering. ____

The first computers used punched paper tape for input. ____

Transistors were an immediate improvement on vacuum tubes. ____

Disk drives were in use before the invention of the microchip. ____

Canada played an important role in the development of computers. ____

In a microchip, the components are soldered to a printed circuit board. ____

It only became possible to manufacture computers commercially after the invention of the microchip. ____

Applications of integrated circuits are limited to computers. ____

HADFORD University

Faculty: Electrical Engineering

Smaller, faster, cheaper!
The computer's family tree

result of computers / *impact to EE* / *reason*

In all fields, the impact of computers has been enormous. Everyday working life has changed for many professionals due to the development of the computer. Obviously, this is also true for electrical engineers. The design, analysis and operation of electrical and electronic systems have been completely dominated by computers. However, the connection is even closer than this – electrical engineers played a key role in the development of the computer in the first place!

Historically, the development of the computer started relatively recently, in the middle of the 20th century. These early models known as *first-generation computers*, were hand built and consisted of circuits containing vacuum tubes. They often used punched paper tape for input and storage. The Colossus computers developed during the Second World War in Britain are famous examples of these first-generation computers.

adv. of transistors / *example of second-gen.* / *conseq. of transistors*

The *second-generation computers* were more advanced. In their design, they used transistors which were soldered to a printed circuit board instead of vacuum tubes. Transistors were rather unreliable at first, but they soon improved and brought great advantages. Firstly they were more reliable than vacuum tubes. Secondly, they were smaller. Finally, they were cheaper to produce and the computers were cheaper to run. The *IBM 1401* was a very popular commercially produced second generation computer and sold over one hundred thousand units. Using transistors improved the central processing unit (CPU) and also the peripheral devices, such as disk drives – both fixed and removable – for storing tens of millions of letters and digits. It became possible to connect a computer to remote terminal units, such as teletype machines, via a telephone connection. This was the very beginning of a computer network and would eventually lead to the Internet that we know today. The invention of the integrated circuit – or microchip – signalled an important development. Computers that contain these devices are known as *third-generation computers*. An integrated circuit is a type of electronic circuit. However, the components are not soldered to a circuit board and their interconnections are formed on one single surface, typically a semiconductor such as silicon. This means that integrated circuits are much smaller than normal circuits. For example, the smallest microchip produced is currently just nine nanometres across.

Integrated circuits have brought many advantages. Firstly, the integration of large numbers of tiny transistors into a small chip was a great improvement on the manual assembly of ordinary circuits, and it became possible to mass produce integrated circuits. In addition, integrated circuits cost much less than discrete circuits because chips with all their components are printed as a single unit and not constructed one element at a time. Obviously, they require much less material in their construction, but the most important thing is that their performance is very high. The components are very small and close together, which means that they can operate quickly and consume little power, because the signals travel short distances.

This new technology had important consequences. Small, low-cost computers were now possible and could be bought by individuals and small businesses. A very early model was the *Apple 1* made by Apple Computer. However, integrated circuits are not only used in computers but are also used in almost all electronic equipment available today and have revolutionized the world of electronics. For example, the mobile phone is a digital appliance that is a fundamental part of modern society, and it was only made possible by the low-cost production of integrated circuits.

4.3 Extending skills

using the Internet effectively

A Discuss these questions.

1 You want to find out about computer-aided design. Where would you look for the information? Why?

2 What keywords would you use to make this search? Why?

B Your search produces 50 results. How can you select the most useful ones without reading all of them? Look at the list of criteria on the right and add a tick or '?'.

C You want to research the following. Choose up to three keywords or phrases for each search.

1 the uses of a disk drive

2 the invention of punched paper tape

3 the origins of the Internet

4 appliances that use microchips

D Go to a computer and try out your chosen keywords.

Criteria for choosing to read a result

It contains all of my keywords. ___

The document comes from a journal. ___

It is in the first ten. ___

It has this year's date. ___

It is a large document. ___

The website address ends in .org ___

The website address ends in .edu ___

The website address contains .ac ___

It is a PDF file. ___

It refers to electrical engineering. ___

It refers to a person I know (of). ___

It refers to an organization I know (of). ___

4.4 Extending skills

analyzing Internet search results • reporting research findings

A What information is contained in the results listing of a search engine?

1 Make a list.

2 Check with the results listings on the opposite page.

B Scan the results listings. Answer these questions.

1 What keywords were entered?

2 Why was *journal* used as a keyword? Why is it not in inverted commas?

C Answer these questions.

1 Which results contain abbreviations or acronyms?

2 Where is each website address?

3 Why are the words in different colours?

4 Which results are PDF documents?

5 Why might it be useful to use the Quick View link for a PDF document?

6 Which results refer to journals?

7 What does *cited* mean? Why is useful to know how many times an article has been cited?

8 Which results are educational sites?

9 Which results are commercial sites?

10 Why did the query in B return fewer results?

11 Which results in B have all the keywords?

D Continue your research on computer-aided design by entering the keywords into a search engine and accessing three of the results.

1 Make notes.

2 Compare your findings with other students.

E Choose the most interesting result. Write a paragraph about the information you discovered. Develop the topic within the paragraph with discourse markers and stance markers.

A

Google

Web Images Groups News Froogle Maps **more »**

computer aided design | Search | Advanced Search | Preferences

About 11,400,000 results (0.17 seconds)

Ad related to **computer aided design**

1 Download Any AutoCAD® - Autodesk.co.uk
www.autodesk.co.uk/YourAutoCAD
Compare AutoCAD® 2013 Products and Download 30-Day Trials.

2 Computer-aided design - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Computer-aided_design
Computer-aided design (CAD), also known as computer-aided drafting (CAD) or **computer-aided design** and drafting (CADD), is the use of computer systems to ...
Overview - Uses - Types - Technology

3 CAD Software - 2D and 3D Computer-Aided Design - Autodesk
usa.autodesk.com/adsk/servlet/item?siteID=123112&id...
CAD software is 2D and 3D computer-aided design software often used by architects, mechanics, inventors, engineers and designers.

4 Computer-Aided Design - Elsevier
www.journals.elsevier.com/computer-aided-design/
Computer-Aided Design is a leading international journal that provides academia and industry with key papers on research and developments in the...

5 Computer Aided Design: 2013 entry Undergraduate Courses at ...
www.ljmu.ac.uk/courses/undergraduate/computer-aided-design
18 Sep 2012 – The School of Engineering, Technology and Maritime Operations at Liverpool John Moores University offers a vibrant and exciting environment ...

B

Google

Web Images Groups News Froogle Maps **more »**

"computer aided design" + journal + "latest technology" | Search | Advanced Search | Preferences

About 222,000 results (0.14 seconds)

1 [PDF] Computer Integrated Manufacturing - English Central
info.englishcentral.net/.../ESAP%20MechEng%20sample%20unit.pdf
File Format: PDF/Adobe Acrobat - Quick View
Results 1 - 5 – computer-aided design (CAD), with data input from the customer's specification, ... computer integrated manufacture"+ "latest technology" ...

2 CAD at Work: Making the Most of Computer-Aided Design...
www.amazon.com › ... › Graphic Design › CAD
CAD at Work: Making the Most of **Computer-Aided Design** (Series on ... this unique book blends vital details on the **latest technology** with business ...

3 [PDF] the current s technology construction current state o technology - IT
www.itcon.org/data/works/att/2010_5.content.01058.pdf
File Format: PDF/Adobe Acrobat - Quick View
by S Barthorpe - 2010 - Related articles
Journal of ... **Computer-Aided Design** and Drawing .... The survey also showed that companies were open to implementing the **latest technology** ...

4 [PDF] customer focused textile and apparel manufacturing systems
www.tx.ncsu.edu/jtatm/volume4issue4/Articles/.../May_Bae_full.pdf
File Format: PDF/Adobe Acrobat
by JH Bae - Cited by 15 - Related articles
19 Sep 2005 – computer-aided design and manufacturing systems, the ... 2.3.2 Computer-Aided Design ...... market, **Journal** of Fashion Marketing and ...

5 IEEE - Which Journal Would Be Right for My Research?
www.ieee.org › Publications & Standards This is a cross-disciplinary **journal** disseminating research on the design of systems .... engineers desiring to keep abreast of the **latest technology** developments. ...

Vocabulary bank

Understanding abbreviations and acronyms

An **abbreviation** is a shorter version of something. For example, PC /piːsiː/ is an abbreviation for *personal computer*.

An **acronym** is similar to an abbreviation, but it is pronounced as a word. For example, *CAD* /kæd/ is an acronym for *computer-aided design*.

We normally write an abbreviation or acronym with **capital letters**, although the full words have lower case letters. However, there are exceptions, such as www, which is often written with lower case letters.

We **pronounce** the vowel letters in **abbreviations** in this way:

A	E	I	O	U
/eɪ/	/iː/	/aɪ/	/əʊ/	/juː/

We normally **pronounce** the vowel letters in **acronyms** in this way:

A	E	I	O	U
/æ/	/e/	/ɪ/	/ɒ/	/ʌ/

Common suffixes

Suffixes for verbs

There are some common verb suffixes. They make nouns into verbs. The meaning is basically *make* + noun, e.g., *to make digital = digitize*.

Examples:

~ize	*computerize, mechanize, digitize, magnetize*
~(i)fy	*classify, identify, specify, electrify, amplify*
~ate	*generate, insulate, regulate, calculate*
~en	*shorten, lengthen, strengthen*

Suffixes for nouns

Many nouns are made by adding a suffix to a verb. This means:

- You can identify many nouns from the suffix.
- You can often discover the verb by removing the suffix. Sometimes you have to make changes to the end of the verb.

Examples:

Verb	Suffix	Noun	Notes
produce	+ *tion*	*production*	remove e
perform	+ *nce*	*performance*	add a or e
measure	+ *ment*	*measurement*	
wire	+ *ing*	*wiring*	remove e
degenerate	+ *ion*	*degeneration*	remove e
multiply	+ *ication*	*multiplication*	change *y* to *i*

Skills bank

Developing ideas in a paragraph

Introducing the topic

In a text, **a new paragraph** indicates the start of **a new topic**.

The topic is given in the **topic sentence**, which is at or near the beginning of the paragraph. The topic sentence gives the **topic**, and also makes a **comment** about the topic.

Example:
In all fields, the impact of computers has been enormous.

The **topic** is *the impact of computers*

The **comment** is that this impact *has been enormous*.

The sentences that follow then expand or explain the topic sentence.

Example:
Everyday working life has changed for many professionals due to the development of the computer.

Developing the topic

A paragraph is normally about the same basic topic (the 'unity' principle). However, within a paragraph, ideas often **develop** beyond the initial comment. This development is often shown by

- **a discourse marker**: *in addition, however,* etc.
- **a stance marker**: *obviously,* etc.

Examples:
However, *the connection is even closer than this.*

Obviously, *this is also true for electrical engineers.*

Discourse markers generally make a connection between the previous information and what comes next. They mainly introduce **contrasts** or **additional information.**

Stance markers show the **attitude** of the writer to the information, i.e., whether he/she is surprised, pleased, unhappy, etc. about the information.

Recording and reporting findings

When you do your research, record information about the source. Refer to the source when you report your findings.

Examples:
Russell (2005) states that ...

As El-Makkawy suggests in his 2010 article in the *Journal of Electrical Engineering*, ...

According to Żak in his book *Systems and Control* (2003), ...

As the writer of the article on the homepage of *www.theiet.org* (March 4, 2010) says, ...

You should give full information about the source in your reference list or bibliography. For more information about this, see Unit 10 ***Skills bank***.

5 THE TELEVISION – FROM CRT TO LCD AND 3D

5.1 Vocabulary

word sets: synonyms, antonyms, etc. • describing trends

A Look at the electrical items on the opposite page.

1. Name the items.
2. Which of the items do you own? How long have you had one?

B Study the words in box a.

1. Find pairs of words with similar meanings.
2. What part of speech is each word?

a

appliance attached big business
channel commercial compact created
designed display flat image immovable
item large picture place programme
screen setting small thin

C Study the Hadford University handout on the right. Find pairs of blue words with similar meanings.

D Study the words in box b.

1. Find pairs of opposites.
2. Add more words to make a set.
3. Give a name to each word set.

b

compact deep economical expensive flat
heavy high large light low narrow
out of date recent wide

E Work with a partner.

1. Choose an electrical item on the opposite page. Describe it. Use words from box b.
2. Your partner should guess which item you are talking about.

F Look at the data in Figure 1 opposite.

1. What does the graph show?
2. Describe what trends you can see in the graph.

G Study the description of Figure 1 on this page. Write one or two words in each space.

H Look at Figure 1 again. Why do you think sales changed in the way they did?

HADFORD *University*

Faculty: Electrical Engineering

Lecture: *Electrical items and appliances*

The work of many electrical engineers concerns the design of *electrical items*. But what exactly are these items? A number of electrical items are involved in performing a function. These are known as *appliances*.

- Portable appliances, e.g., an electric kettle.
- Fixed appliances, e.g., a refrigerator.

Another important aspect of appliances is where you find them – in a commercial setting or in the home. Designing appliances is an important part of an electrical engineer's work. However, there are certain items that do not really do a job. They may, for example, provide entertainment. This kind of item is not called an appliance, but is still created by electrical engineers.

Figure 1 shows changes ____________ sales ____________ different types of television set ____________ 2000 and 2010. There was a ____________ ____________ in sales of CRT TVs ____________ 2005 when there was a 40% ____________. In the same period, sales of LCDs ____________ ____________. In 2005 there was an ____________ of 23% and after this, sales continued to ____________ ____________ every year. The sales of 3D TVs ____________ ____________ 5% ____________ the 10-year period.

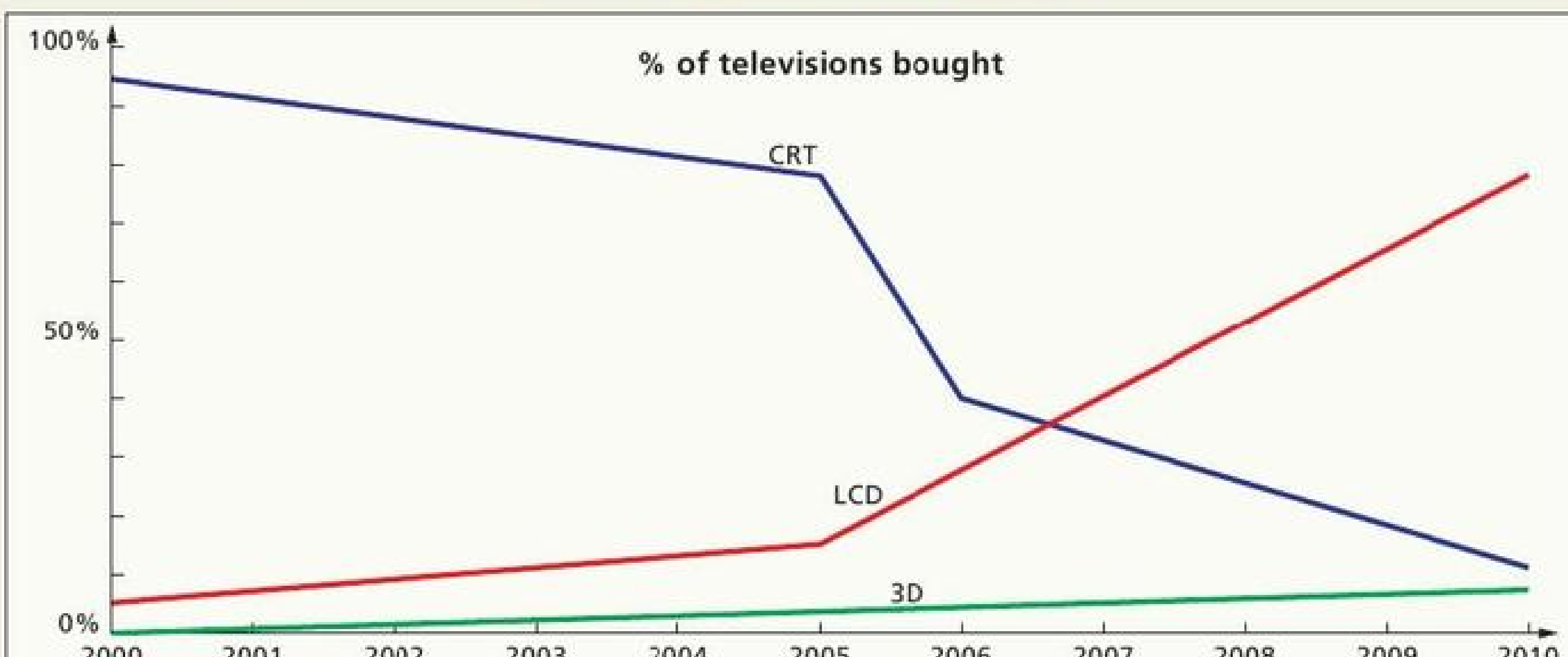


Figure 1: Sales of television by type (2000 and 2010)

5.2 Listening

lecture organization • 'signpost' language

A You are going to hear a lecture about recent developments in television design. Look at the lecture slides. What will the lecturer talk about? Make a list of points.

B Listen to Part 1 of the lecture. How will the lecture be organized? Number these topics.

- liquid crystal displays ___
- traditional cathode ray tube TV ___
- 3D television ___
- plasma screen ___
- digital TV technology ___

C Study the topics in Exercise B.

1 Write some key words for each topic.
2 Can you match the topics with Slides 1–4?
3 What is a good way to make notes?
4 Make an outline for your notes.

D Listen to Part 2 of the lecture.

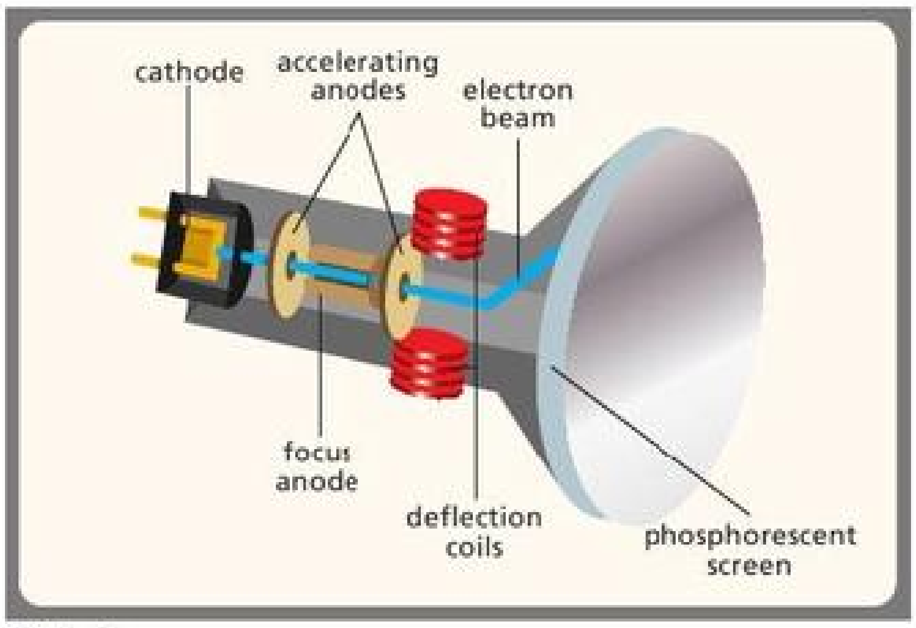
1 Add information to your outline notes.
2 Which of the topics in Exercise B are discussed? In what order?
3 Which are better according to the lecturer – analogue or digital TVs?

E Listen to Part 3 of the lecture. Make notes.

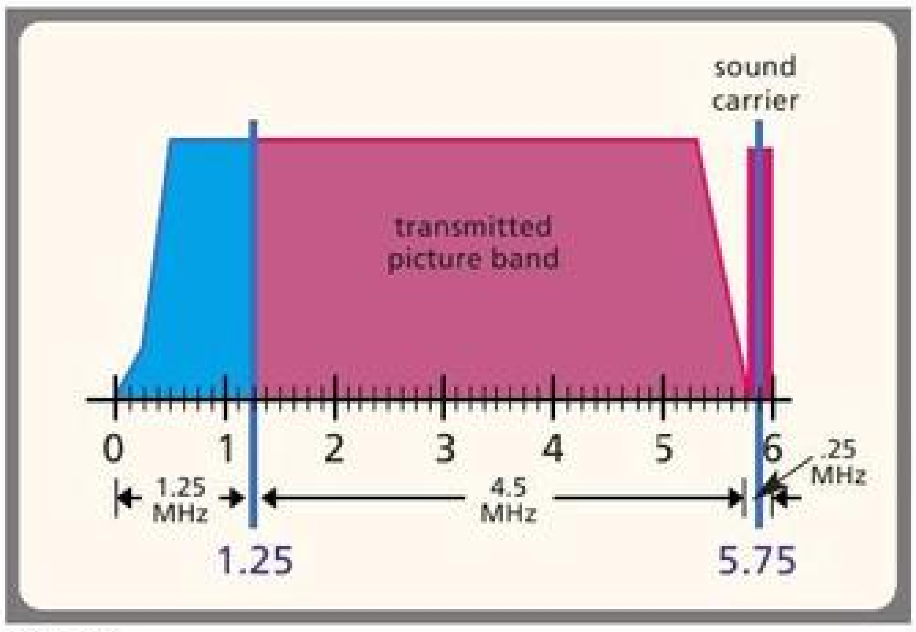
1 Which topics in Exercise B are discussed?
2 Which topic has not been mentioned?
3 What device uses something similar to fluorescent lamps?
4 What device uses polarized filters?

F The lecturer used these words and phrases. Match synonyms.

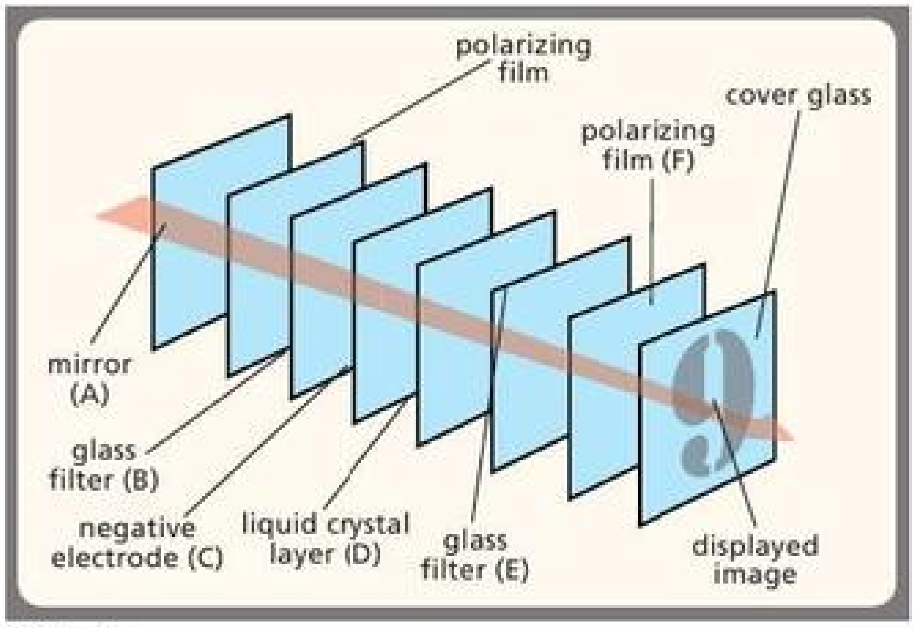
1	rows ☐	a	combination
2	display ☐	b	material
3	composite ☐	c	lines
4	resolution ☐	d	show
5	thin ☐	e	not straight
6	substance ☐	f	clarity
7	twisted ☐	g	flat



Slide 1



Slide 2



Slide 3

Slide 4

5.3 Extending skills

note-taking symbols • stress within words • lecture language

A Look at the student notes on the right. They are from the lecture in Lesson 5.2.

1. What do the symbols and abbreviations mean?
2. The notes contain some mistakes. Find and correct them.
3. Make the corrected notes into a spidergram.

3) Digital TV res.
e.g., 512 x 400
4) Analogue TV:
19.39 Mbit/s = 100x better
resolution!!
5) Plasma screen – plasma cells
(= gases + metal) between
polarized filters
cell + current + phosphor
= coloured light
6) LCD needs background light
pixel = liquid crystal cell between
glass
liquid crystal = twisted molecules
+ current = untwist → allows light
to pass
painted cells = red/yellow/blue
(primary)

B Listen to the final part of the lecture.

1. Make some notes.
2. Why does the lecture have to stop?
3. What is the research task?

C Listen to some stressed syllables. Identify the word below in each case. Number each word.

Example: You hear: *1 sem* /sem/
You write:

analogue	___	horizontal	___
analyze	___	molecules	___
assignment	___	overview	___
device	___	resolution	___
display	___	seminar	1
fluorescent	___	transmission	___

D Study the extract from the lecture on the right.

1. Think of one word for each space.
2. Listen and check your ideas.
3. Match words or phrases from the blue box with each word or phrase from the lecture.
4. Think of other words or phrases with similar meanings.

as I was saying   basically   clearly   crucial
in fact   in other words   obviously   of course
possibly   probably   some people say
that is to say   we can see that

______________, the big problem with analogue TV is resolution. A digital TV can receive and decode much more data, and *it* ______________ *that* digital screens can display more pixels than a traditional analogue TV. ______________, that makes a big difference! LCDs are ______________ very similar to plasma screens – they are also light and thin. They are also light and thin. But they are ______________ very different. *What I* ______________ *is*, they are based on very different technology, and it's ______________ that we understand this difference. Anyway, er ... *to return to the main* ______________, digital TVs offer a range of advantages.

E Discuss the research task set by the lecturer.

1. What kind of information should you find?
2. What do you already know?
3. Where can you find more information?

5.4 Extending skills

making effective contributions to a seminar

A Study the photos connected to the topic of 3D TV on the opposite page.

1 What are the items?

2 How are they connected to 3D TV technology?

B Listen to some extracts from a seminar about 3D TVs.

1 What is wrong with the contribution of the last speaker in each case? Choose from the following:
   - it is irrelevant
   - the student doesn't contribute anything to the discussion
   - the student interrupts
   - it is not polite
   - the student doesn't explain the relevance

2 What exactly does the student say, in each case?

3 What should the student say or do, in each case?

C Listen to some more extracts from the same seminar.

1 How does the second speaker make an effective contribution in each case? Choose from the following:

   He/she …
   - brings the discussion back to the main point
   - brings in another speaker
   - asks for clarification
   - links when not sure the contribution is new
   - paraphrases to check understanding
   - gives specific examples to explain a point
   - links when not sure the contribution is relevant
   - disagrees politely with a previous speaker
   - links to a previous speaker

2 What exactly does the student say, in each case?

3 What other ways do you know of saying the same things?

D Make a table of **Do**'s (helpful ways) and **Don't**s (unhelpful ways) of contributing to seminar discussions.

Do	Don't
ask politely for information	demand information from other students

E Work in groups.

1 The teacher will ask you to look at information about one type of 3D TV technology on the opposite page (Group A) or another type on page 105 at the back of the book (Group B). Study your type of technology.

2 How does your type of 3D TV work? Make sure you can explain your technology clearly.

3 Conduct a seminar. One or two people should act as observers.

F Report on your discussion and present your 3D technology, giving clear explanations. As a class, decide which technology is the most effective and why.

3D TV technology

Group A

3D TV technology using passive lenses

There are two main types of passive lens used in the creation of 3D TV images:

1 Anaglyphic images can be used to create a 3D effect when viewed with anaglyph glasses. The images contain two colour layers superimposed on each other, but in slightly different positions on the screen (Picture 1). Each layer is filtered with a different colour, one for each eye. These are viewed using glasses with coloured lenses (usually red and cyan) (Picture 2) and the brain combines them to produce the effect of depth. This technology is relatively cheap, at least the glasses are not expensive to produce. However, there is always some colour loss in the final viewed image.

2 Polarization is another way of showing 3D content. 3D glasses (Picture 4) with polarized lenses block certain wavelengths of visible light: they use vertical polarization in one lens and horizontal polarization in the other. On the screen, you can see two images shot at slightly different angles from two different projectors (Picture 3). Each image is polarized in such a way that it is only visible to one eye. Just as with anaglyphic technology, the brain then combines the two images into one 3D object. Colours are seen more naturally with this technology. However, if the viewer moves his/her head to one side, the 3D effect disappears.

Vocabulary bank

Vocabulary sets

It is a good idea to learn words which go together. Why?

- It is easier to remember the words.
- You will have alternative words to use when paraphrasing research findings.
- It is not good style to repeat the same word often, so writers, and sometimes speakers, make use of words from the same set to avoid repetition.

You can create a vocabulary set with:

synonyms	words with similar meanings, e.g., *thin/flat/slim*
antonyms	words with opposite meanings, e.g., *out of date/up to date*
hypernyms	a general term for a set of words, e.g., *electrical appliance = mobile phone, TV, digital camera,* etc.
linked words	e.g., *huge, large, medium-sized, compact, tiny*

Describing trends

You can use a variety of phrases to discuss trends and statistics.
Examples:

Go up	No change	Go down	Adverbs
rise *increase* *grow* *improve* *soar*	*stay the same* *remain at …* *doesn't change* *is unchanged*	*fall* *decrease* *decline* *worsen* *drop* *plunge* *plummet*	*slightly* *gradually* *steadily* *significantly* *sharply* *dramatically*

Stance

Speakers often use certain words and phrases to show how they feel about what they are saying. Common stance words are:

adverbs	*arguably, …* *naturally, …* *sadly, …*
phrases	*of course, …* *it's essential to/that …* *we might say that …*

In many cases, different stance words and phrases are used in spoken and written language.

Spoken	Written
another thing	*additionally*
it seems	*evidently*
unfortunately	*regrettably*
believe	*contend*

Skills bank

Signpost language in a lecture

At the beginning of a lecture, a speaker will usually outline the talk. To help listeners understand the order of topics, the speaker will use phrases such as:

To start with *I'll talk about ...*
Then *I'll discuss ...*
After that*, we'll look at ...*
I'll finish by *giving a summary of ...*

During the lecture, the speaker may:

indicate a new topic	*Moving on (from this) ...*
say the same thing in a different way	*What I mean is, ...* *That is to say, ...* *To put it another way, ...*
return to the main point	*Where was I? Oh, yes, ...* *To return to the main point ...* *As I was saying ...*

Seminar language

The discussion leader may:

ask for information	*What did you learn about ...?* *Can you explain ...?* *Can you tell me a bit more about ...?*
ask for opinions	*What do you make of ...?* *This is interesting, isn't it?*
bring in other speakers	*What do you think, Majed?* *What's your opinion, Evie?*

Participants should:

be polite when disagreeing	*Actually, I don't quite agree ...*
make relevant contributions	*That reminds me, ...*
give examples to explain a point	*I can give an example of that.*

Participants may

agree with the previous speaker	*I agree, and that's why ...* *That's true, so I think ...* *You're absolutely right, which is why ...*
disagree with the previous speaker	*I don't think I agree with that. In my opinion, ...* *I'm not sure that's true. I think ...*
link to a previous speaker	*As Jack said earlier, ...* *Going back to what Leila said a while ago, ...*
ask for clarification	*Could you say more about ...?*
paraphrase to check understanding	*So what you're saying is, ...*
refer back to establish relevance	*Just going back to ...*

Participants may not be sure if a contribution is new or relevant:
I'm sorry. Has anybody made the point that ... ?
I don't know if this is relevant, but ...

6 CONTROL SYSTEMS

6.1 Vocabulary
paraphrasing at sentence level

A Study the words in the blue box.

1 Copy and complete the table. Put the words in one or more boxes, in each case.

2 Add affixes to make words for the empty boxes. (Some will not be possible.)

3 What is the special meaning of each word in electrical engineering?

4 Find a synonym for each word in the box.

5 Group the words in the blue box according to their stress pattern.

calculate damped eliminate exceed fluctuate offset oscillation overshoot predict significant stable test tune unstable

Noun	Verb	Adjective
elimination	eliminate	eliminated

B Study the four graphs on the opposite page. Discuss these questions using words from Exercise A.

1 What do the graphs show?

2 What happens to the temperature in each graph?

C Student A has written about the relationship between the set and actual temperatures of a domestic oven over time, but there are some mistakes. Change the blue words so that the sentences are true.

D Student B has also written oven temperatures. Match each sentence with a corrected sentence from Exercise C.

E Look at the four graphs again on the opposite page. Which situation is best? Why?

F Think of an example of oscillation in electrical appliances or in everyday life.

1 Are the oscillations a problem or a benefit?

2 Write some sentences to describe how the oscillations can be damped for your example.

3 Give your sentences to your partner. Your partner should try to guess what you have described.

4 Rewrite your partner's sentences with the same meaning.

Student A

1 Figure 2 shows that the oven temperature is stable at both set values.

2 In Figure 3, the reaction time is slow, but there is a significant overshoot and the initial oven temperature is below the set temperature value.

3 The final temperature in Figure 3 is unstable because it is overdamped.

4 The unstable oscillation has been added in Figure 4, but there is still considerable overshoot.

5 The system shown in Figure 5 is damped and stable, with a slow reaction time.

Student B

a This graph shows that there is no more ringing, but initially the oven temperature exceeds the set value.

b In this graph, there is tight loop control.

c Temperature stability is never achieved in this graph.

d In this graph, the temperature changes quickly, but it initially goes above the set value and there is a significant final offset.

e The system shown in this graph is underdamped and there is oscillation.

Figure 1: *A domestic oven*

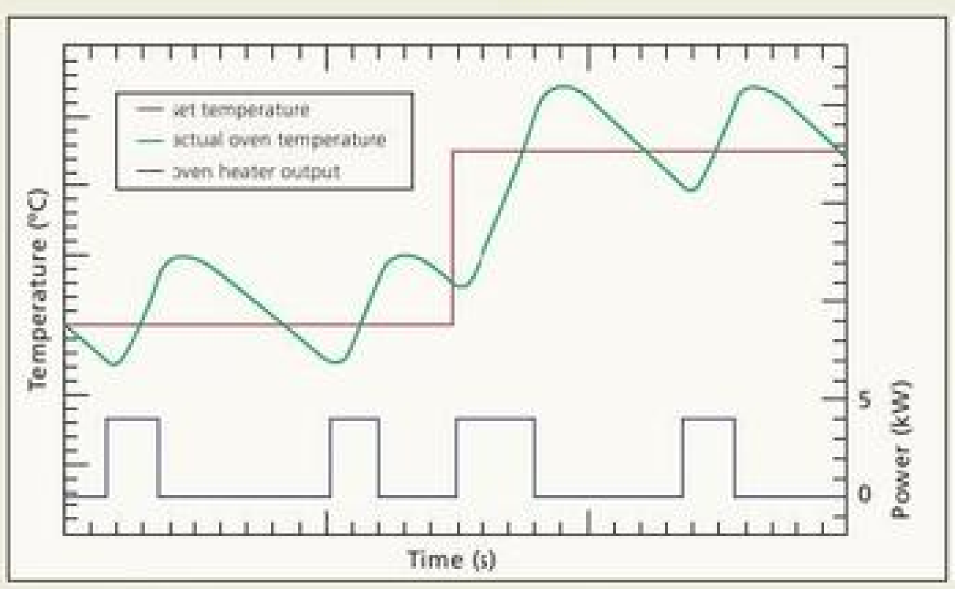


Figure 2: *Oven temperature change for a set temperature increase – on–off heater system*

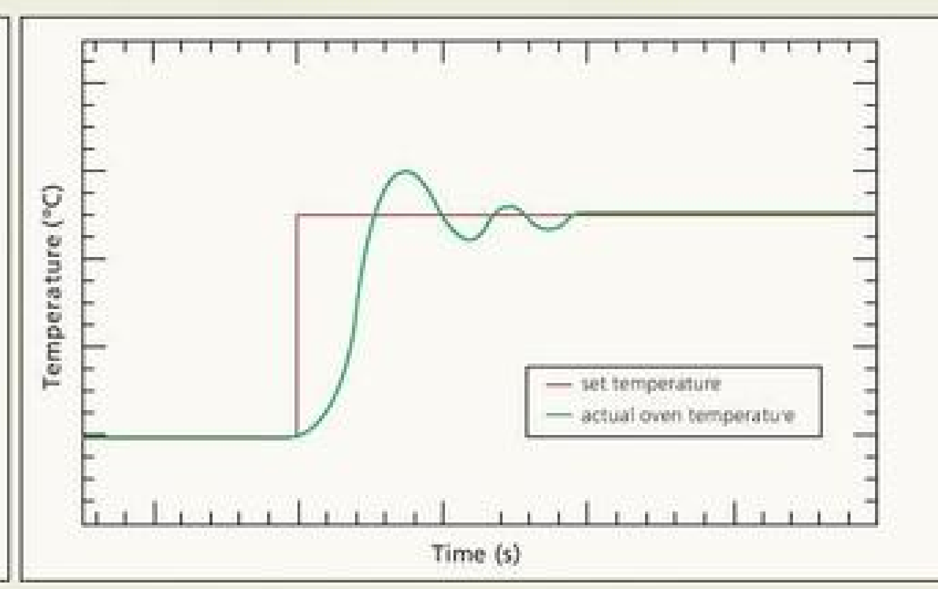


Figure 3: *Oven temperature change for a set temperature increase – variable heater with proportional (P) controller*

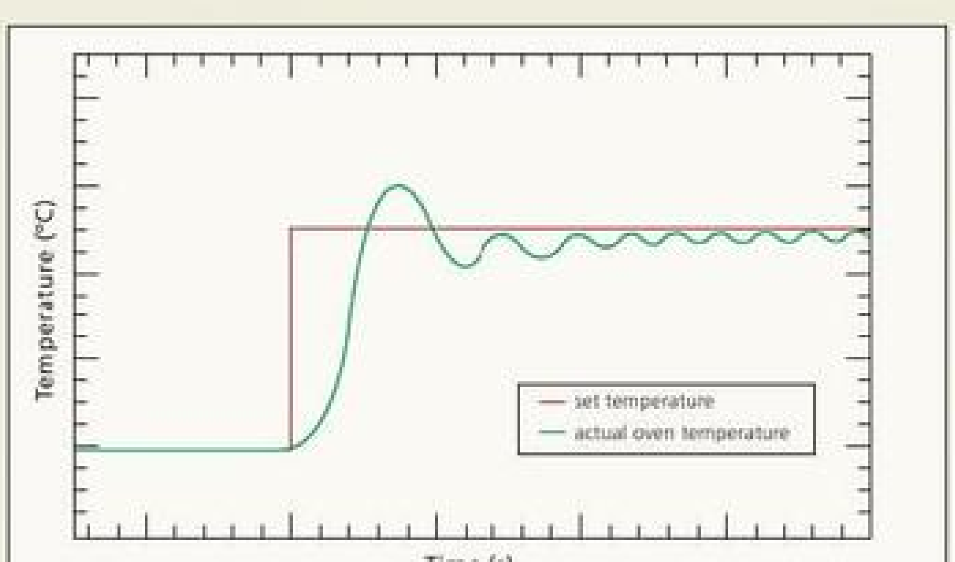


Figure 4: *Oven temperature change for a set temperature increase – variable heater with proportional and integral (PI) controller*

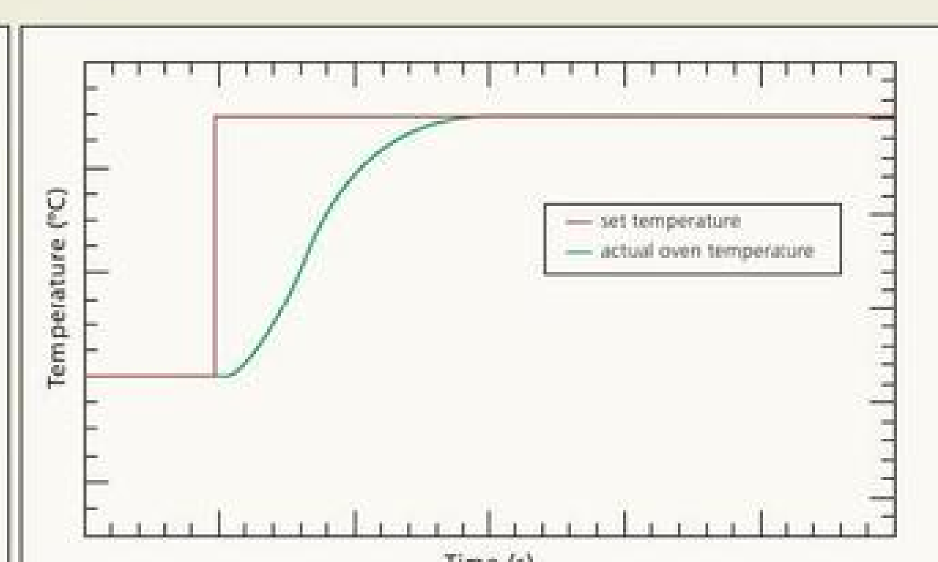


Figure 5: *Oven temperature change for a set temperature increase – variable heater with proportional, integral and derivative (PID) controller*

6.2 Reading

identifying subject–verb–object in long sentences • paraphrasing

A Look at the three electrical devices on the right.

1. What are these devices, and where would you find them?
2. What is the function of each of the devices?

B What do you know about these three devices?

1. What is the specific function of each one?
2. How do they work?
3. What do they have in common?

C Look at the illustration, the title, the introduction and the first sentence of each paragraph on the opposite page.

1. What will the text be about?
2. Using your ideas from Exercises A, B and C1, write some research questions.

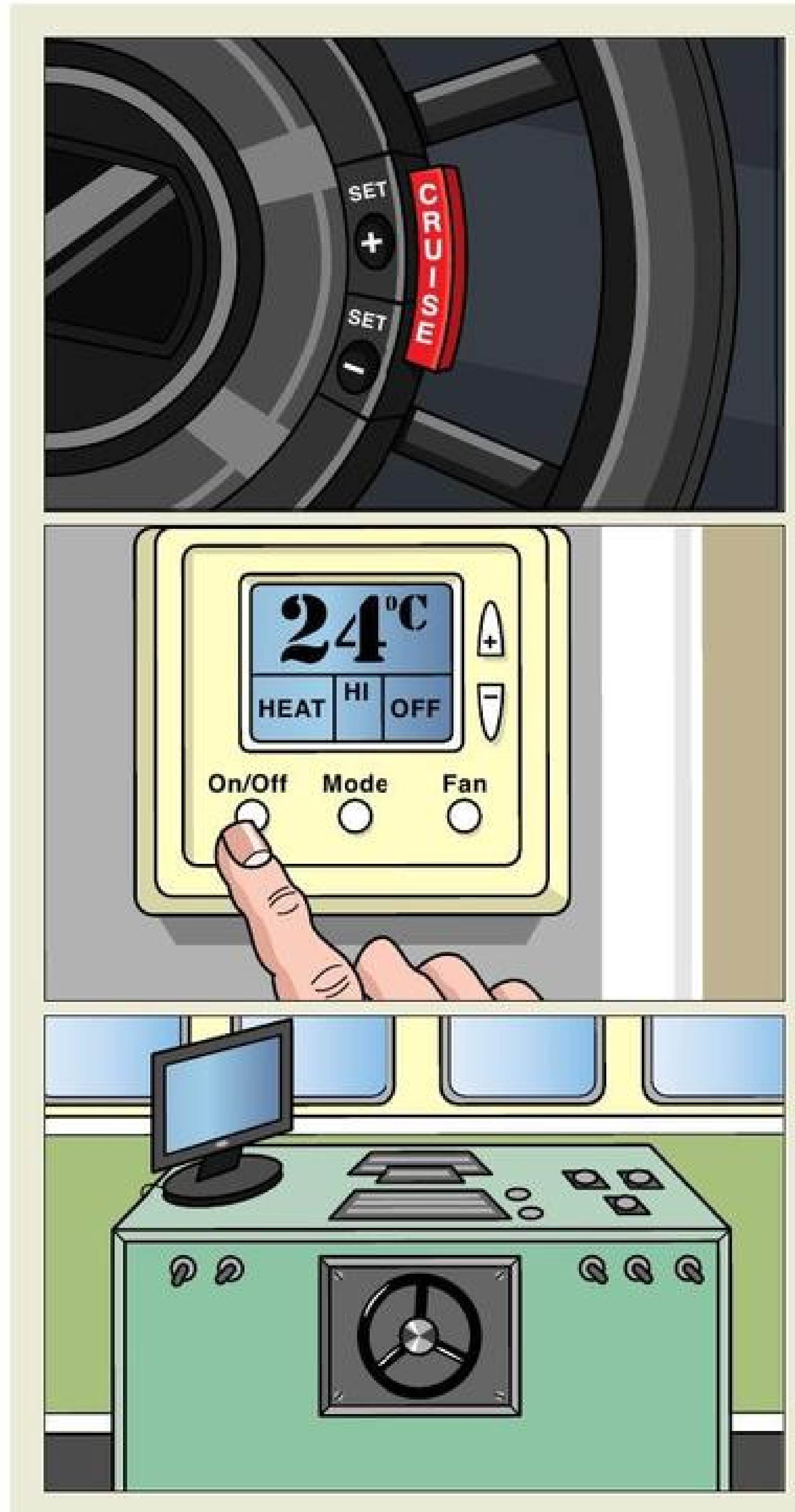
D Read the text. Does it answer your questions?

E Study the highlighted sentences in the text. Find and underline the subject, verb and object or complement in each sentence.
See *Skills bank*

F Two students paraphrased part of the text.

1. Which part of the text are these paraphrases of?
2. Which paraphrase is better? Why?

G Work in groups. Write a paraphrase of a different part of the text.
See *Vocabulary box*



Student A

We must remember that each PID control system must be tuned.

During this process, the parameters for P, I and D are calculated depending on the type of system in question.

After this, they are tested in practice.

A PID controller does not guarantee ideal control.

Student B

An important feature of PID control systems is tuning.

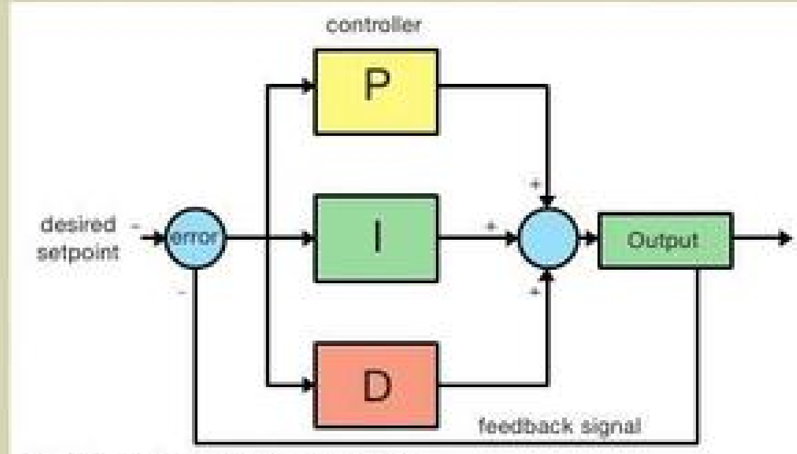
This involves deciding on the values for P, I and D. These will depend on exactly what system is involved.

After this, the values need to be trialled under working conditions.

This type of system does not automatically provide perfect control.

Control loop feedback mechanisms

Many electrical devices use various types of feedback control. Think of the electric oven in your kitchen. When you select a certain temperature, how does the oven heater know how much power to supply and for how long? The answer lies in the control loop feedback mechanism.



PID loop feedback controller

The simplest type of feedback control is on–off. Here, the oven heater can only be at maximum power or turned off. When the required temperature is programmed, the heater is switched on at maximum power and only turns off when the set point is reached. As you can see in Figure 1, this results in a large fluctuation in oven temperature. Clearly, this is far from perfect.

The PID controller is a generic control loop feedback mechanism which improves on the on–off system mentioned above. It is widely used in industry in various fields, such as cruise control in cars. It is also used extensively in the domestic sector in, for example, a home thermostat. The controller involves three separate parameters: the proportional (P), integral (I) and derivative (D) constants. We will now look at how it might work in the case of the oven. The power output the oven heater provides needs to be variable rather than simply on–off.

One possibility is to make the heater output proportional to the difference, or error, in temperature between the oven now and the temperature we have set it at. As Figure 2 on page 47 shows, this proportional correcting parameter (P) can solve the large fluctuation seen in the on–off system. We can see the proportional value as determining the reaction to the current error. However, if a relatively fast reaction time is required, there is a danger that the system is underdamped and therefore oscillates and becomes unstable. There is also a significant overshoot, where the temperature initially goes above the temperature required. A further problem with a proportional relationship between heater output and temperature difference is the final oven temperature. It will always be slightly below the set temperature, since the heater will only supply heat if the oven temperature and set temperature are different. This is known as offset or droop.

The problem with offset or droop can be solved by adding an integral term (I) to the proportional one we have just looked at. The contribution from the integral term is proportional to the error and to its duration. The integral value determines the reaction based on the sum of recent errors. The integral term not only eliminates droop, but also speeds up the progression to the set temperature. However, with this combination of proportional and integral control the system still tends to overshoot, as can be seen in Figure 3 on page 47.

The addition of a third element of control, called the derivative control component (D), can overcome to some extent this problem with overshoot. The derivative value determines the reaction based on the rate at which the error has been changing. It is effectively a way of getting the system to predict future errors. As we can see in Figure 4 on page 47, adding a derivative component provides a damped response and reduces the overshoot. This results in an effective and efficient control system.

It must be remembered that every PID control system needs to be tuned. In the tuning process, the values for P, I and D are chosen according to the nature of the system in question and then tested in practice. They can then be adjusted until the tightest loop control is achieved without the system fluctuating and becoming unstable. However, the use of a PID controller does not necessarily guarantee ideal control or stability. Everything depends on the values chosen for the three parameters during the crucial tuning operation.

6.3 Extending skills
understanding complex sentences

A Study the words in box a from the text in Lesson 6.2.

1 What part of speech are they in the text?

2 Find one or more words in the text with a similar meaning to each word in box a.

a

supply switch perfect
widely parameters set solve
droop process

B Complete the summary with words from Exercise A.

Control loop mechanisms can be used to control any ____________ which has a measurable output, and an input which influences the output. When the system is ____________ on, a ____________ output value must be chosen, and this information is then ____________ to the controller. These systems are used ____________ in a range of contexts to ____________ problems with the regulation of a range of different variables. The controller's ____________ need to be set carefully, to avoid ____________ and provide ____________ control.

C Study the words in box b.

1 What is each base word and its electrical engineering meaning?

2 How does the affix change the part of speech?

3 What is the meaning in the text in Lesson 6.2?

b

electrical heater variable
possibility proportional contribution
reaction tightest stability

D Study sentences A–E on the opposite page.

1 Copy and complete Table 1. Put the parts of each sentence in the correct box.

2 Rewrite the main part of each sentence, changing the verb from active to passive, or vice versa.

E Look at the 'Other verbs' column in Table 1.

1 How are the clauses linked to the main part of the sentence?

2 In sentences A–C, what does each relative pronoun refer to?

3 Make the clauses into complete sentences.

6.4 Extending skills
writing complex sentences

A Make a single sentence from each box on the right, using the method given in red. Include the words in blue. Then write all the sentences as one paragraph.

Some car manufacturers have developed a more advanced system of cruise control.
This system is called adaptive cruise control.
This system uses radar to detect the speed and distance of the vehicle in front.
relative, passive, past participle   Recently

The system uses this radar information to maintain a safe distance between the two vehicles.
This system also uses a signal to maintain a safe distance between the two vehicles.
This signal transmits the car's present speed.
relative, passive, ellipsis   This information

Companies might develop further safety features.
These safety features could give visual warning signals.
These safety features could give audio warning signals.
These signals tell the driver when to brake.
relative, passive, ellipsis, present participle
In the future

B Study the notes on the opposite page which a student made about a case study. Write up the case study. Include the ideas from Exercise A.

1 Divide the notes into sections to make suitable paragraphs. Where should the paragraph in Exercise A go?

2 Decide which ideas are suitable topic sentences for the paragraphs. Which idea can you use as a topic sentence for the paragraph in Exercise A?

3 Make full sentences from the notes, joining ideas where possible, to make one continuous text.

A In the final graph, a derivative control component, which is based on the rate of change of the error, was added to the system.

B Three different ways in which control loop feedback mechanisms can be set up will be described here.

C We can also add an integrative term, which eliminates droop so successfully that it is a key component in many common control loop feedback mechanisms which have been designed recently.

D As well as being stable, a control mechanism must react quickly and accurately to an input signal.

E Using all three considered parameters, the control system performs its task effectively.

Table 1: Breaking a complex sentence into constituent parts

Main S	Main V	Main O/C	Other V + S/O/C	Adv. phrases
A a derivative control component	was added (to)	the system	which is based on the rate of change of the error	In the final graph
B				

Cruise control in cars

- basic function: maintain set speed = no intervention required
- ~~driver controls speed via accelerator pedal~~ → cruise control takes over
- activated: buttons on steering wheel
- cruise control - around for long time
- developments in electronics → improved considerably
- how it works?
- no cruise control: driver adjusts speed by pressing pedal → limits quantity of air to engine through throttle valve
- cruise control: control loop controls throttle → keeps speed at set value
- key elements: vehicle speed sensor (VSS) in transmission → sends signal to cruise control module (CCM) about present speed → CMM compares 2 speeds → sends signal to actuator → adjusts throttle linkage → guides car's speed towards set speec → maintains speed
- features of good cruise control system:
  - accelerates the car quickly to desired speed
  - no overshooting
  - little deviation of speed - independent of:
    - weight
    - road conditions - steep hill / on the flat

PID control - sum 3 factors → required throttle position

- how to stop cruise control:
  - release switch on steering wheel
  - switches on brake & clutch pedal → pressed → disengage system
  - speed less than 40 kph → doesn't work
- more advanced system: adaptive cruise control

Reporting findings

You cannot use another writer's words unless you directly quote. Instead, you must restate or **paraphrase**.

There are several useful ways to do this:

use a synonym of a word or phrase	*fluctuates → oscillates in the introduction phase → early in the test*
change negative to positive, or vice versa	*the temperature was unstable → the temperature was not stable*
use a replacement subject	*the temperature may fall → there may be a fall in temperature*
change from active to passive, or vice versa	*the sensor sends a signal → a signal is sent (by the sensor)*
change the order of information	*in the introduction phase, the temperature is high → there is a high temperature early in the test*

When reporting findings from one source, you should use all the methods above.

Example:

Original text	*The system became a little unstable when the sensor sent the signal.*
Report	*At the moment the signal was transmitted, there was incomplete stability of the system.*

Important

When paraphrasing, you should aim to make sure that 90% of the words you use are different from the original. It is not enough to change only a few vocabulary items: this will result in plagiarism.

Example:

Original text	*If the air temperature starts to fall, does this mean the oven temperature will also drop?*
Plagiarism	*If the air temperature drops, does this also mean a fall in the oven temperature?*

Skills bank

Finding the main information

Sentences in academic and technical texts are often very long.

Example:
Following the design of an automatic cruise control in vehicles for the domestic market, in trials some ***engineers*** *using a PID feedback control mechanism clearly* ***demonstrated*** *effective* ***performance*** *where the car adjusted to the set driving speed more quickly than in previous tests, and used less fuel in the process.*

You often don't have to understand every word, but you must **identify the subject, the verb and the object**, if there is one.

For example, in the sentence above, we find:
subject = *engineers*
verb = *demonstrated*
object = *performance*

Remember!

You can remove any leading prepositional phrases at this point to help you find the subject, e.g., *Following the design of ... / in trials*

You must then find the **main words which modify** the subject, the verb and the object or complement.

In the sentence above we find:

Which *engineers*? = some of those using a PID feedback control mechanism

How *demonstrated*? = clearly

What *performance*? = effective one where the car adjusted to the set driving speed more quickly, and used less fuel in the process

Ellipsis

Sometimes, if the meaning is clear, words are implied rather than actually given in the text.

Examples:
- *There were many different controllers* (which were) *considered by the engineers.*
- *The engineers tested a proportional control and* (the engineers tested) *an integral control.*

7 ELECTRIC POWER GENERATION, TRANSMISSION AND DISTRIBUTION

7.1 Vocabulary

compound nouns • fixed phrases

A Study the words in box a.

1 Match nouns in column 1 with nouns in column 2 to make compound nouns.

2 Which word in each compound noun has the strongest stress?

B Study the phrases in box b.

1 Complete each phrase with one word.

2 Is each phrase followed by:
- a noun (including gerund)?
- subject + verb?
- an infinitive?

3 What is each phrase used for?

C Look at the pictures on the opposite page showing the process for generating electricity with a wind turbine and then transmitting the electricity. What happens at each stage?

D Read extracts A–F on the right. They are from a leaflet about using wind to make electrical energy.

1 Match each extract with a picture on the opposite page.

2 Complete each sentence with one or more phrases from box b.

E Look at the photos in the Hadford University handout on the opposite page. What do they show?

F Read the text under the photos. Match the phrases in box c with the underlined phrases in the handout.

G Complete this introduction from a leaflet talking about the benefits of wind turbines. Use phrases from boxes b and c.

> Wind turbines are a fantastic source of power for ____________ reasons. ____________ the fact that wind is a renewable resource, it is also clean. ____________ sustainability, this is an important point to ____________ when choosing a source of energy. And, ____________ being clean, wind power is also cheap. ____________ research in Denmark, wind power can be used ____________ a country's energy costs can be significantly reduced. ____________ wind power is clearly of great interest to everyone!

a

1	2
conductor construction copper electricity load neon power transmission	balancing conductor costs distribution light network resistance station

b

as shown ... as well ... in addition ... in order ... in such a way ... in the case ... known ... the end ... the use ...

A A generator is used ____________ convert mechanical energy input into low-voltage electrical energy output. ____________ wind power is pollution-free and relatively cheap.

B A transformer is used ____________ the current voltage is converted from 690 V to 10,000–30,000 V.

C The turbine is pointed in the direction of the wind. ____________ larger turbines, this is done with a computer-controlled motor.

D At ____________ the process, electricity is fed into a large-scale power transmission network, ____________ the grid.

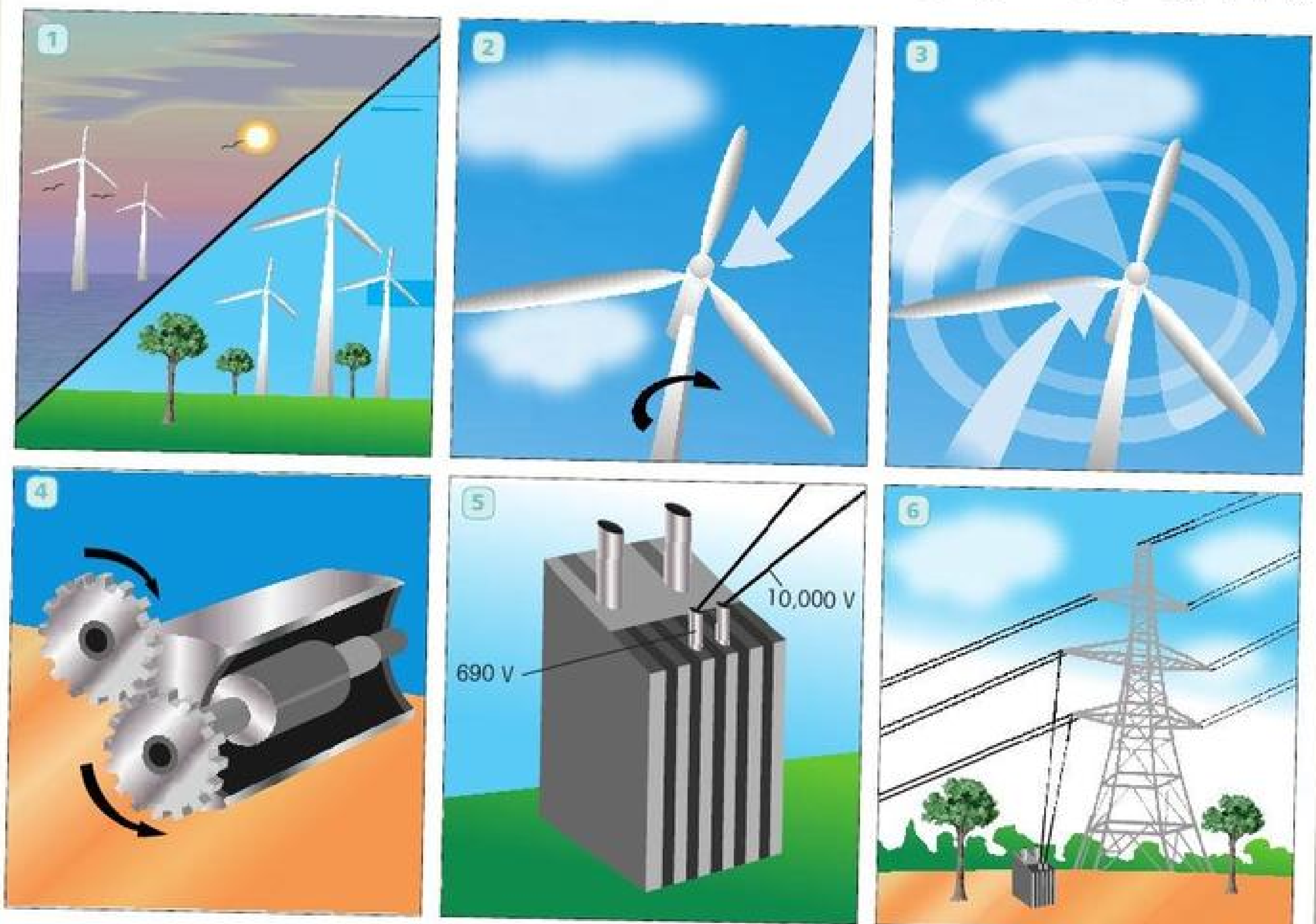
E The wind turbine is sited where there are strong, regular winds. This location depends on the surface of the earth, for example, if there are obstacles, ____________ on the height above the earth that the turbine is built. ____________ typical sites on land, offshore sites are also possible.

F The wind turns the turbine blades ____________ the picture.

c

a number of a variety of bear in mind based on deal with from the point of view of the beginning of the development of

How wind turbines work



Different types of wind turbine and their locations

HADFORD University

There are several different types of wind turbine available for power generation and these are designed to handle different situations. They can rotate around a horizontal or a vertical axis. The evolution of horizontal-axis wind turbines came first, and they are also more common. However, they need to be positioned towards the wind in order to work, whereas vertical-axis turbines do not. This is a factor engineers need to consider when deciding which turbine is best.

The location for a wind turbine is chosen using various criteria, for example, the location's wind power density (WPD). Offshore sites are often chosen for their greater WPD due to the lack of obstacles on the ground. These turbines are the start of the process that brings electricity to our homes.

7.2 Listening

fixed phrases • sequencing information in sentences

A You are going to hear this lecture.
Write six questions you would like answered.

B Listen to Part 1 of the lecture.

1 What is the lecturer going to talk about today? Write *yes*, *no* or *not mentioned*.
   - different types of power station ______
   - electricity distribution ______
   - alternating current ______
   - types of conductor ______
   - transformers ______
   - electricity supply and demand ______
   - locating power lines ______

2 What is electricity distribution?

C Listen to Part 2 of the lecture.

1 Make notes in an appropriate form.

2 What is Joule's law?

3 What is the consequence of Joule's law on power transmission? How is the problem overcome?

4 Were your questions in Exercise A answered?

D Match each phrase in the first column of the table on the right with the type of information that can follow.

E Listen to Part 3 of the lecture.

1 Make notes on the information that comes after the phrases in Exercise D.

2 Were your questions in Exercise A answered?

Faculty: Electrical Engineering
HADFORD *University*
Generation, transmission and distribution of electricity (Lecture 1)
Lecture overview
- Types of power station
- Transmission via power lines
- Voltage choices
- Energy losses
- Types of current
- Types of conductor

Fixed phrase	Followed by ...
1 An important concept (is) ...	a different way to think about the topic
2 What do I mean by ...?	an imaginary example
3 As you can see, ...	a key statement or idea
4 Looking at it another way, ...	a concluding comment giving a result of something
5 In mathematical terms, ...	a new idea or topic that the lecturer wants to discuss
6 Say ...	a comment about a diagram or picture
7 The point is ...	an explanation of a word or phrase
8 In this way ...	a general idea put into a mathematical context

F Listen for sentences 1–4 in Part 4 of the lecture. Which sentence (**a** or **b**) follows in each case? Why?
See *Skills bank*

1 A major problem with power transmission is that it is difficult to store electrical energy.
   a So this energy needs to be generated more or less as it is required.
   b So we need to generate this energy more or less as it is required.

2 If there is an imbalance, the whole power system can fail, causing blackouts.
   a When these blackouts occur, large areas of the country are left without electricity for several hours.
   b Large areas of the country are left without electricity for several hours when these blackouts occur.

3 There are a range of alternative power routes available.
   a With alternative power routes, the important thing is that if some lines stop working, power can be directed through other lines.
   b What's important about alternative power routes is that if some lines stop working, power can be directed through other lines.

4 Using a long-distance network means that it is easier to balance the demand for electricity with production.
   a With demand, the interesting thing is that it may not be distributed evenly over a country.
   b What's interesting is that demand may not be distributed evenly over a country.

G This lecturer is not very well organized. What problems are there in the lecture?

7.3 Extending skills

stress within words • fixed phrases • giving sentences a special focus

A Listen to some stressed syllables. Identify the word below in each case. Number each word.

Example:

You hear: *1 mish* /mɪʃ/ You write:

alternating	___	energy	___	power	___
conductor	___	generation	___	pylons	___
demand	___	imbalance	___	station	___
distribution	___	network	___	transmission	1

B Listen to the final part of the lecture from Lesson 2.

1 Complete the notes on the right by adding a symbol in each space.

2 What research task(s) are students asked to do?

Transmitting energy ___ some energy loss
Transformer ___ step up ___
down voltage ___ reduce loss
___ voltage = ___ current = ___ loss
___ long distances ___ high voltage
___ high voltage ___ thinner conductors ___
cheaper
BUT:
___ Too thin ___ weak ___ extra costs, e.g.,
supports ___ pylons
___ Too high voltage ___ not safe
Transformer ___ 2 coils ___ core
1st winding ___ magnetic flux in core ___
different voltage in 2nd winding
2nd voltage ___ no. of turns in winding

C Study the phrases from the lecture in the blue box. For which of the following purposes did the lecturer use each phrase?

- to introduce a new topic
- to emphasize a major point
- to add a point
- to finish a list
- to give an example
- to restate

et cetera
In other words, ...
Let's take ...
Let me put it another way ...
Not to mention the fact that ...
Plus there's the fact that ...
The fact of the matter is, ...
You've probably heard of ...

D Rewrite these sentences to give a special focus. Begin with the words in brackets.

1 Raising the voltage reduces current and resistive losses. (*It*)

2 The voltage value is difficult to set because there are physical limits and financial considerations. (*Two sentences. First = 'It'; Second = 'The reason'*)

3 The transmission of electricity is much more expensive because of all these extra costs. (*It*)

4 All transformers follow these basic principles. (*It*)

5 The distribution of electricity to customers comes after the transmission process. (*What*)

See *Skills bank*

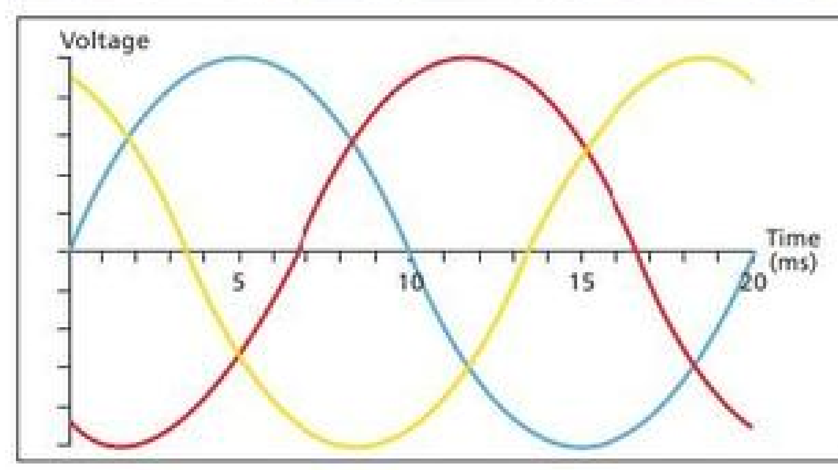
E Choose one section of the lecture. Refer to your notes and give a spoken summary. Use the fixed phrases and ways of giving special focus that you have looked at.

F Work with a partner. In the leaflet in Lesson 7.1 you read about wind power.

1 Think of some more advantages and disadvantages of wind power. Make lists.

2 Present your ideas to another pair. Practise using fixed phrases and ways of giving special focus. **See *Vocabulary bank* and *Skills bank***

7.4 Extending skills
making effective contributions to a seminar



A Look at the diagram on the opposite page.

1. What does it show?
2. What do the different colours show?
3. What is the difference between light industry and heavy industry?

B Listen to the first extract from a seminar about electricity distribution.

1. What question will the students discuss?
2. What *isn't* part of the distribution process?

C Listen to Extract 2 of the seminar. Are these sentences true or false?

1. All customers need the same voltage. ____
2. Different customers need different types of current. ____
3. Three-phase current is suitable for customers in rural areas. ____
4. Single-wire earth return is a good system for heavy industry. ____
5. Cost is the main issue when deciding the best way to distribute electricity. ____

D Study the categories **a**–**d** below and the phrases in the blue box.

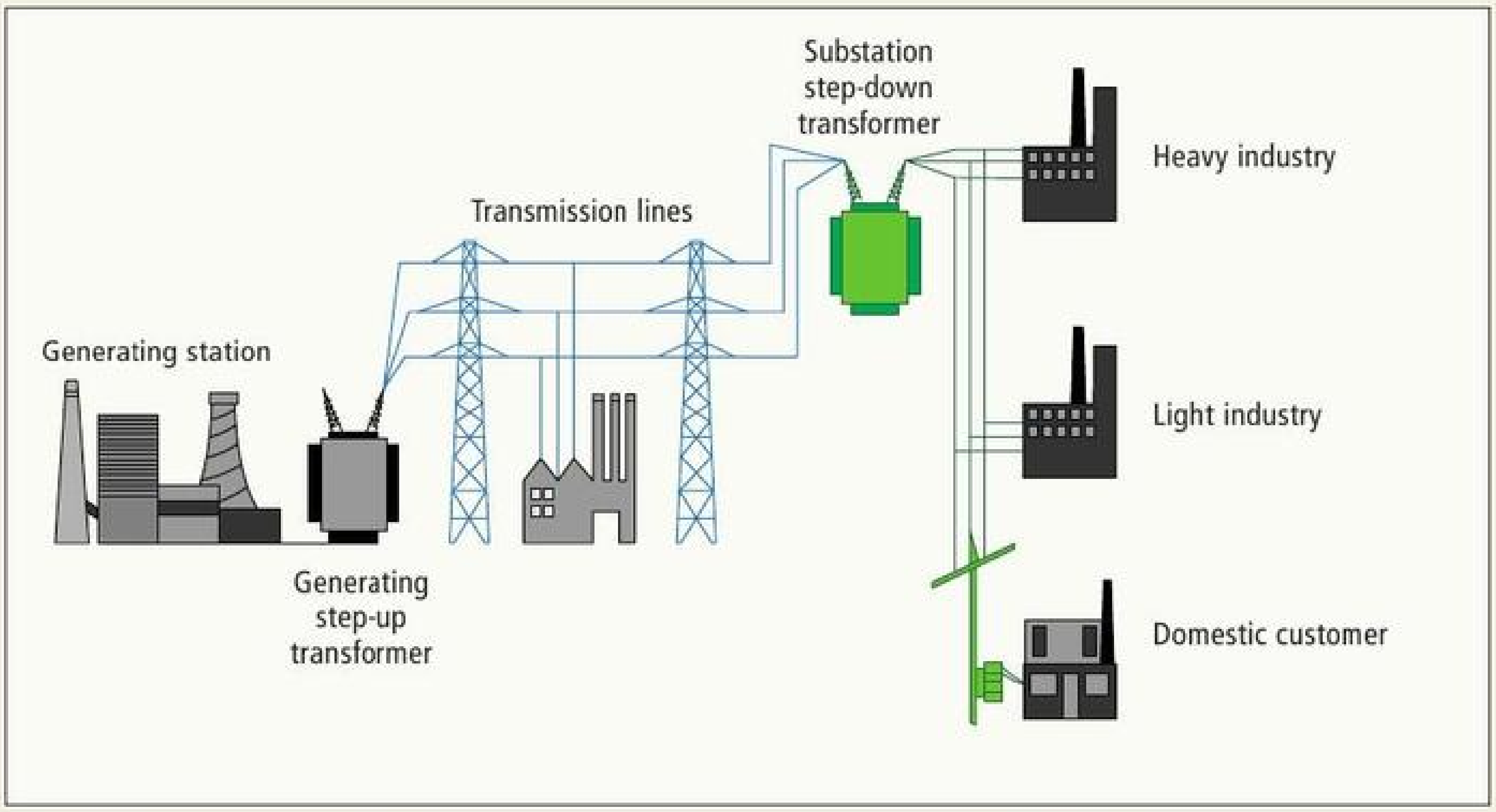
1. Write **a**, **b**, **c** or **d** next to each phrase to show its use.
   - **a** introducing
   - **b** asking for clarification
   - **c** agreeing/disagreeing
   - **d** clarifying
2. Listen to Extract 2 again to check your answers.

I'd like to make two points. First, ... ____
Can you expand on that? ____
The point is ... ____
What's your second point? ____
My second point is that ... ____
Yes, but ... ____
I don't agree with that because ... ____
Sorry, but who are we talking about, exactly? ____
We need to be clear here. ____
In what way? ____
What I'm trying to say is, ... ____
Can you give me an example? ____
Look at it this way. ____
Absolutely. ____
I'd just like to say that ... ____

E Work in groups of four to research the main types of power station. Each person should choose a different type of station:
Student A: read about *nuclear* on page 103.
Student B: read about *oil-fired* on page 104.
Student C: read about *hydroelectric* on page 105.
Student D: read about *solar* on page 106.
After reading the notes, report back orally to your group. Use fixed phrases to ask for and give clarification.

F Work in groups. Choose one of the power stations shown in the photographs.

1. Have a practice committee meeting in which you decide where the power station should be located.
2. Report to the class on your discussion, giving reasons for your decisions.



Nuclear power station

Oil-fired power station

Hydroelectric power station

Solar power station

Vocabulary bank

Recognizing fixed phrases from electrical engineering (1)

There are many fixed phrases in the field of electrical engineering.

Examples:

Phrase	Meaning in the discipline
electricity meter	a meter that measures electricity use
copper conductor	a conductor made of copper
neon light	a light containing neon
conductor resistance	the resistance of the conductor

Keep a list of fixed phrases used in electrical engineering and remind yourself regularly of the meaning.

Recognizing fixed phrases from academic English (1)

There are also a large number of fixed phrases which are commonly used in academic and technical English in general.

Examples:

Phrase	What comes next?
As we have seen ...	a reminder of previous information
An important concept is ...	one of the basic points underlying the topic
As you can see, ...	a reference to an illustration OR a logical conclusion from previous information
As shown in ...	a reference to a diagram or table
... in such a way that ...	a result of something
In addition to (X, Y)	X = reminder of last point, Y = new point
As well as (X, Y)	
In the case of ...	a reference to a particular topic or, more often, sub-topic
At the same time, ...	an action or idea which must be considered alongside another action or idea
... based on ...	a piece of research, a theory, an idea
Bear in mind (that) ...	key information which helps to explain (or limit in some way) previous information
The point is ...	the basic information underlying an explanation
in order to (do X, Y)	X = objective, Y = necessary actions/conditions
In financial terms, ...	something seen from a financial point of view
In other words, ...	the same information put in a different way
Looking at it another way, ...	
In this way ...	a result from previous information
Say ...	an example
What do I mean by (X)?	an explanation of X

Make sure you know what kind of information comes next.

Skills bank

'Given' and 'new' information in sentences

In English, we can put important information at the beginning or at the end of a sentence. There are two types of important information.

1 Information which the listener or reader already knows, from general knowledge or from previous information in the text. This can be called 'given' information. It normally goes at the beginning of the sentence.

2 Information which is new in this text. This can be called 'new' information. It normally goes at the end of a sentence.

Example:
In Lesson 2, the lecturer is talking about the problems of matching the supply and demand for electricity, so an imbalance = given information.

Given	New
If there is an imbalance,	*the whole power system can fail, causing blackouts.*
When blackouts occur,	*large areas of the country are left without electricity for several hours.*

Giving sentences a special focus

We sometimes change the normal word order to emphasize a particular point, e.g., a person, an object, a time.

Examples:

Normal sentence	*Enrico Fermi created the first controlled nuclear fission chain reaction in 1942.*
Focusing on person	*It was Enrico Fermi who created ...*
Focusing on object	*It was the first controlled nuclear fission chain reaction which Enrico Fermi created ...*
Focusing on time	*It was in 1942 that Enrico Fermi ...*

Introducing new information

We can use special structures to introduce a new topic.

Examples:
The transmission of electricity is my subject today.
→ ***What I am going to talk about today is** the transmission of electricity.*

Alternative power line routes are very important.
→ ***What is very important is** alternative power line routes.*

An imbalance in supply and demand can cause blackouts.
→ ***The reason for blackouts is** an imbalance in supply and demand.*

Extremely hot weather leads to an increase in demand for electricity.
→ ***The result of extremely hot weather is** an increase in demand for electricity.*

Clarifying points

When we are speaking, we often have to clarify points. There are many expressions which we can use.

Examples:
Let me put it another way ...
Look at it this way ...
What I'm trying to say is ...
The point/thing is ...

8 TELECOMMUNICATIONS

8.1 Vocabulary

synonyms • nouns from verbs • paraphrasing

A Discuss the following questions.

1. What is meant by *telecommunication*?
2. Which of the items in box a are examples of telecommunication?

B In pictures A–J, all the items and graphs are connected to telecommunication. What do they show?

C Look up in a dictionary each noun in box b.

1. Is it countable, uncountable or both?
2. What is its engineering meaning?
3. What is a good synonym?
4. What useful grammatical information can you find?

D Study the two lists of verbs in box c.

1. Match the verbs with similar meanings.
2. Make nouns from the verbs if possible.

c

1	2
demonstrate, happen, operate, provide, receive, respond, send, transcribe, use	work, show, utilize, transmit, answer, supply, convert, take place, pick-up

E Look at the Hadford University handout.

1. How does the writer restate each section heading within the paragraph?
2. Find synonyms for the blue words and phrases. Use a dictionary if necessary.
3. Rewrite each sentence to make paraphrases of the texts. Use:
   - synonyms you have found yourself
   - synonyms from Exercise C
   - the nouns you made in Exercise D
   - passives where possible
   - any other words that are necessary

   Example:
   The electric telegraph was the first significant development in telecommunication history.
   → *The initial breakthrough in telecommunication was the invention of the telegraph.*

a

computer fixed-line phone
mobile phone radio smoke signals
telegraph wireless mouse

b

application breakthrough
characteristic development
device information message
process purpose receiver
signal technology transmitter

HADFORD *University*

Key moments in the history of telecommunication

A The initial breakthrough

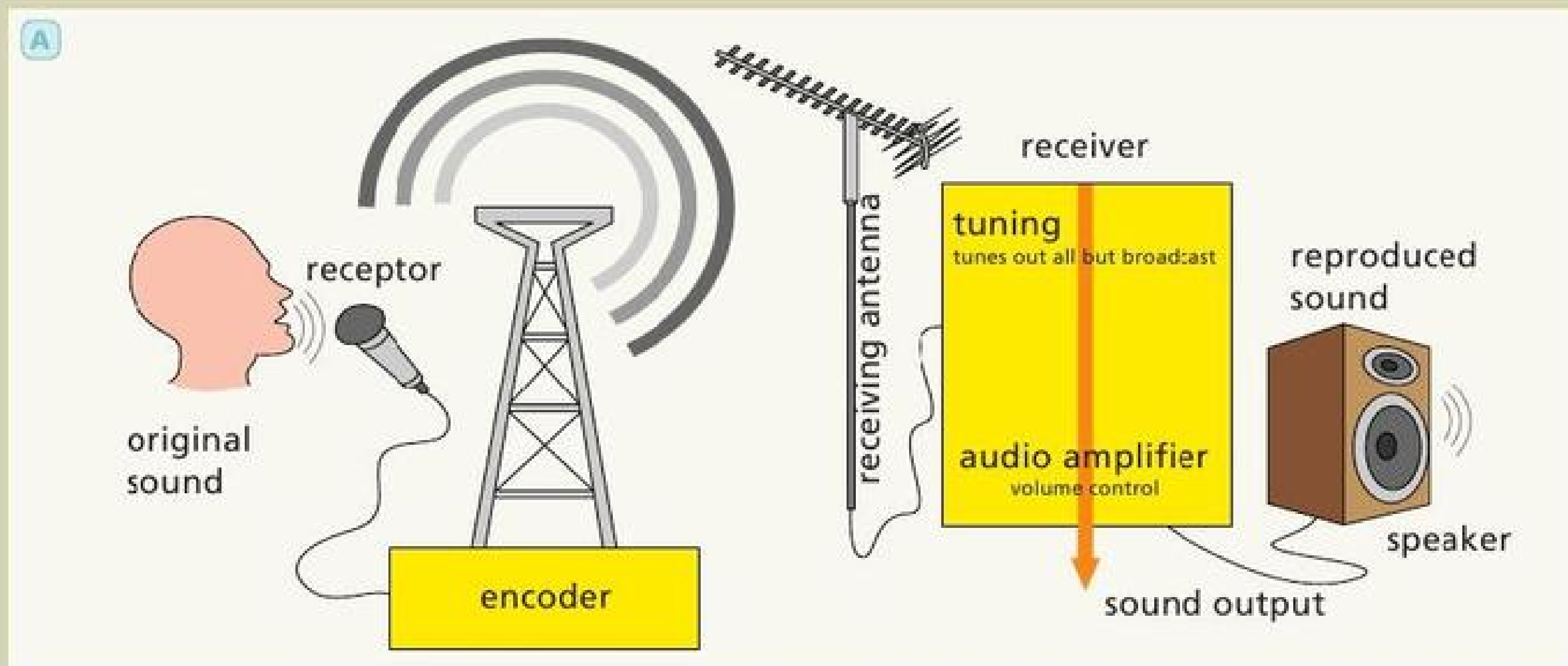
The electric telegraph was the first significant development in telecommunication history.
In the 1830s, electricity was used to send information long distances. The most successful form of the telegraph enabled an operator to transcribe a message into Morse code. The device then sent the coded message down an electric wire as a series of electric signals.

B The revolution

Telecommunication changed dramatically when Marconi showed it was possible to send information without the use of wires. He used radio waves to do this, but nowadays we can also use infrared light or laser light for the same purpose. Wireless technology has been used in devices, such as a computer mouse, to transfer data over short distances, but also over long distances, as, for example, in a global positioning system.

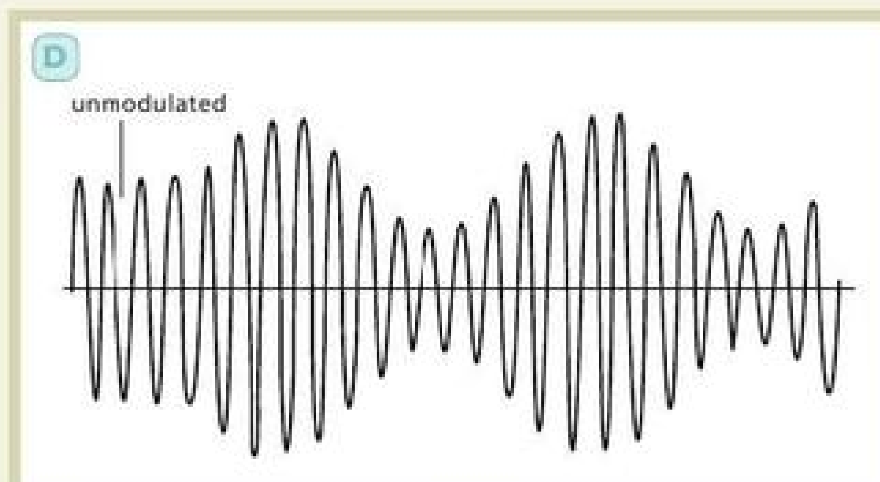
F Look at the telecommunication items in box a again. Try to add to the list.

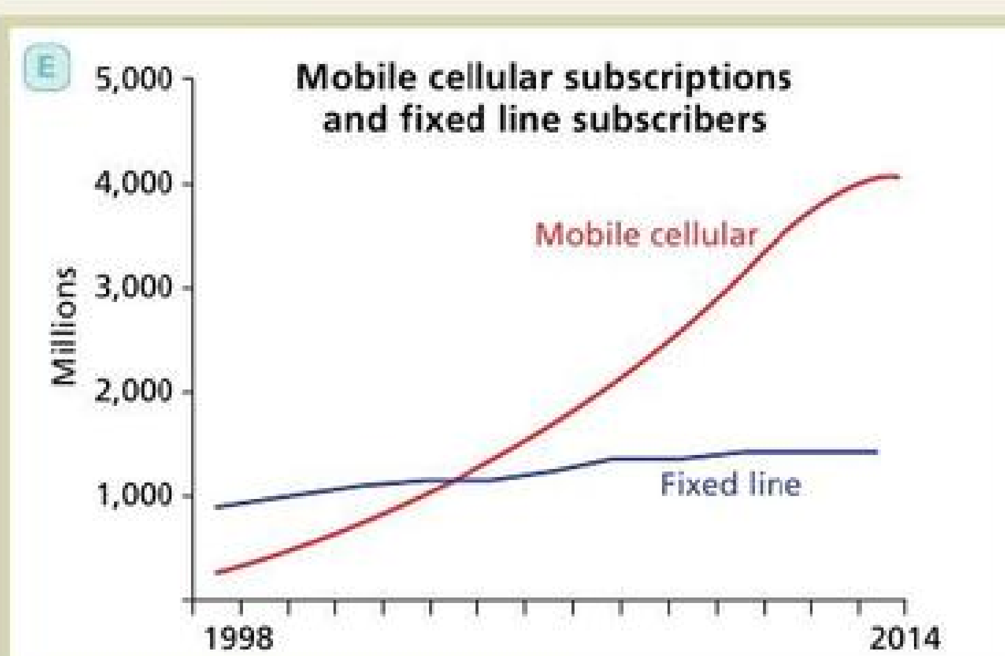
1. Do they come before or after the initial breakthrough? Do they come before or after the revolution?
2. Which items offer the most effective communication in your opinion? Why?


A
original sound
receptor
encoder
receiving antenna
receiver
tuning
tunes out all but broadcast
audio amplifier
volume control
sound output
reproduced sound
speaker

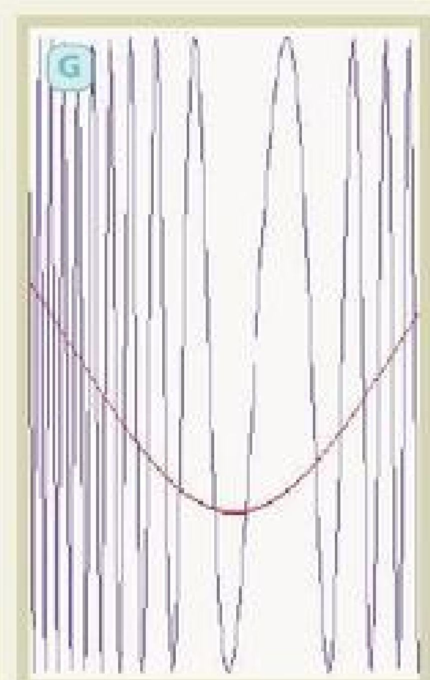

B

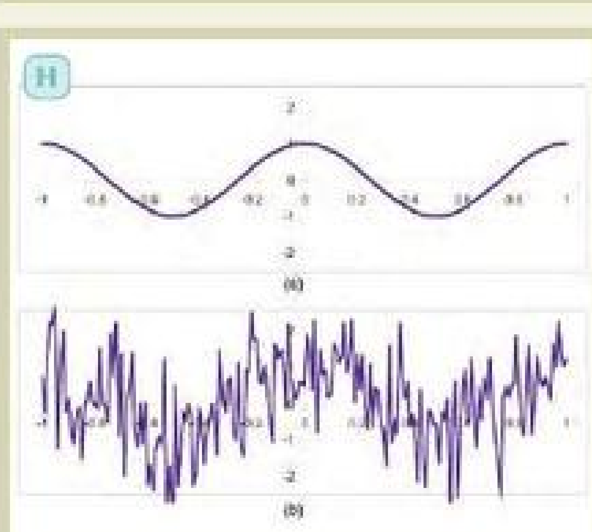

C


D
unmodulated


E
Mobile cellular subscriptions and fixed line subscribers
5,000
4,000
3,000
2,000
1,000
Millions
Mobile cellular
Fixed line
1998
2014


F
I
J
K
L
M
N
O


G


H


I
facebook
Facebook helps you connect and share with the people in your life.


J
1 new message received

A Look at the items in the blue box. What role do they play in telecommunication?

B Look at the four types of writing on the right.

1 What should the writer do in each type?

2 Match each type with one of the writing assignment titles (A–D) below the slide.

3 What topics should be covered in each piece of writing?

C Read the title of the text on the opposite page and the first sentence of each paragraph.

1 What will the text be about?

2 Choose one of the assignments in Exercise B. Write four research questions which will help you to find information for your writing.

D Read the text.

1 Look back at the items in box a. Were you right about the role they play in telecommunication?

2 Using your own words, make notes from the text on information for your assignment title.

3 Work with another person who has chosen the same title as you. Compare your notes.

E Study the highlighted sentences in the text.

1 Underline all the subjects and their verbs.

2 Which is the main subject and verb for each sentence?

F Study the table on the right.

1 Match each word or phrase with its meaning.

2 Underline the words or phrases in the text which the writer uses to give the definitions.

See *Vocabulary bank*

deterioration line medium modulation network receiver signal transmitter

HADFORD *University*

There are four main types of writing in Electrical Engineering:

- outline/research report
- description of an object
- description of cause and effect
- description of a process

A Compare and contrast the radio and the mobile phone.

B What are the main elements in a telecommunication system?

C How does a radio broadcast work?

D What were the effects of the main discoveries in telecommunication?

Word/phrase	Meaning
1 carrier wave	the physical medium through which the information signal travels
2 physical channel	data, which no-one else can access, transmitted from one user to another
3 duplex	a waveform that is modified by an input signal to carry information
4 point-to-point communication	data transmitted from a central user to a large number of other users
5 coaxial cable	describes a device that contains both a transmitter and a receiver
6 broadcast communication	a type of transmission line for radio frequency signals

The rise (and rise) of telecommunications

The word 'telecommunication' was actually invented in France at the beginning of the 20th century. It comes from the Greek word for 'far away' and the Latin word for 'to share', so it means 'sharing information with someone far away'. Of course, communication over considerable distances had existed long before this, for example using smoke signals. But with the production of electricity and conducting metal wires in the 19th century, it became possible to communicate over much longer distances using the telegraph and telephone. Later, the invention of wireless communication using radio waves led to the development of the radio and television and, more recently, microwaves have been used for mobile phones. Telecommunication is now a key part of the world economy, and its importance is growing all the time.

All telecommunication systems have three basic elements. First, the system contains a transmitter, where the message is taken and converted into a signal. For example, in the electric telegraph, the message was converted into a code invented by Samuel Morse. Then, the signal is transmitted through a 'physical channel', or medium. Examples of this medium are optical fibres and coaxial cables, which are cables consisting of three layers – an inner conductor surrounded by a layer of insulation, surrounded by a tube of conducting shield. The channel can also be simply 'free space'. This is clear air or space and is the channel for radio waves, for example, which can also be transmitted through a vacuum. Finally, a receiver converts the signal back into information that can be understood.

Radio broadcasting and mobile phones are two examples of telecommunication, but they have very different characteristics. The radio is a one-way system. In other words, the communication goes only from the radio station to the listeners. A mobile phone, on the other hand, is 'duplex', that is, a two-way system. This means that communications are both transmitted and received by the device. Interestingly, these two systems are completely separate, and need to be isolated from each other inside the phone. This is because the receiver needs to deal with power at very low levels, often microwatts, while the transmitter operates at a much higher power level, up to the level of kilowatts.

Another important difference between radio transmissions and mobile phones is that the radio provides 'broadcast communication', which is communication that takes place between one powerful transmitter and a large number of smaller radio receivers. Mobile phones are quite different, and provide 'point-to-point communication' – communication between one transmitter and a single receiver.

A key feature of telecommunication is 'modulation'. This process, which takes place at the transmitter, changes the message in some way before it is sent. Modulation can change, for instance, an analogue signal into a digital one. This is used in most analogue fixed-line telephones, in which the voltage signal is directly determined by the strength of the speaker's voice. Converting this analogue signal into digital data has several advantages. First, it can be transmitted along optical fibres, which is considered to be a very efficient and relatively inexpensive way of sending digital information over long distances. Second, there is less deterioration of the signal due to noise, as there would be with an analogue signal.

Modulation can also solve another common problem. It is difficult to send a low-frequency signal over free space, so such a signal can be combined with a carrier wave, a high-frequency wave that is modified in order to carry information. This can be done through amplitude modulation (AM) or through frequency modulation (FM), and as a result, the radio signal can be broadcast successfully.

Telecommunication has had an enormous impact on modern society. With the arrival of the Internet – digital data which can be sent along the same optic fibres used for fixed-line telephones – telecommunications is now a multi-trillion dollar industry which provides a range of practical applications in a variety of forms. However, it has also had an increasingly important impact on people's social interaction, as shown most recently with text messaging technology and social networking sites on the Internet. These trends will no doubt continue, and telecommunication will remain a key field of research and development in the future.

8.3 Extending skills

passives in dependent clauses • essay plans

A Find the words in the box in the text in Lesson 8.2.

1 What part of speech is each word?

2 Think of another word which could be used in place of the word in the text. Use your dictionary if necessary.

elements surrounded shield characteristics isolated deterioration common impact range trends field

B Study sentences A–D on the right.

1 Identify the dependent clause.

2 Copy the table under the sentences and write the parts of each dependent clause in the table.

3 Rewrite the sentence using an active construction.

Example:
A This is the channel for radio waves, which the transmitter can also send through a vacuum.

A This is the channel for radio waves, which can also be sent through a vacuum by a transmitter.

B This means that the communication is both transmitted and received by the device.

C This is used in most fixed-line telephones, in which the voltage signal is directly determined by the strength of the speaker's voice.

D It can be transmitted along optical fibres, which is considered to be a very efficient and relatively inexpensive way of sending digital information over long distances.

Subject	Verb	By whom/what
(radio waves) which	can be sent	by a transmitter

C Read the writing plans and extracts on the opposite page.

1 Match each plan with a writing assignment title in Lesson 8.2.

2 Which piece of writing is each extract from?

3 Which part of the plan is each extract from?

D Work with a partner.

1 Write another paragraph for one of the plans.

2 Exchange paragraphs with another pair. Can they identify where yours comes from?

8.4 Extending skills

writing complex sentences • writing essay plans • writing essays

A Make complete sentences from these notes. Add words as necessary.

A radio – different – 'one-way' system – communication – one direction

B final similarity – utilize free space – physical channel

C another feature – in common – use wireless technology

D first important difference – radio – 'broadcast communication' – one transmitter – sends data – many small receivers

E radio – mobile phone – examples – telecommunication – share – many characteristics

F important similarity – three basic elements – telecommunication system – transmitter – medium – receiver

B The sentences in Exercise A are topic sentences for paragraphs of writing assignment title A in Lesson 8.2. Put them in the best order for the piece. What is the main topic for each paragraph?

C Look at the writing assignment title on the opposite page.

1 What kind of writing is this?

2 Do some research and make a plan.

3 Write the piece. See *Skills bank*

Writing plans

A

1 Telecommunication system: a way of communicating with people who are far away
2 Transmitter:
   - message is taken
   - message converted to signal
   - signal modulated, e.g., analogue to digital / combined with carrier wave (AM/FM modulation)
3 Physical channel: message travels to receiver via, e.g.,
   - atmosphere (sound)
   - optical fibres
   - cable
   - free space (radio waves)
4 Receiver: signal converted back into understandable information
5 Summary of 3 main points

B

1 Telecommunications: from smoke signals to the Internet
2 Discovery of electricity + conducting metal wires:
   - telegraph and telephone invented – used Morse code
   - communication over longer distances possible
3 Discovery of wireless transmission with radio waves:
   - radio + television invented
   - telephones became more efficient
4 Discovery of digital signals + optical fibres
   - more efficient, less deterioration of signal
   - Internet became possible
5 Overall effect of developments in telecommunication
   - opened up a wide range of practical applications
   - changed people's social interaction

Writing extracts

1

All these discoveries in the field of telecommunication have had important consequences for modern society. We can now enjoy a wide range of practical services, such as receiving news from all around the world in a very short time. However, these developments have also resulted in social changes, for instance, in the way that we interact with other people. We can now talk to people on our mobile phones, which has changed when and where we can contact people. But we can also send SMS text messages and, perhaps most important of all, we can use the Internet to interact, through emails, social networking sites and other applications. As a result, the way we lead our lives nowadays is very different, in terms of both quantity and quality of communication.

2

The second main element in a telecommunication system is the physical channel. This is the medium through which the signal travels from the transmitter to the receiver. For example, with sound, the medium is the atmosphere. There are many different physical channels available for telecommunication. Radio waves use 'free space'. This is a little different from the atmosphere because radio waves can be transmitted through a vacuum, while sound, for instance, cannot. Coaxial cables and optical fibres are other examples of physical channels. Optical fibres are a very successful way of transmitting digital data over long distances, and are used in fixed-line telephone networks and Internet connections.

Writing assignment title

What are fibre-optic cables and how are they used in a fibre-optic telecommunication system?

Vocabulary bank

Understanding new words: using definitions

You will often find new words in academic texts. Sometimes you will not be able to understand the text unless you look the word up in a dictionary, but often a technical term will be defined or explained immediately or later in the text.

Look for these indicators:

is or *are*	*... 'free space'. This is clear air or space ...*
brackets	*... coaxial cables (cables consisting of three layers ...*
or	*... 'physical channel', or medium.*
which	*... 'broadcast communication', which is communication that takes place ...*
a comma or a dash (–) immediately after the word or phrase	*... the carrier wave, a high-frequency wave modified in ...* *... 'point-to-point communication' – communication between one transmitter and ...*
phrases such as *that is, in other words,*	*In other words, the communication goes only from ...* *... is 'duplex', that is, a two-way system. This means that communications are both transmitted and received ...*

Remember!

When you write assignments, you may want to define words yourself. Learn to use the methods above to give variety to your written work.

Understanding direction verbs in essay titles

Special verbs called **direction verbs** are used in essay titles. Each direction verb indicates a type of essay. You must understand the meaning of these words so you can choose the correct writing plan.

Kind of essay	Direction verbs
Outline/research report	*State ... Say ... Outline ... Summarize ... List ... Select ... Present ... What is/are ...? Evaluate ... Examine ... Comment on ... Give reasons for ...*
Description of an object	*Describe ... Compare ... Contrast ... What ...? Illustrate ... Distinguish between ...*
Description of cause and effect	*Describe ... How ...? Why ...? Explain ... List ... What are the causes/effects...? Give reasons for ...*
Description of a process	*How ...? Describe the stages ... What steps ...?*

Skills bank

Choosing the correct writing plan

When you are given a written assignment, you must decide on the best writing plan before you begin to write the outline. Use key words in the essay title to help you choose – see *Vocabulary bank*.

Type of writing – content	Possible structure/typical language used
Outline/research report Understand the **purpose** for doing this outline/research. List briefly the **most important points** of something. Select according to length constraints. **Order** for clear presentation. **Example:** *What are the main elements in a telecommunication system?*	• Introduction – describe topic/context • subheading 1, 2, 3, etc. • basic operation/function of element 1, 2, 3, etc. • brief conclusion / summary
Description of an object (involves compare and contrast) According to the **purpose**, give a clear, detailed explanation so that it can be recognized and/or drawn. Start with a **central feature** and relate everything to it. Do by straight **description** or by **comparing** to a standard or familiar object. Then use these aspects as the basis for paragraphing. **Example:** *Compare and contrast the radio and the mobile phone.*	• describe size, shape, colour, material, function, etc. • *A is similar to B except …* • *A ..., whereas B …* • *A … . On the other hand, B …* *etc.* • brief conclusion/summary
Description of cause and effect According to the **purpose**, list the **important causes and effects.** Give **reasons.** Emphasize the causes, the effects or both. Look behind the surface structure at the **how** and **why**, not just **what/who/when.** **Example:** *What were the effects of the main discoveries in telecommunication?*	• introduction – explain context • most important point 1: explain/give reason • next point 2: • explain/give reason, etc. • brief conclusion/summary
Description of a process According to the **purpose**, give a clear detailed description of the **steps** of the process. Give a **reason** for each step. State the **outcome** of each step, where applicable. Explain each **component** as and when it enters the process. **Example:** *How does a radio broadcast work?*	• Introduction – explain context • *First of all, the ...* • *Then ...* *etc.* • first, then, next, after that, finally, before, after, at the same time, while, during • brief conclusion/summary

9 SIGNAL PROCESSING

9.1 Vocabulary

fixed phrases and terms in electrical engineering

A Match the words to make fixed phrases.

1	alternating ☐	a	wave
2	frequency ☐	b	station
3	carrier ☐	c	current
4	mobile ☐	d	phase
5	solar ☐	e	modulation
6	single ☐	f	power
7	power ☐	g	loss
8	energy ☐	h	phone

B Study the words and phrases in the blue box.

1 Complete each phrase in column 2 with a word from column 1.

2 Which phrase(s) can you use to:

- agree only partly with a point?
- begin talking about several points?
- talk about a particular example?
- introduce the first of two ideas?
- introduce the second of two ideas?
- focus on the most important point?
- give a reason for a point?
- mention an idea?
- talk about certain circumstances?

C On the opposite page are five electronic devices and a list of five technologies that use signal processing.

1 What are the five devices (1–5)?

2 Match each device with the technology it uses.

3 What does the technology do? How does it help improve what the device does?

4 Match each technology with the appropriate quote (A–E).

5 Replace the words in italics with a phrase from Exercise B.

D Read the extract from the Hadford University handout about signal processing on this page.

1 Match the blue words in this extract with the definitions on the opposite page.

2 Use your dictionary to check words you do not know.

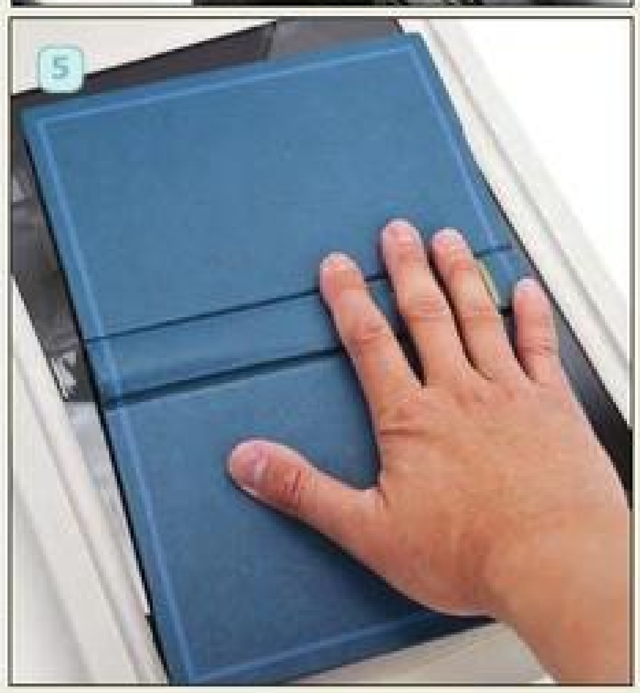
E Complete the table on the right.

1	2
a	... start with
to	... people think
the	on ... other hand
some	to ... extent
many	on ... one hand
this	... real question is
that	on ... grounds that
	in ... case like this
	in ... sort of situation

HADFORD *University*

- A signal consists of the plots of a trace of an independent variable plotted against a dependent variable, showing its amplitude.
- Sound is a signal which is a pressure wave with a compression phase and a rarefaction phase.
- Signals can have continuous or discrete values.
- The signal to be processed is often a periodic wave distorted by random noise. Noise often occurs on pick-up.
- Noise can be of both high and low frequency and can be eliminated using physical barriers.

Base form	Other related forms	
code		
convert	conversion	converted
extract		
filter		
hold		
plot		
process		
sample		
smooth out		
soundproof		



A 'I believe it's wrong to do this, *because* it distorts the truth of what you see.'

B '*The important thing is*: does it mean fewer crashes?'

C '*First of all*, it's much easier to store things in this form. *But* there is sometimes a loss in quality.'

D 'Sometimes you can only hear the drums. *When this happens*, you need to use it to boost the treble frequencies.'

E '*They say* it eliminates the problem altogether. I *don't agree completely*. Sometimes I have to hang up and ring again.'

www.hadfield.ac.uk/biz/def

Definitions

A the time interval during which an elastic wave decompresses or lowers the pressure of the gas (e.g., air) through which it is travelling

B the maximum absolute value of a periodically varying quantity

C unwanted interference characterized by overlapping disturbances occurring with no recognizable regularity

D type of domain where signal strength can be represented graphically as a function of frequency, rather than as a function of time

E a type of elastic wave that can travel through gases (e.g., air), liquids and solids

F whole numbers, i.e., -12, 1, 259, etc.

G a line drawn by a recording instrument

H a wave whose displacement repeats itself identically at regular intervals of time or distance, or both

I the time interval during which an elastic wave compresses or raises the pressure of the gas (e.g., air) through which it is travelling

J the reception of a signal by a processing device

K physical factors that obstruct the passage of something

L a mathematical variable which depends on and responds to the independent variable

9.2 Listening
using the Cornell note-taking system

A Study Slide 1 on the right. What questions do you think the lecturer will answer?

B Listen to Part 1 of the lecture.

1. Complete the *Notes* section at the bottom of the page. Refer to Slides 2 and 3 as needed.
2. What is the lecturer's story about? Why is it not given in the notes?
3. Complete the *Summary* section.
4. Answer the *Review* questions.

C Create a blank Cornell diagram. Listen to Part 2 of the lecture.

1. Complete the *Notes* section.
2. Write some *Review* questions.
3. Complete the *Summary* section.
4. Were your questions in Exercise A answered?

D Study the phrases in column 1 of the blue box. Listen to some sentences from the lecture. Which type of information in column 2 follows each phrase?

HADFORD University

Signal Processing (Lecture 1)

- Types of signal processing
- Applications of signal processing

Slide 1

1	2
1 As we shall see …	a developing trend
2 So it should be clear that …	information about a point the speaker will make later
3 It's true to say that …	an aspect of a topic the speaker wants to focus on
4 Research has shown that …	a statement the speaker agrees with
5 In terms of …	a conclusion
6 It could be argued that …	an idea the speaker may not agree with
7 From the point of view of …	
8 Increasingly we find that …	

HADFORD University

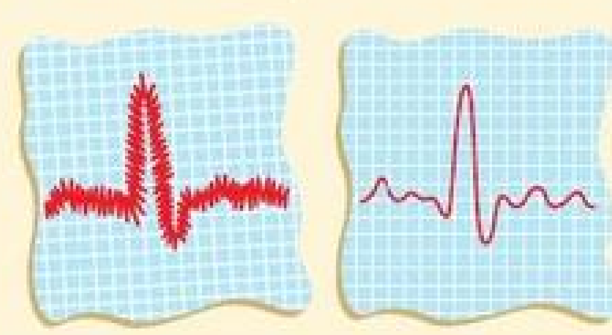
Signal: $f(x_1, x_2, \ldots)$

x_1 = temperature,

x_2 = distance,

x_3 = time etc.

Slide 2



Slide 3

Review	Notes
2 main approaches to signal processing are …?	____________ signal processing
	____________ signal processing
What is a signal?	Signal = $f(x_1, x_2, \ldots)$ = a function of one or more independent variables
	e.g., x_1 = temperature/distance/time/etc. For us, x_1 = ____________
What sorts of signal are there?	Continuous time signals + ____________ time signals
Are these digital or analogue?	Continuous time signals = ____________ signals
	For discrete time signals:
	Continuous amplitude of dependent variable = ____________ signal
	Amplitude coded into discrete values (usually ____________ code) = digital signal
What is processing? An example?	Processing = make signals better, e.g., reduce ____________ of an ECG scan
What are 3 ways to process signals?	1. analogue processing = most common up to ____________
	2. digital processing = more convenient + accurate + ____________
	3. mixed processing = combination of analogue + digital, e.g., ____________ transmission

Summary

9.3 Extending skills

recognizing digressions • understanding source references

A Study the words and phrases in box a.

1. Mark the stressed syllables.
2. Listen and check your answers.
3. Which word or phrase in each group has a different stress pattern?

B Study the phrases in box b.

1. Do you think the phrases show a digression (start or end) or a relevant point? Write **D** or **R**.
2. Look at the **D** phrases. Do they start or end the digression?

C Listen to the final part of the lecture from Lesson 9.2.

1. Take notes using the Cornell system. Leave spaces if you miss information.
2. What topic does the lecturer mention that is different from the main subject?
3. Why does the lecturer mention this topic?
4. What is the research task?
5. Compare your notes in pairs. Fill in any blank spaces.
6. Complete the *Review* and *Summary* sections.

a

1. analogue signal, binary code, discrete value, random noise
2. frequency, processing, barrier, dependent
3. amplitude, compression, conversion, extraction
4. modulation, periodic, variable, interference

b

Now, where was I?

It's the first of these points that I'm going to focus on now ...

By the way, ...

So to get back to the main topic ...

I have a little story to tell you ...

If we move on now to ...

You don't need to take notes on this ...

The point of that story was ...

If we turn now to ...

When we look at digital signal processing we'll find ...

D What information does the lecturer provide about sources? Listen to the extracts and complete the table below.

	Extract 1	Extract 2	Extract 3	Extract 4
Name of writer				
Title and date of source				
Location				
Type of reference				
Relevant to ...?				
Introducing phrase				

E Use your notes to write 75–100 words about active noise control (ANC).

F Work in groups. Study the four types of speech recognition system in box c. Choose one type you would like to find out more about and then discuss these questions.

1. What kind of information will you need to find?
2. What ideas do you already have?
3. Where can you go to find more information?

c

Speech (voice) recognition systems

- speaker verification
- natural language processing
- speaker-independent voice recognition
- speaker-dependent voice recognition

9.4 Extending skills

making effective contributions to a seminar

A Look at the words in the blue box. They have either four or five syllables. Identify their stress patterns.

> applications artificial capabilities
> computational development
> microprocessor numerically operations
> programmable recognition

B Work in pairs.

Student A: Think of good ways to take part in a seminar.

Student B: Think of bad ways to take part in a seminar.

C You are going to hear some students in a seminar. They have been asked to discuss the question: 'How did digital signal processing develop?'

1. Listen to the four seminar extracts. Decide whether each contribution is good or poor.
2. Give reasons for your opinion.

D Work in a group of three or four.

1. Discuss your information for the topics in Lesson 9.3, Exercise F. Agree on the best description.
2. Discuss how best to present this information.
3. Present a description of your topic to the whole class.

E Study Figure 1 on this page. What does each part of the diagram show?

F Study the information in Figure 2 on the opposite page. In pairs or groups, discuss the following:

1. What benefits of speech recognition technology does the information mention?
2. What disadvantages are given?
3. Do you think speech recognition is reliable and useful? Tell the class about your thoughts saying what they are based on.

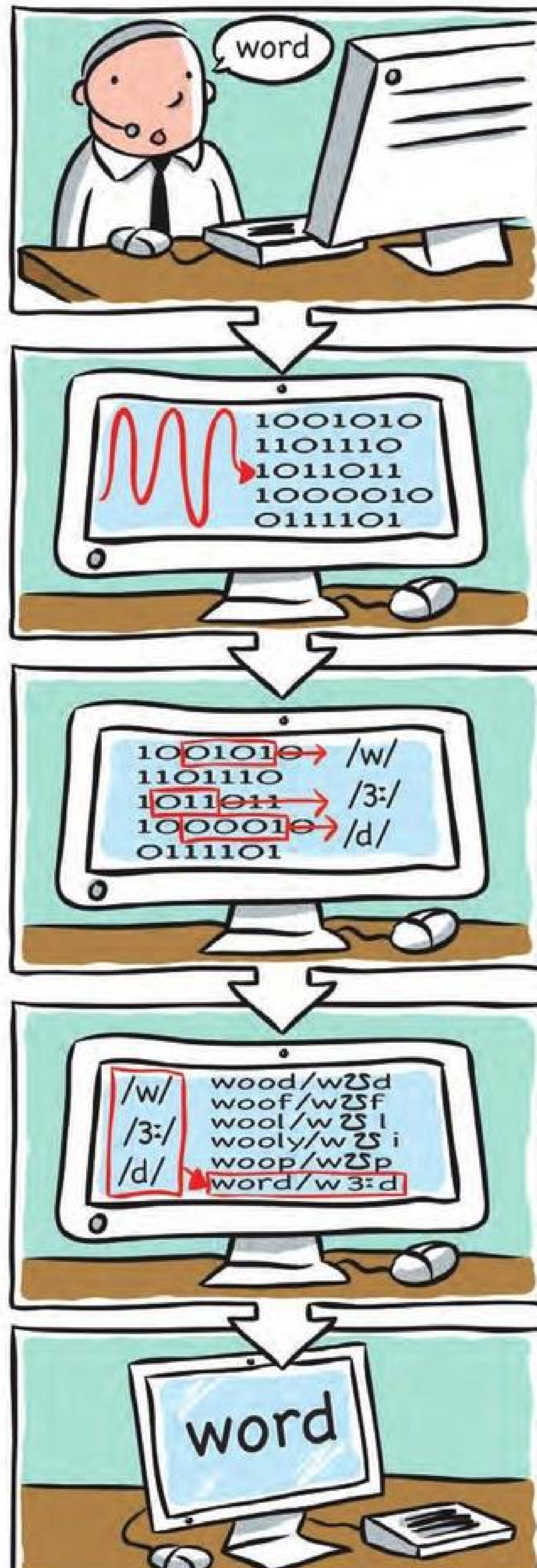
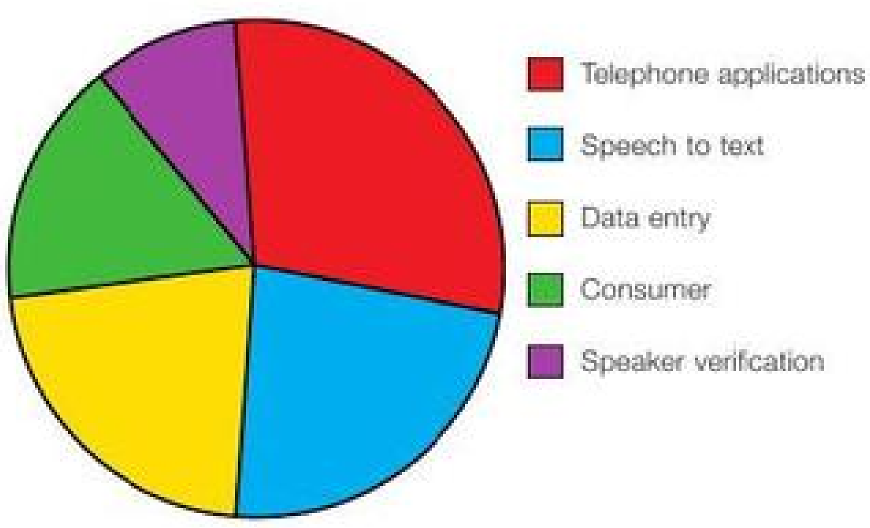


Figure 1

Technical report

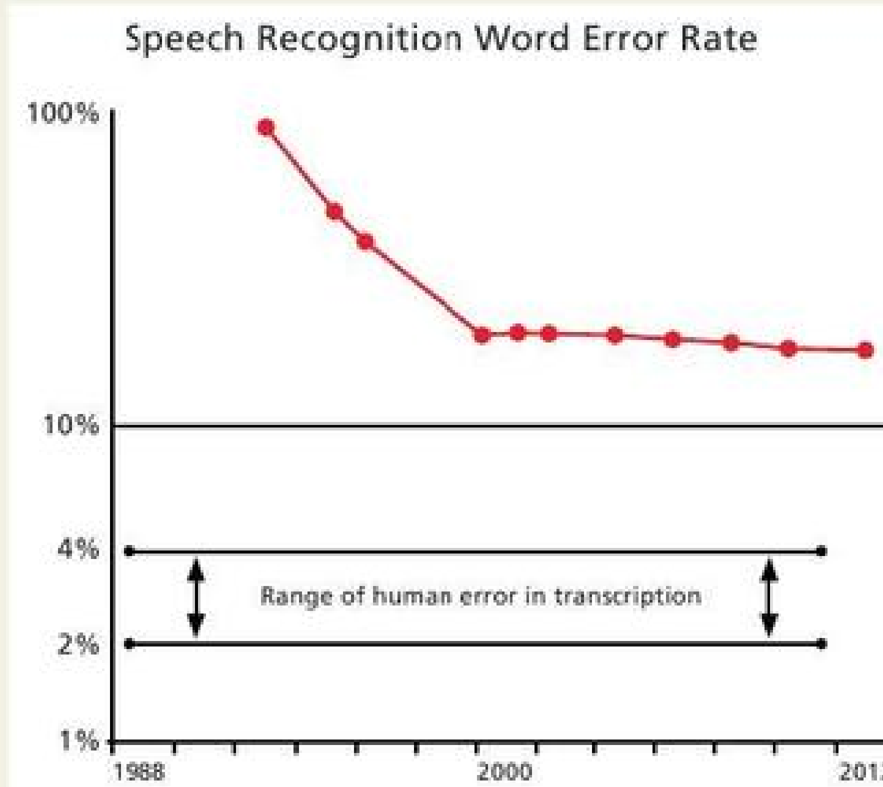


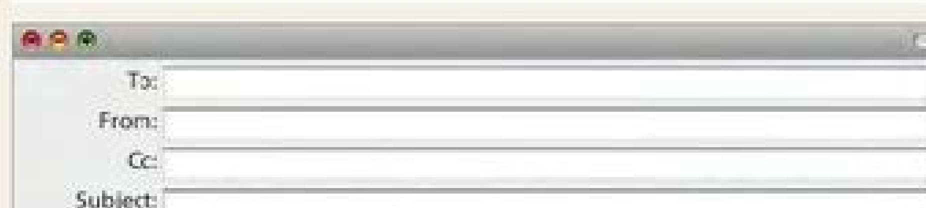
The idea that computers can understand spoken orders is fast becoming accepted technology and there is a growing market for software that can offer this. It is estimated that this market was worth $2.5 billion in 1998 and is set to increase. The diagram shows the relative importance of various sectors.

From voice recognition to artificial intelligence

It is believed that at some point in the future, speech recognition will transform into speech understanding. The software that allows computers to decode what someone has said may one day allow them to understand not just the words, but the meaning behind them. It's true that this will require more powerful computers and much more sophisticated software. But an enormous technological shift of this nature – and experts predict it will take at least 25 years – will transform the computers we use today into real thinking machines and make communication between humans and computers a two-way intelligent conversation.

Chris lost his voice at a bad moment





When I bought my new computer, it came with Windows Speech Recognition – and I'm using it right now to write this email. It isn't perfect but it's a fantastic improvement on the first speech recognition software I got 12 years ago. That was a real disaster! Now I don't have to write everything down – just correct the bits it gets wrong. I'm so tired of writing and writing! I'm going to upgrade to the next version when it comes out. They say it's much more accurate – within 99%, they say. Can that be true?! Have you heard anything about it? I think voice recognition technology must be one of the top greatest inventions of mankind...

Figure 2: Advantages and disadvantages of speech recognition technology

Vocabulary bank

Recognizing fixed phrases from electrical engineering (2)

Make sure you understand these phrases from signal processing.

active noise control
analogue filter
analogue signal processing
analogue to digital converter
band-elimination filter
binary form
compression phase
continuous time signals
dependent variable
destructive interference
digital signal processing
digital to analogue converter
discrete value
elastic wave
frequency domain
high-frequency sound waves
independent variable
integrated circuit chips
low-pass filter
noise-cancelling headphones
numerical calculations
passive soundproofing
periodic wave
phase cancellation
physical barrier
power line pick-up
pressure wave
random noise
rarefaction phase
speech recognition

Recognizing fixed phrases from academic English (2)

Make sure you understand these fixed phrases from general spoken academic English.

As we shall see, ...
But the real question is ...
From the point of view of ...
In a case like this, ...
In terms of ...
In the sense that ...
In this sort of situation, ...
That's the reason why ...
Increasingly, we find that ...
It could be argued that ...
It's true to say that ...
Many people think that ...
On the grounds that ...
On the one hand, ...
On the other hand, ...
Research has shown that ...
So it should be clear that ...
That would be great, except ...
To some extent ...
To start with, ...

Skills bank

Using the Cornell note-taking system

There are many ways to take notes from a lecture. One method was developed by Walter Pauk at Cornell University, USA.

The system involves **Five Rs**.

record Take notes during the lecture.

reduce After the lecture, turn the notes into one- or two-word questions which will help you remember the key information.

recite Say the questions and answers aloud.

reflect Decide on the best way to summarize the key information in the lecture.

review Look again at the key words and the summary (and do this regularly).

Recognizing digressions

Lecturers sometimes move away from the main point in a lecture to tell a story or an anecdote. This is called a **digression**. You must be able to recognize the start and end of digressions in a lecture.

Sometimes a digression is directly relevant to the content of the lecture, sometimes it has some relevance and sometimes, with a poor lecturer, it may be completely irrelevant. Sometimes the lecturer points out the relevance.

Don't worry if you get lost in a digression. Just leave a space in your notes and ask people afterwards.

Recognizing the start	*That reminds me ...*
	I remember once ...
	By the way, ...
Recognizing the end	*Anyway, where was I?*
	Back to the point.
	So, as I was saying ...

Understanding the relevance	*Of course, the point of that story is ...*
	I'm sure you can all see that the story shows ...
	Why did I tell that story? Well, ...

Asking about digressions	*What was the point of the story about the hospital that was closed?*
	Why did the lecturer start talking about note-taking?
	I didn't get the bit about ...

Referring to other people's ideas

We often need to talk about the ideas of other people in a lecture or a tutorial. We normally give the name of the writer and the name of the source. We usually introduce the reference with a phrase; we may quote directly, or we may paraphrase an idea.

Name and introducing phrase	*As Chen points out ...*
	To quote Chen ...
Where	*in* The Electrical Engineering Handbook ...
What	*we can think of noise reduction as ...*

10 ELECTRIC CARS

10.1 Vocabulary

'neutral' and 'marked' words • expressing confidence/tentativeness

A Study the words in box a.

1 Use your dictionary to find out the meanings.
2 What part of speech is each word?
3 How do we use them to talk about batteries?

a
charge discharge last lead-acid lifespan lithium power powerful recharge run store

B Read the Hadford University handout.

1 Use your dictionary or another source to check the meanings of the highlighted phrases.
2 Which are the stressed syllables in each phrase? Which two phrases have the same stress pattern?

C Look at the pictures on the opposite page.

1 What does each picture show?
2 For each picture, describe what is happening. Use the highlighted phrases from Exercise B and words from Exercise A.

HADFORD *University*

Problems with internal combustion engine cars

With the increase in petrol prices, the traditional car is becoming more and more expensive to run. In addition, there is the problem of pollution damage – in particular, air pollution. This consists of carbon emissions coming from a car's exhaust pipe as the fossil fuel is burnt, as well as non-climate damage occurring, for example, as a side-effect of the manufacturing process.

D Study the words in box b.

1 Check the meanings, parts of speech and stress patterns.
2 Put the words into the correct box in the table below, as in the example.

b
brilliant collapse enormous huge insignificant massive minimal outstanding plummet plunge rocket significant slump soar superb tremendous

Neutral	Marked
rise, increase	rocket, soar
fall, decrease	
big, large	
good	
small	

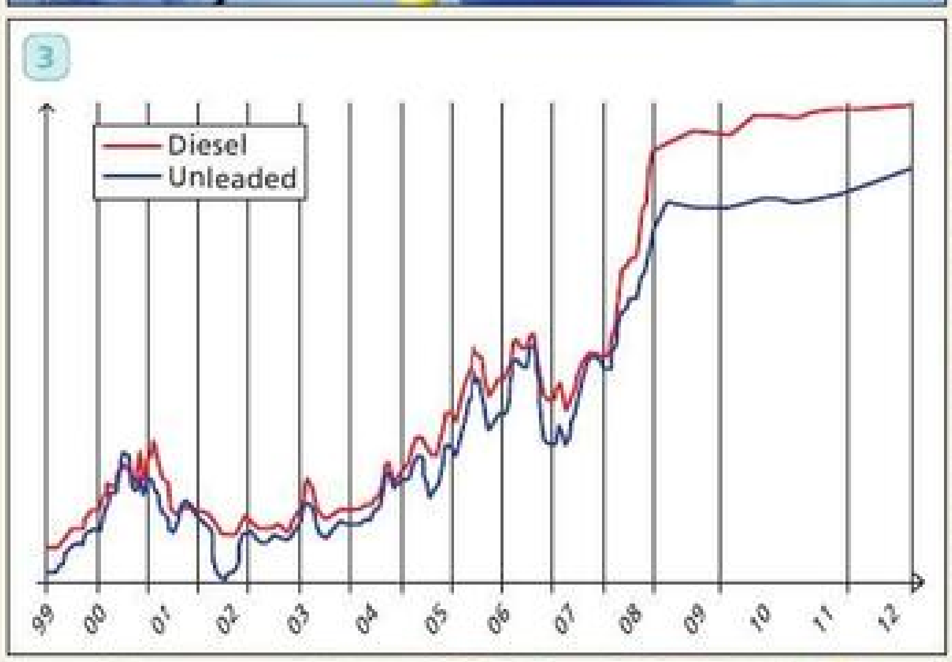
E Read the extract from ElectroCar's webpage about its new lithium battery.

1 Use a marked word in place of each of the blue (neutral) words.
2 Look at the red phrases. How strong or confident are they?

ElectroCar – which battery?

It's clear that lead-acid batteries, with their short lifespan, were completely unsuitable for electric cars. It's fair to say that nickel-cadmium batteries were a big improvement when they appeared in the 1990s, but their 'memory effect', resulting in a large drop in voltage, was a big disadvantage. It was unlikely that this type of battery could ever work in a car. Some people think there may be developments to come but it's generally accepted that this is unlikely.

After years of research, we have undoubtedly found a good solution: lithium batteries. With their big charge capacity, you can be confident that there will be no decrease in power due to memory loss. This could be the solution to the electric-car battery problem.


Diesel
Unleaded
99
00
01
02
03
04
05
06
07
08
09
10
11
12


lead-acid
nickel-cadmium
lithium
Time
Charge


AA
DURACELL
PLUS POWER
LONG LASTING POWER GUARANTEED
12 BATTERIES

10.2 Reading

identifying stance and level of confidence • inferring implicit ideas

A Study the sentence on the right. Each phrase in box a could go in the space. What effect would each one have on the base meaning? Mark from *** = very confident to * = very tentative.

> The use of electric cars
>
> ____________________
>
> a reduction in pollution damage.

a

- probably caused ____
- may have contributed to ____
- was possibly one of the factors which contributed to ____
- could have been a factor which led to ____
- caused ____
- seems to have caused ____

B Survey the text on the opposite page.

1. What will the text be about?
2. Write three research questions.

C Read the text. Does it answer your questions?

D Answer these questions.

1. Is the writer for or against electric cars?
2. Why does the article talk about batteries so much?
3. What advantages and disadvantages of lithium batteries does the article mention?
4. Which is the writer more worried about: the carbon emissions, or the non-climate damage, of electric cars?
5. In what ways does an electric car pollute?

E Find the phrases in box b in the text. Is the writer *confident* (**C**) or *tentative* (**T**) about the information which follows?

b

- Much of the data available suggests ... ____
- Experts seem to agree ... ____
- many people have claimed ... ____
- the evidence does not support ... ____
- It is obvious ... ____
- A recent study has found ... ____
- It appears to be the case ... ____

F Look at the writer's description of the recent interest in electric cars (paragraph 1, sentences 1–3).

1. Underline the marked words.
2. What does the choice of these words tell you about the writer's opinion of electric cars?
3. Find neutral words to use in their place.

G Study the example sentence on the right, and then sentences A and B.

1. Divide sentences A and B into small parts, as in the example sentence.
2. Underline any linking words (e.g., conjunctions).
3. Find the subjects, verbs, objects/complements and adverbial phrases which go together.
4. Make several short, simple sentences which show the meaning.

Example:

> Sales of electric cars | have rocketed | over the past few years | <u>because</u> | according to some commentators | they | are | the perfect answer to many of the problems of modern life.

A

> Operating electric cars produces few or no emissions, but producing the electricity to power them currently relies heavily on fossil fuels.

B

> Some electric cars also have a system called regenerative braking, in which some of the energy lost as the car brakes can be sent to and stored in the battery.

Are electric cars greener?

1 Recently there has been a huge interest in electric cars. Sales have rocketed over the past few years because, according to some commentators, they are the perfect answer to many of the problems of modern life. They offer outstanding savings in terms of running costs as petrol prices soar, and a tremendous contribution to reducing air pollution. But is this true? Much of the data available suggests that electric cars are more environmentally friendly than petrol- or diesel-driven cars. But some people question this data and say there is little difference between the two types of car in terms of the pollution damage they create. So who's right?

2 First, let's look at the most important part of an electric car – the battery. All cars have a battery, but in traditional cars it is only used to start the car and run some of the accessories, such as the cigarette-lighter. In an electric car, on the other hand, the battery is the only source of power and runs everything, including the engine. Clearly, this kind of battery needs to be powerful so the driver can travel wherever he or she wants to go – and return home. It must also be possible to recharge the battery again and again. For many years, this sort of battery simply did not exist. But now, new technology has made it possible: a lithium battery can be strong enough to power a car, and on a single charge, an "80-mile range is achievable ... with careful driving [1]."

3 Experts seem to agree that lithium batteries have a lot of advantages over traditional lead-acid batteries. They hold their charge, losing only about 5% per month. Unlike other rechargeable batteries, they don't need to be completely discharged before recharging. They can also be recharged hundreds and hundreds of times, with no side-effects.

4 However, there are a number of problems with lithium batteries. A battery big enough to power an electric car is very heavy, sometimes over 400 kg. In addition, this sort of battery costs a lot of money, so electric cars tend to cost considerably more than internal combustion engine cars. Lithium batteries also have a lifespan which is shorter than the car's, and it can be difficult to calculate exactly how long they will last [2]. Finally, recharging this sort of battery takes a considerable time, around 4 hours – certainly much longer than filling the car with petrol, and it can be difficult to find somewhere to do this if you are not at home.

5 Despite these drawbacks, many people have claimed that electric cars are a better choice because they produce less pollution and can help reduce carbon emissions. But the evidence does not support this belief. It is obvious that while the car is moving, there are no fumes coming out of an exhaust pipe. However, the electricity used to recharge the battery must come from somewhere and that probably involves burning fossil fuels. As a recent report states, electric cars "... have somewhat higher damages and global-warming potential than other technologies ... in large measure due to the continued conventional emissions from the existing and likely future grid [3]." So if an electric-car owner uses electricity from the national grid, it may pollute more than a traditional petrol-driven car. Some writers argue that electric cars are greener because their engines are much more efficient than those in traditional cars: an overall efficiency of 48%, compared to 25% for petrol cars [4]. Some electric cars also have a system called regenerative braking, in which some of the energy lost as the car brakes can be sent to and stored in the battery. One manufacturer claims that up to 64% of this energy can be recovered in this way [5].

6 However, apart from power generation, there are other hidden sources of pollution that need to be considered, such as in the manufacture of the battery and electric motor. And this pollution may involve not just carbon emissions. A recent study has found that battery manufacture "poses issues of worker exposure to metals as well as a potential for both conventional and greenhouse gas emissions from the manufacturing process [3]." The hidden costs of using electric vehicles mean that the overall costs may not be significantly different from those for other fuel types after all.

7 It appears to be the case, then, that developments in electric cars need to go hand in hand with new technologies that help produce cleaner energy. Otherwise, there is a danger that electric cars will only give the impression of being green.

10.3 Extending skills

types of writing • situation–problem–solution–evaluation essays

A Read the three writing assignment titles. What types of writing are they?

1. Compare the internal combustion engine car and the electric car.
2. What are the main elements of an electric car?
3. Consider the reasons why sales of electric cars have not yet overtaken those of petrol-driven cars.

B Look at text A on the opposite page. Copy and complete Table 1.

C Look at text B on the opposite page. Copy and complete Table 2.

D Look again at the solutions in Exercise B (Table 1). What are their possible advantages and disadvantages?

E Read the title of writing assignment 3 again.

1. Make a plan for this piece of writing.
2. Write a topic sentence for each paragraph of the body of the text.
3. Write a concluding paragraph.

Table 1

Situation	
Problem	
Solutions	

Table 2

Solution	
Arguments for	
Arguments against	

10.4 Extending skills

writing complex sentences • references • quotations

A Expand these simple sentences. Add extra information. Use the ideas in Lesson 10.3.

1. There has been an increase in interest in electric cars recently.
2. Electric cars have powerful batteries.
3. There have been some key developments in battery technology.
4. Electric cars may initially appear green.
5. Electric cars may cause more non-climate damage than conventional cars.
6. Batteries for electric cars have several important disadvantages.

B Look at text C on the opposite page. Copy and complete Tables 1–3.

C Look at text D on the opposite page.

1. Complete a further row of Table 1.
2. How could you write this as a reference?

D What do the abbreviations in the blue box mean?

E Look back at the text on page 81 (Lesson 10.2).

1. Find all the research sources ([1] to [5]).
2. Mark the page numbers for the books next to the correct reference in the list (C) on the opposite page.
3. What punctuation and formatting is used before and within each direct quote? Why?
4. What phrases are used to introduce each direct quote? Why does the writer choose each phrase?

Table 1: *Referencing books*

Author(s)	Place	Publisher	Date

Table 2: *Referencing journals*

Name of journal	Volume	Pages

Table 3: *Referencing websites*

Retrieval date	URL

© cf. edn. ed(s). et al. ibid.
n.d. op. cit. p. pp. vol.

A

Nicholas Fisk
New member

Hi everyone! I've got a bit of a problem. I use my car to travel to work and back every day. I live outside town, and the round trip is about 70 km. I recently bought an electric car – I thought it would be perfect for the sort of driving that I have to do. I was told that on a full battery it could do up to 100 km, so that was fine. But I'm finding that, as I arrive home in the evening, the battery is really low. Last week, there was a lot of traffic, and I thought I wasn't going to make it home! I've phoned the car dealer, and he told me not to worry because the charge gradually increases during the first few weeks – it takes a bit of time to reach its maximum value. Otherwise, he suggested recharging the battery at work during the day – but that isn't going to be easy. What you all think? Any ideas?

Source: www.electriccarforum.uk

B

It is not clear whether electric cars that use electricity from the national grid to recharge their batteries are in fact any cleaner than normal petrol-driven cars. As a result, some researchers are looking at the possibility of designing a solar-powered vehicle, with photovoltaic solar panels placed on its rooftop. This would appear to be a very attractive solution. The vehicle uses clean renewable energy, and this is clearly a great advantage over rechargeable electric cars. However, there are some serious disadvantages, apart from the obvious one that sun is needed for the vehicle to work. Photovoltaic cells are not particularly efficient, with only around 30% of the incoming solar energy being converted into usable power. This results in much less power than a normal petrol-driven engine. "An entire … rooftop covered in photovoltaic cells could only generate a tiny fraction of the energy needed to propel the car 33.4 miles – the average distance an American drives in a ay."(Banholzer) One solutions would be to make the car extremely light, carrying only one passenger, with no luggage. However, no solar-powered cars have entered commercial production so far.

C

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D

ELECTRIC CARS

The Greener Choice?

Brian Venture

Wentworth & Bourne

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Vocabulary bank

Recognizing fixed phrases relating to electric cars

Make sure you understand these key phrases connected to electric cars, their technology and related issues:

air pollution
carbon emissions
clean energy
electric car
electric motor
environmentally friendly
fossil fuel
lead-acid battery
lifespan
lithium battery
manufacturing process
new technologies
non-climate damage
petrol-driven car
petrol prices
pollution damage
rechargeable battery
regenerative braking
side-effect

Recognizing fixed phrases from academic English (3)

Make sure you understand these key phrases from general academic English.

One of the …
In some circumstances, …
Even so, …
… , as follows: …
The writers assert/maintain/conclude/ assume/state/agree/suggest that …
In this sort of situation …
It is obvious/clear that …
It appears to be the case that …
The research/A survey found that …
Research has shown …
The evidence does not support this idea.

Recognizing levels of confidence in research or information

In an academic context, writers will usually indicate the level of confidence in information they are giving. There is a strong tendency also for writers to be tentative when stating facts.

Examples:
It appears to be the case that … / This suggests that … **(tentative)**
The evidence shows that … / It is clear that … **(definite/confident)**

When you read a 'fact' in a text, look for qualifying words before it, which show the level of confidence.

Recognizing 'marked' words

Many common words in English are 'neutral', i.e., they do not imply any view on the part of the writer or speaker. However, there are often apparent synonyms which are 'marked'. They show attitude, or stance.

Examples:
*Petrol prices **rose** by 10% last year.* **(neutral)**
*Petrol prices **soared** by 10% last year.* **(marked)**

Soared implies that the writer thinks this is a particularly big or fast increase.

When you read a sentence, think: *Is this a neutral word, or is it a marked word? If it is marked, what does this tell me about the writer's attitude to the information?*

When you write a sentence, think: *Have I used neutral words or marked words? If I have used marked words, do they show my real attitude/the attitude of the original writer?*

Extend your vocabulary by learning marked words and their exact effect.

Examples:

Neutral	Marked
go up, rise, increase	*soar, rocket*
go down, fall, decrease	*slump, plummet*
say, state	*assert, maintain, claim, argue, allege*

Skills bank

Identifying the parts of a long sentence

Long sentences contain many separate parts. You must be able to recognize these parts to understand the sentence as a whole. Mark up a long sentence as follows:

- Locate the subjects, verbs and objects/complements by underlining the relevant nouns, verbs and adjectives (where they are the complements).
- Put a dividing line:
  - at the end of a phrase which begins a sentence
  - before a phrase at the end of the sentence
  - between clauses
- Put brackets round extra pieces of information.

Example:

However, apart from power generation, there are other hidden sources of pollution that need to be considered, such as those involved in the manufacture of the battery and electric motor.

(However,) (apart from power generation,) | there | are | other hidden sources of pollution | that | need to be considered, | (such as | those involved in the manufacture of the battery and electric motor).

Constructing a long sentence

Begin with a very simple SV(O)(C)(A) sentence and then add extra information.

Example:

	Electric cars		need	batteries		
As most people realize,	*electric cars*	*on our roads today generate*	*all need*	*batteries,*	*which use electricity,*	*probably produced by burning fossil fuels.*

Writing a bibliography/reference list

The APA system is probably the most common in the social sciences. Information should be given as shown in the following source references for a book, an Internet article and a journal article. The final list should be in alphabetical order according to the family name of the writer. See the reference list on page 83 for a model.

Author	Date	Title of book	Place of publication	Publisher
L. A. A. Warnes,	2002.	*Electronic and Electrical Engineering.*	Basingstoke:	Palgrave Macmillan.

Writer or organization	Title of Internet article	Full URL	Date accessed	Date
J. S. Dhulipala,	Electrical engineering: Its applications in various fields.	Available: http://www.suite 101.com/content/electrical-engineering-a16669	[Accessed Feb. 14, 2014.]	2007.

Author	Title of article	Title of journal	Volume and page numbers
L. Herous, A. Benretem, I. Meghlaoui, and D. Khalfa,	Influence of wind speed on the conversion system of a low power wind turbine.	*Harvard Business Review,*	vol. 10, pp. 164–169. 2010.

More information on the IEEE referencing system can be found at: www.ieee.org/documents/ieeecitationref.pdf

11 MICROELECTROMECHANICAL SYSTEMS

11.1 Vocabulary linking ideas

A Look at the diagram on the opposite page.

1. Put the following devices under the correct heading: light bulb, hairdryer, bicycle, washing machine, gun, TV aerial.
2. Give more examples of each type of device.
3. For the electromechanical devices, what are the electrical and mechanical components?

B Study the linking words and phrases in box a.

1. Put them into two groups for:
   - **a** discussing reasons and results
   - **b** building an argument
2. Is each linking word used to join ideas:
   - **a** within a sentence?
   - **b** between sentences?
3. Can you think of similar linking words?
4. Put the linking words from question 1b in a suitable order to list points in support of an argument.

C Study the words in box b.

1. Sort the words into two groups according to whether they are concerned with *size* or with a *component of a mechanical device*.
2. Are the words nouns, verbs or adjectives? What are their stress patterns?
3. What other words or phrases have the same meaning?

D Read the text on the right.

1. Complete each space with a word or phrase from box a or box b. Change the form if necessary.
2. Can you think of other words or phrases with the same meaning as the blue words?
3. Match the phrases below with a later phrase that refers back to them.

   Example:
   animals – *these unwanted creatures*

E Do the general knowledge quiz on the opposite page.

a

another point is as a result
because finally firstly for example
in addition moreover
one result of this is secondly since so

b

base cantilever fraction hinge
huge layer mask mass
massive microscopic mirror screen
small spring surface tiny

c

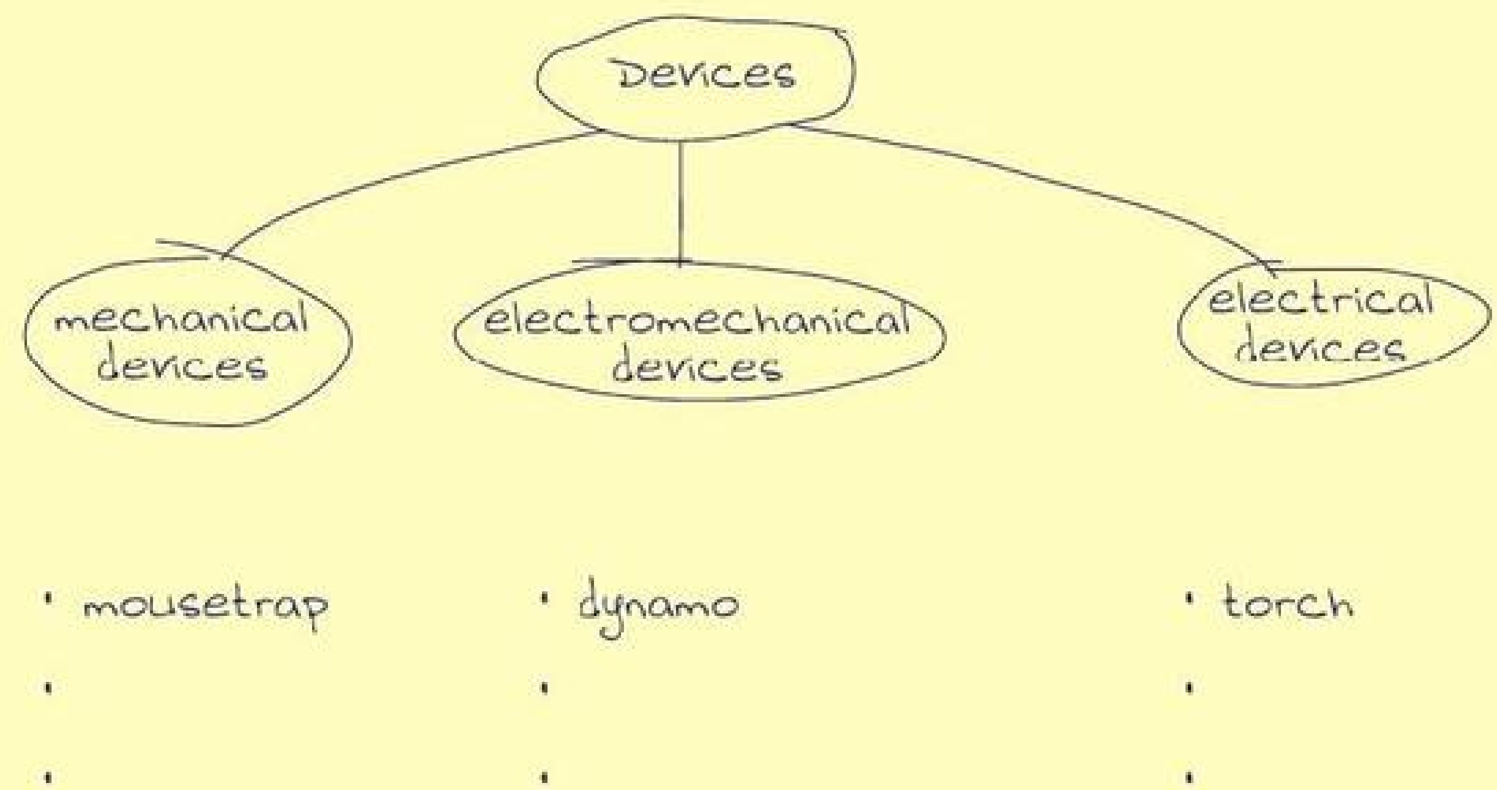
animals inventions traditional
mechanical trap a mouse
glue trap stuck

The design of mousetraps

Removing ______ animals from buildings has been a ______ problem for many people throughout history. ______ , there have been many different inventions to deal with these unwanted creatures. The two main designs are as follows.

______ , there is the traditional *mechanical trap*. In this device, a heavy wire ______ , placed on a wooden ______ , is pulled open and secured so the attached ______ cannot pull it closed. When a mouse steps on the trap, the animal's ______ on a sensor plate causes the trap to shut in a ______ of a second. Consequently, the mouse is killed instantly.

______ , there is the more recent *glue trap*. In this design, a ______ of glue is spread on a ______ , such as a tray. Food, for example, a piece of cheese, can be placed on this. When the animal walks on the glue, it gets stuck. ______ it cannot move, it is easily found and removed. ______ that the animal can suffer ______ it may not die immediately. ______ , the trap can only be used indoors. These two drawbacks may explain why the traditional mechanical trap is still the most popular.



HADFORD University

General Knowledge Quiz

1 Give an example of:

a photosensitive material
b a form of radiation
c an acid
d a light source
e an image
f a pattern
g dissolving
h a gas
i a reflection
j a shade of colour

2 What are these?

a silicon
b X-rays
c an electron beam
d an accelerometer
e an airbag
f a projector
g a car tyre
h a hearing aid

11.2 Listening

recognizing the speaker's point of view • making notes • writing up notes

A You are going to listen to a lecture by a guest speaker in the Electrical Engineering faculty at Hadford University. Look at the poster on the right.

1 What is the lecture going to be about?

2 Decide on how you are going to make notes. Prepare a page in your notebook.

B Listen to Part 1 of the lecture and make notes.

1 What do MEMS and NEMS stand for?

2 What are the two main types of MEMS?

3 What is special about them?

4 In which devices can you find them?

C Listen to Part 2 of the lecture and make notes.

D Using your notes, answer the questions in the handout on the right.

E Refer to the model Cornell notes on page 107.

1 Check your answers with the model.

2 Complete the *Review* and *Summary* sections of the Cornell notes.

F The lecturer talks about the influence that MEMS have had on electrical engineering. Listen again to part of the lecture. Which words tell us whether the information is fact or opinion?

G Study the phrases in the blue box. Which type of information below follows each phrase in the blue box? Listen to some sentences from the lecture.

- restatement
- definite point
- summary of a source
- example
- statement of a topic
- another point
- tentative point
- clarification
- purpose for speaking

H Write out one section of your notes in complete sentences.

See *Skills bank*

HADFORD *University*

Visiting Speaker: Dr Mary Myatt

15th February 5:00 p.m.

'Electromechanical systems at the *micro* and *nano* levels'

Dr Myatt will look at these fascinating devices which are already being used in a wide range of different areas.

1 What are the two main processes in the manufacture of MEMS?

2 What application of MEMS did the lecturer mention first?

3 What are the component parts of the MEMS used in this application?

4 What improvements have MEMS brought to this application?

5 What was the second application of MEMS the lecturer mentioned?

6 What are the component parts of the MEMS used in this second application?

7 What improvements have MEMS brought to this application?

8 In which ways does the lecturer believe that MEMS are an important development in electrical engineering?

1 that is to say, ...
2 To some degree, ...
3 don't misunderstand me, ...
4 it is fair to say that ...
5 in an attempt to ...
6 ... gave a description of ... in ...
7 Briefly, he explained how ...
8 with respect to ...
9 she has no doubt that ...
10 ... is a case in point.
11 Not only that, but ...
12 to the extent that ...

11.3 Extending skills

stress in phrases • building an argument

A Study the phrases in box a.

1 Mark the stressed syllables in each phrase.
2 Listen and check your answers.
3 Which phrases have adjective + noun? Which word has the stronger stress in these phrases?

B Look at the topics below.

- nanoelectromechanical systems
- problems of implementation
- potential of NEMS

1 What would you like to know about these topics?
2 Prepare a page in your notebook to make some notes.
3 Listen to the final part of the lecture (Part 3) and make notes. If there is information which you miss, leave a space.
4 Compare your notes with someone else's. Fill in any blank spaces.

C Answer the questions in the Hadford University handout, using your notes.

D Study the stages of building an argument (a–f) in box b.

1 Put the stages in an appropriate order.
2 Match each stage (a–f) with a phrase from box c.

E Look at box b again.

1 Listen to a section from the lecture. Make notes on what the lecturer says for each stage of the argument (a–f).
2 Check your answers to Exercises D and E1.

F Use your notes to write 75–100 words about the main points in the final part of the lecture.

G In groups, discuss the research task set by the lecturer. Talk about these questions:

1 What three devices did the lecturer mention?
2 Which one will you choose?
3 What ideas do you already have?
4 What kind of information will you need to find?
5 Where can you go to find more information?

Report back to the class on your discussion. In Lesson 11.4 you will take part in a seminar on this topic.

a

building blocks
carbon nanotubes
car crash sensor
chemical properties
current density
digital switch
electromechanical device
integrated system
manufacturing processes
weighing device

HADFORD *University*

1 What do NEMS have in common with MEMS?
2 What is the main use of NEMS?
3 Can NEMS be manufactured in a similar way to MEMS? Why or why not?
4 What are carbon nanotubes?
5 How can they be used as NEMS?
6 What are the disadvantages of carbon nanotubes?
7 What is your research task?

b

a giving a counter-argument
b giving your opinion
c stating the issue
d supporting the reason with evidence
e rejecting a counter-argument
f giving a reason for your opinion

c

It's quite clear that …
The question is …
Research has concluded that …
I'm afraid that just isn't true.
Some people claim …
The evidence lies in the fact that …

11.4 Extending skills

stress in phrases • making effective contributions to a seminar

A Study the terms in box a.

1 Explain the meaning of the terms.

2 Mark the main stress in each term.

B Study the words in box b. Match the words in columns 1 and 2 to make phrases.

b 1	2
blood	health
developing	microchip
global	infection
HIV	process
roll-over	test
semiconductor	centimetres
square	world
testing	bar

C Study the MicroLabs web page on the opposite page.

1 What is a lab-on-a-chip, do you think?

2 What are the benefits of a lab-on-a-chip? Use the diagram on the web page to help you.

3 What do you think the blood, urine and saliva tests are used for?

4 Why do you think new drugs are tested using a lab-on-a-chip?

5 What other applications can you think of for a lab-on-a-chip?

D Study the phrases in box c.

1 For what purpose would you use these phrases in a seminar?

2 Which phrases can you use for linking your new point to a contribution by another speaker?

E Listen to some students taking part in a seminar. They have been asked to research lab-on-a-chip technology. While you listen, make a note of:

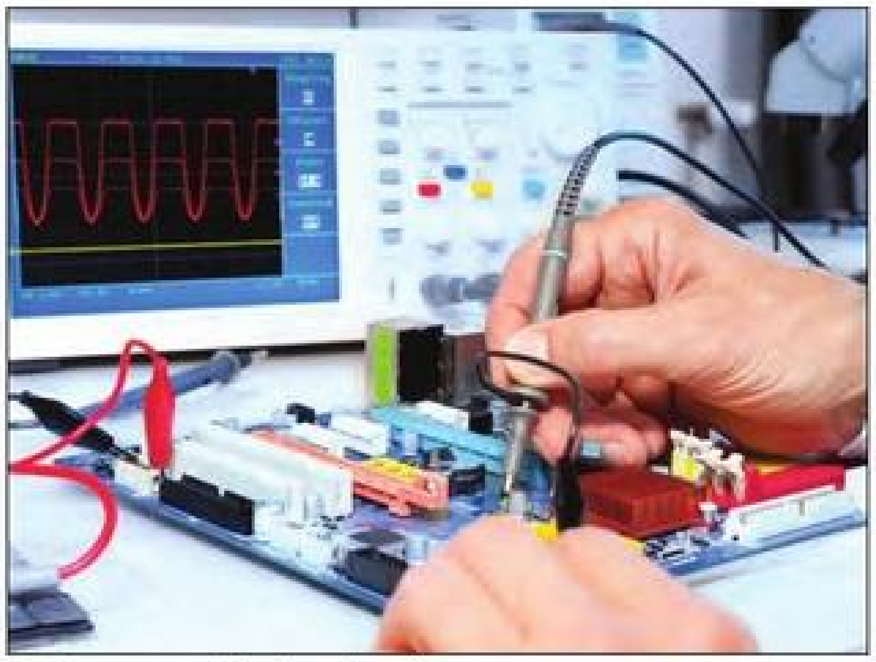
1 the main topic of each extract

2 further details of each topic

F Discuss your findings on your chosen MEMS device with your group. One person from the group should report the conclusions of the discussion to the class.

a

better process control
blood pressure sensor
conventional laboratory methods
lower manufacturing costs
open-top sports car
typical semiconductor processing
white blood cells



Lab-on-a-chip technology

c

I'd like to start by explaining ...

To carry on from this first point, I want secondly to look at ...

I don't think that is the main reason.

That seems like a very good point X is making.

I'm going to expand the topic by mentioning ...

On the other hand, you might want to say that ...

As well as this issue, we can also look at a very different issue.

So to sum up, we can say that ...

Does anybody have any opinions or anything they would like to add?

I think we need a different viewpoint.

OK, to continue then ...

Following on from what X has said ...

Micro Labs

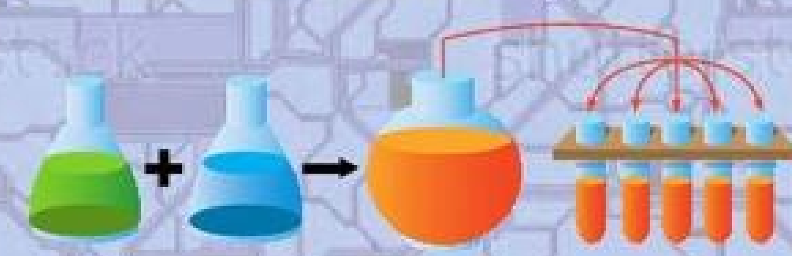
supplier of high-quality lab-on-a-chip components

Home | Products | Promotion | Innovation | Help | Contact us

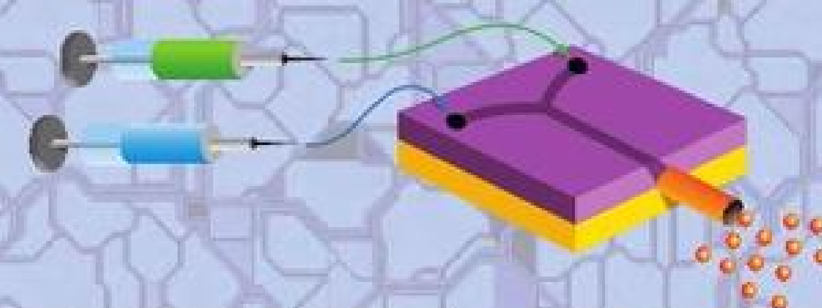
Who we are:

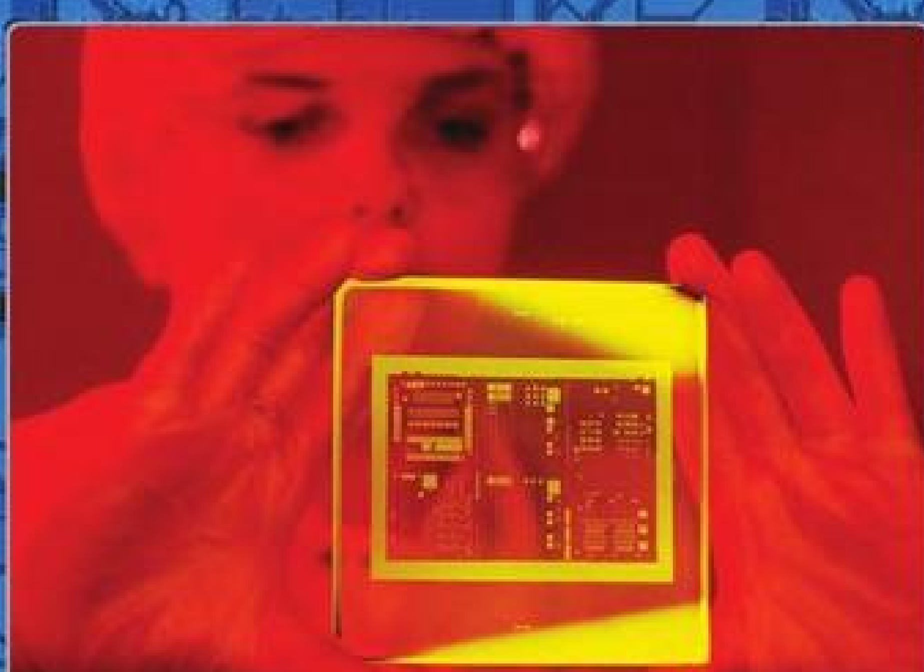
MicroLabs has been manufacturing glass-based lab-on-a-chip products for more than ten years. MicroLabs has extensive experience in micromachining and microfluidics, and is an important supplier of microfluidic devices to a wide range of markets. MicroLabs provides high-quality lab-on-a-chip components for analytical instrumentation. We also carry out research and development for science and industry.

Traditional laboratory



Lab-on-a-chip





Some of the most important applications of our lab-on-a-chip devices are:

1 Instant blood tests / urine tests / saliva tests

2 Testing new drugs

3 Other applications

Advantages of lab-on-a-chip technology

- less waste
- faster analysis
- improved process control
- lower manufacturing costs
- safer chemical studies
- compact systems

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Vocabulary bank

Linking words

We use linking words and phrases to join ideas together in a sequence, to show how the ideas are related.

Some linking words can be used to join independent and dependent clauses in a sentence.

Examples:

*A TV aerial isn't a mechanical device, **because** there are no moving parts.* OR ***Because** there are no moving parts, a TV aerial isn't a mechanical device.*

Other linking words join sentences in a text.

Example:

*A hairdryer is powered by electricity, but has some moving parts. **As a result**, it is an electromechanical device.*

When building an argument, it is a good idea to use linking words to add points:

Examples:

Firstly, ...
For example, ...
Another point is ...
Secondly, ...
In addition, ...
Moreover, ...
... whereas ...
Finally, ...

Using words with similar meanings to refer back in a text

It is a good idea to learn several words with similar or related meanings. We often build cohesion in a text by using different words to refer back to something previously mentioned.

Examples:

First mention	Second mention	Third mention	Fourth mention
small animals	*unwanted creatures*	*mice*	*they*
invention	*design*	*trap*	*device*

Recognizing fixed phrases from academic English (4)

In Units 7 and 9, we learnt some key fixed phrases from general academic English. Here are some more to use when speaking.

Don't misunderstand me.
I'm afraid that just isn't true.
In an attempt to ...
... is a case in point ...
Not only that, but ...
Some people say ...
The effect of ...
The history of ...
The presence of ...
There is a correlation between ... and ...
To some degree ...
To the extent that ...
What's more ...
With respect to ...

Skills bank

Writing out notes in full

When making notes we use as few words as possible. This means that when we come to write up the notes, we need to pay attention to:

- the use of numbers and symbols for words and ideas, e.g.,

  Notes: (a) Deposition stage: thin layers of material deposited on base

  In the first stage, *known as deposition, thin layers of material are deposited on a base.*
- making sure the grammatical words are put back in, e.g.,

  Notes: Photosensitive layer → masked

  This *photosensitive layer* ***is*** *masked.*
- making the implied meanings clear, e.g.,

  Notes: Advantage of MEMS = ↑ image quality

  The main *advantage of MEMS in this device is the* ***improved*** *image quality* ***that is achieved.***

Building an argument

A common way to build an argument is:

1. First, state the issue:
   How small can MEMS be built?
2. Next, give a counter-argument:
   Some people claim there is no limit.
3. Then give your opinion:
   I'm afraid that just isn't true.
4. Then give evidence for your opinion:
   The main problem is with the transduction element of the system.

Linking to a previous point when your contribution is new

When you want to move the discussion in a new direction, introduce your comments with phrases such as:

Following on from what X said, I'd like to talk about ...
I'm going to expand the topic by mentioning ...
As well as internal migration, we can also look at a very different sort of issue.

Summarizing a source

When we talk about the ideas of other people in a lecture or a seminar, we often give a summary of the source in a sentence or two.

Examples:

A book by (name of writer) *called* (name of book) *published in* (year) *gives an explanation of how ...*

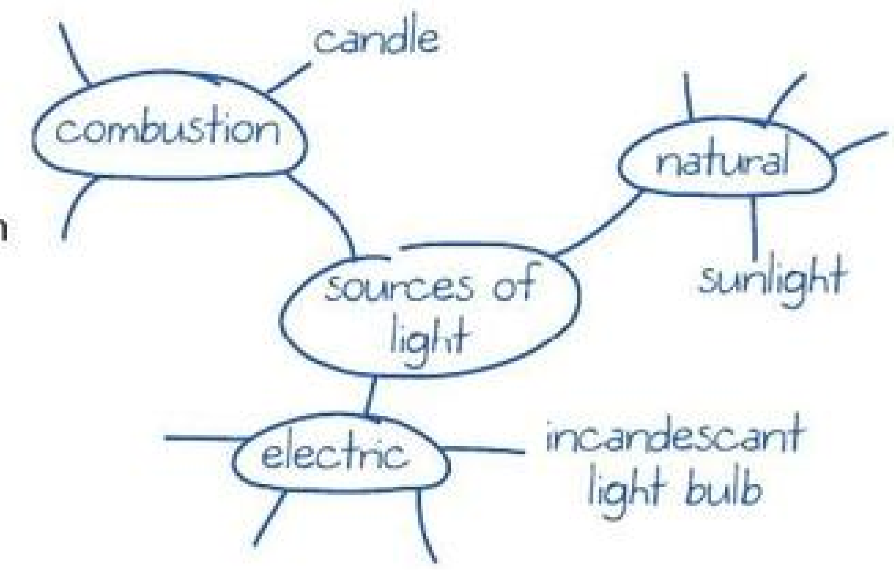
Briefly (name of writer) *explains how ...*

An introduction to (topic) *can be found in* (name of writer).

12 LIGHTING ENGINEERING

12.1 Vocabulary

linking ideas • referring back



A Look at the spidergram on the right.

1. What other sources of light do you know? Add them to the appropriate category.
2. Look at the figures on the opposite page. What sources of light do they show? Add them to the appropriate category on the spidergram.

B Study the words in box a.

1. What part of speech is each word?
2. Copy and complete the table with other forms for each word.
3. Group the words according to their stress pattern.
4. Which words have a connection with lighting?

Noun	Adjective	Verb
installation, installer	installed, installing	install

a

artificial colour diffuse domestic efficient emit fixture installation power reliable visible

C Read the LEA text on the opposite page.

1. What type of text is it?
2. Check the meanings of any unfamiliar words.
3. Look at the highlighted words. Connect each word or phrase to a noun or idea it refers back to.

Example: *the book* refers to the previously mentioned *text*

D Read the text on the right.

1. What part of speech is each blue word?
2. Find synonyms for the blue words. Use a dictionary if necessary.
3. What is the function of the red words and phrases?

E Look at Figure 1 on the opposite page.

1. What does the graph show?
2. What are the implications of this?
3. Which text from Exercises C and D does the graph illustrate?

F Study the verbs in box b. What are the noun forms?

G Look at Figure 2 on the opposite page.

1. What does the diagram show?
2. Look at the notes below the diagram describing the process. Do they use the active or the passive form? Discuss the process in pairs.
3. Write a short paragraph, using ideas from your discussion. Use the passive form of verbs where appropriate.

Lighting technology: The fourth generation

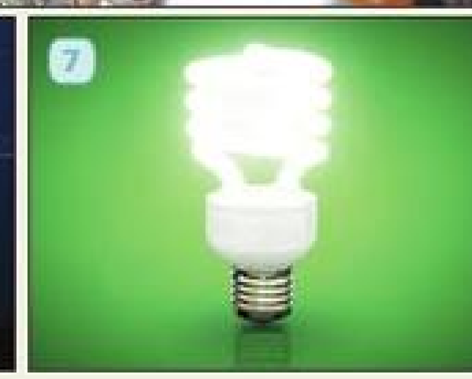
The world's population is increasing sharply, and more and more people want to work and continue social activities when the sun has gone down. This means that there has been a steady increase in the demand for artificial lighting. Initially, this was achieved using combustion sources, such as candles and gas lighting. Then the incandescent light bulb was invented and this soon became the world's most common source of light. However, the filament light bulb has many drawbacks: most importantly, it consumes a lot of electricity.

One of the main alternatives to the incandescent bulb is fluorescent lighting. Fluorescent lamps became available in the 1930s, and it soon became clear that they had several significant advantages over incandescent bulbs. Firstly, they are more efficient, converting more of the input power to visible light. Secondly, they last longer provided they are not switched on and off too often. Fluorescent lamps are long, thin tubes, so have a very different shape from traditional bulbs, but more recently more compact ones have been made which resemble traditional incandescent lamps.

A more recent invention is the light-emitting diode, or LED. After candles, incandescent bulbs and fluorescent lamps, LEDs are seen as the fourth generation of lighting technology. They are rapidly becoming a valid alternative due to their considerable advantages over other sources of light. According to a Japanese market research firm, LED sales are beginning to overtake sales of fluorescent and filament lamps.

b

change collide create emit flow hit move release



www.lightingengineeringassociation.com/reports&publications/finding-alternatives-to-incandescent-light

LEA Lighting Engineering Association

Reports and Publications

Light Years Ahead: Finding alternatives to incandescent light** by **Marion Martin
Published by Hadford University Press, 2014.

Light Years Ahead is an essential text for lighting engineers and those wishing to specialize in the field. The main thesis of the book, as the title suggests, is that we need to explore alternative light sources for homes and industry. In this respect, Martin argues that the lighting industry must consider two factors equally: the economic and the environmental costs. The scope of the book is ambitious, linking all key aspects of lighting-related studies, such as the planning and design of light fixtures, installation issues and the support required in the case of technical malfunctions. With regard to the latter, the author presents an excellent study of the complexities of a range of modern electrical lighting systems. I would strongly recommend it to all practitioners and graduate students interested in this branch of engineering.

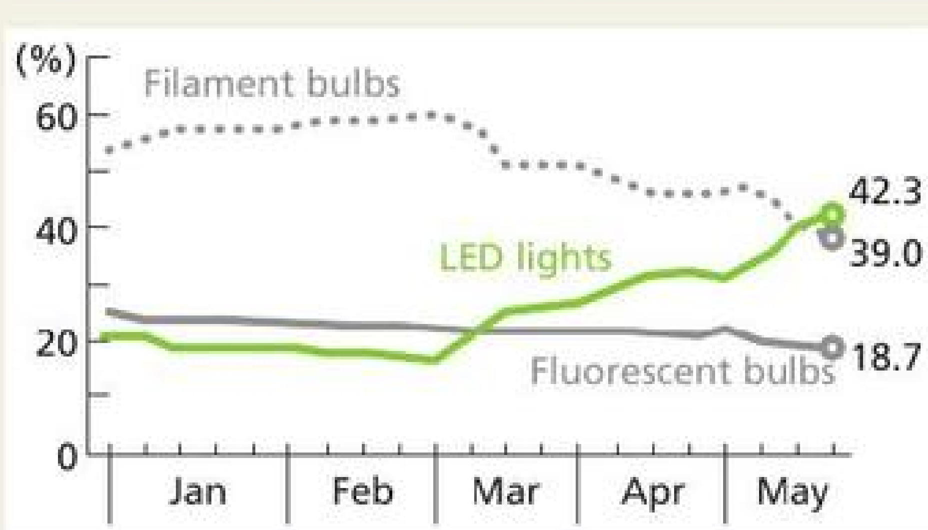


Figure 1: *Breakdown of lighting-device sales of major Japanese retailers in 2011 (Source: GfK Marketing Services Japan Ltd)*

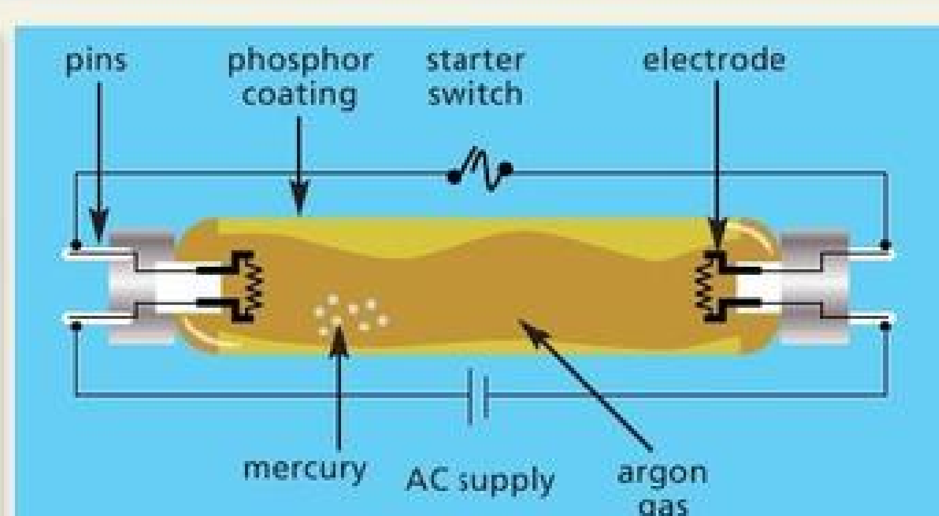


Figure 2: *Turn on lamp → current flows to electrodes creates voltage difference → free electrons move through gas → mercury changes from liquid to gas → electrons collide with gaseous mercury atoms → atoms emit ultraviolet light photons → photons hit phosphor atoms → phosphor releases white light*

A Discuss the following question.

What factors are important when choosing the light source for:

• a vehicle brake light? • street lighting? • a torch?

B Study the words in box a.

1 Match words in the left and right columns to make compounds.

2 Which compounds have adjective + noun?

3 Which word has the stronger stress in these phrases?

C Read the text on the right.

1 Complete the text using the phrases from box a.

2 How do you expect the text to continue?

D Survey the text on the opposite page.

1 How is the text organized?

2 For each of the four sections, write a question you would like the text to answer.

E Read the text.

1 Were your questions answered?

2 Use the information in the text to create a spidergram.

F Look at the underlined words in the text. What do they refer back to?

G Find synonyms for the blue words and phrases.

H Study the highlighted clauses in the text.

1 Rewrite them using passive verbs.

2 Find other examples of passives.

3 Why is the passive form commonly used in this type of writing?

I Study the sentences on the right. Each sentence completes one of the four sections in the text. Decide on the best location for each sentence. Explain your decisions.

J Reread the texts in the unit so far about fluorescent lamps and LEDs.

1 Make notes, comparing fluorescent lamps and LEDs to traditional incandescent bulbs. Copy the table for your notes.

2 Write a summary of the key differences for a company which wants to build a new office complex. Finish with your recommendation.

a

electrical	bulb
electron	device
incandescent	material
life	length
light	diode
light-emitting	span
red	movement
semiconductor	bulb
wave	light

Using LEDs for home and industry: Introduction

A ______________ (LED) is basically a sort of very small light bulb which can be a component in an electrical circuit. However, it is very different from a normal ______________ because it does not have a filament and does not get hot when in use. Its light comes from ______________ in a ______________, in a process known as electroluminescence. LEDs were invented in the 1960s and originally emitted low-level ______________, but there are now different colours, and include ultraviolet and infrared ______________. Thanks to their long ______________ and small size, LEDs have a wide range of different uses and are found in all sorts of electrical devices …

A LEDs are also very sensitive to changes in voltage and current, and series resistors or current-regulated power supplies may be required for complete efficiency.

B Developing a diode which emitted white light took electrical engineers some time.

C In addition, there are also non-visual applications using infrared LEDs in machine vision, such as barcode scanners and optical mice.

D Despite some problems with heat loss, they are the most popular way of making white-light LEDs.

Fluorescent lamps	Traditional incandescent bulbs	LED
• less energy required	•	•

Some key features of LEDs

Electroluminescence

An LED is a type of diode and, like all diodes, consists of a piece of semiconductor material with some impurities added to it. While current can flow from the anode to the cathode, it is impossible for it to flow in the other direction. The added impurities mean there are additional atoms, and these atoms can create 'holes' where electrons can go. In this way, there are two types of charge carriers: electrons and electron holes. Both of these move, or 'flow', from the electrodes, but in different directions. When an electron and a hole meet, they recombine and the electron falls into a lower energy level. This releases energy in the form of photons, and can result in the production of light – a process called electroluminescence. However, light is not always emitted. The wavelength of the light which the diode emits depends on the energy gap of the semiconductor, and this is determined by the type of material it is made of. For example, in the case of silicon diodes, no visible light is released.

White light

There are two main processes which can be used to create strong white-light LEDs. The first is to use three different LEDs together, each emitting one of the three primary colours of light: red, green and blue. These are known as multicoloured white LEDs. This creates the impression of white light because the three colours are mixed together by the eye. However, it is not easy to blend and diffuse the three colours successfully, so this process is not particularly common.

The second process uses a phosphor coating to transform blue or ultraviolet photons into broad-spectrum white light. These are called phosphor-based white LEDs, and they work in a very similar way to a fluorescent lamp.

Advantages of LEDs

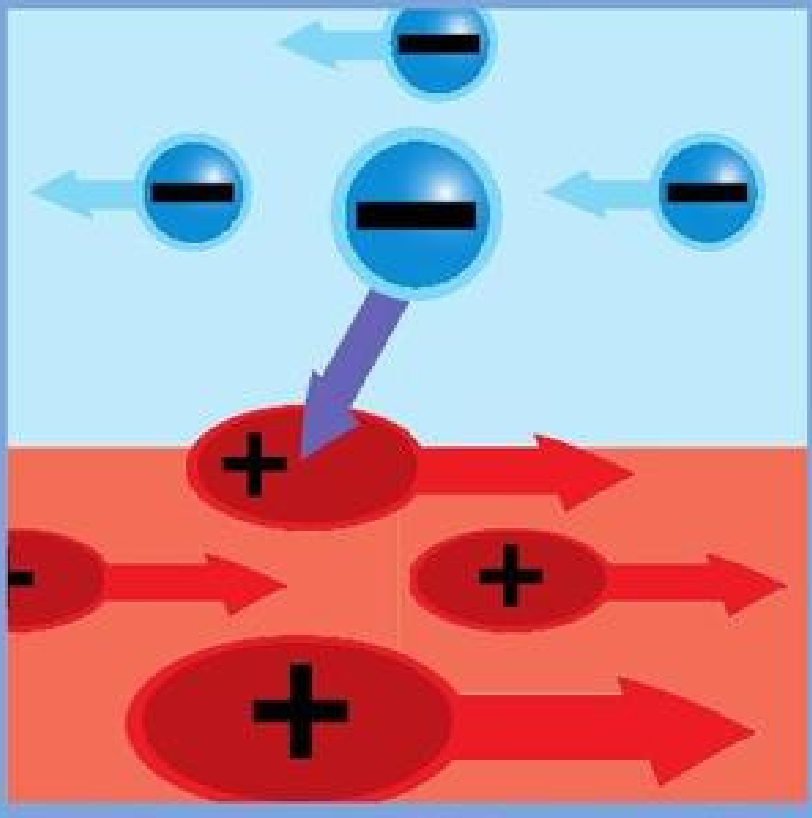
LEDs have a wide range of advantages over traditional incandescent filament bulbs. First of all, they are very small, often less than 1 mm^2, and this means they can be used in a variety of situations where other lighting options are not suitable. LEDs also consume much less energy. Some sources suggest that the carbon footprint of a building can be reduced by more than 60% if its lights are converted from traditional bulbs to LEDs. Furthermore, LEDs are more robust and reliable, and have a longer lifespan. According to some sources, they can last three times longer than fluorescent lamps and thirty times longer than traditional bulbs. A final benefit is that LEDs light up very quickly, often in less than a microsecond.

LEDs suitable for domestic lighting, however, are considerably more expensive than traditional bulbs and they require more careful heat management than both incandescent bulbs and fluorescent lamps. For example, they cannot be used when the ambient temperature of the operating environment goes above 35°C.

Applications of LEDs

LEDs are used in a variety of different applications in which their advantages over more traditional lighting can be exploited fully. The small size of LEDs, their low energy consumption and reliability make them perfect for all types of sign, such as message displays used at airports and train stations. Since most LEDs produce one-colour light, this means they are suitable for traffic lights. Another sort of sign that LEDs are used for is brake lights for vehicles. Here, because of their long lifespan and quick switching time, they are significantly safer, giving drivers up to 0.5 of a second more reaction time.

Currently, lighting is the main application for LEDs, especially since the development of high-efficiency, high-power versions. They are used in street lighting, and automotive and aviation lighting, as well as backlighting for LCD televisions and laptop screens. The fact that they are small, have a long life and require little power means that LEDs are suitable for hand-held torches and camera flashes on mobile phones.



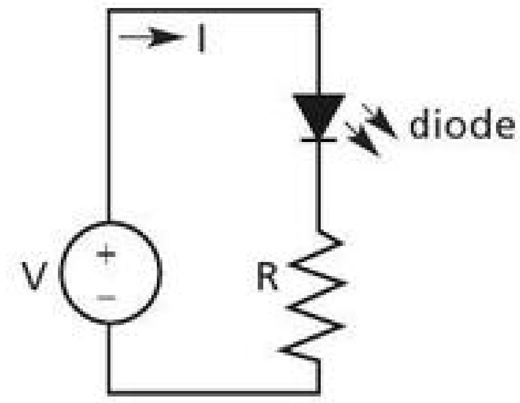
Current flowing across a diode causes positive electron holes to move in one direction and negative electrons in the other. When an electron meets a hole, it falls into it and, since holes have a lower energy level than electrons, the electron emits its excess energy in the form of photons.

12.3 Extending skills

structure of laboratory reports • understanding technical terms

A Look at the diagram on the right.

1 What does the circuit consist of?
2 What sort of current does the circuit require?
3 Why is the resistor required? Is it always necessary?
4 Is this an energy-efficient circuit?
5 How can the value of the required resistor R be calculated?



B Study the section headings for a laboratory report on the right. Which question(s) below does each section answer? Write the number of each question by the correct heading.

1 How was the experiment done?
2 What was found?
3 What do we definitely know from the findings?
4 What apparatus was used?
5 What is the significance of the results?
6 Where are sources of information recorded?
7 Why was the experiment done?
8 What theories are the experiment based on?

Introduction	___	Results	___
Theory	___	Discussion	___
Experimental procedure	1	Conclusions	___
		References	___

C Read the Hadford University handout.

1 Work in groups of three. Each person should choose one of the terms to research, using notes provided by the teacher.
2 Explain your term to your group.

HADFORD *University*

Electric Circuit Course

Course tutor: Dr Robert Sarga

In our lab session next week, we'll be conducting an experiment. Before the session, you'll need to find out or revise the meaning of the following terms:

- parallel circuit
- series circuit
- open circuit
- reverse-biased (backward-biased)
- anode/cathode
- Ohm's law

Also, please read the guidelines on the module homepage for writing a lab report. Log sheets for recording the results of the experiment will be provided.

12.4 Extending skills

structure and content of laboratory reports • linking ideas

A Read Text A on the opposite page.

1 Which section of a lab report is this?
2 What are the two main aspects of this section?

B Look at the verbs in column 1 in the blue box. Which nouns from column 2 can each verb go with?

1	2
assemble connect decrease measure repeat set verify	an ammeter a circuit a component the current a law the power supply a process results the voltage

C Read Text B from the same report.

1 Put the verbs in brackets in the correct tense and form.
2 Which section of the report does Text B belong to?

D Study the six parts from the same report on the opposite page.

1 Which section does each part belong to?
2 Find synonyms for the blue words.

E Look at a student's lab notes on the right.

1 Which report section are the notes for?
2 Write a paragraph, using the notes.

Experiment → showed good agreement to theory (Ohm's law): resistance constant (fixed resistors) so voltage change → current change: V/R=I
Discrepancies between theory/practice = problems with equipment (no digital multimeter)
LED trials:
• ↓ power source voltage → LED voltage ↓→ current ↓→ LED became dimmer ∴ LED voltage = LED brightness
• reversed anode/cathode position (reverse-biased) → no current + no voltage → no light = open circuit: electric polarity of LED = key factor

A

A typical problem for electrical engineers is how to measure accurately the current and voltage in various types of electrical circuit. Ohm's law describes the relationship between current, voltage and resistance in a circuit. However, it is an empirical observation, and does not always hold true in practice. LEDs are a common component in circuits, and engineers need to know how to maximize and adjust their brightness. The aim of this experiment is to discover the best way to measure the voltage and current in a parallel circuit and to see whether the circuit verifies Ohm's law. In addition, the aim is to investigate what factors affect the brightness of LEDs, and whether or not the electric polarity of an LED is an important factor.

B

The circuit (*assemble*) as shown in Figure 1, with three pairs of components in parallel. Each parallel section (*contain*) a resistor in series with an LED. The first LED (*pair*) with a 330-ohm resistor, the second with a 220-ohm resistor, and the third with a 1,000-ohm resistor. LEDs of three different colours (*select*): red, yellow and green …
The power supply (*set*) to 8 volts and all components (*check*) to make sure they were working correctly. The voltage across each resistor and LED (*measure*) …
This process (*repeat*) three times using 6 volts, 4 volts and finally 2 volts. After all the measurements for each voltage setting (*take*), the current through each LED (*calculate*) by dividing the voltage across the resistor by the resistor's value …

1

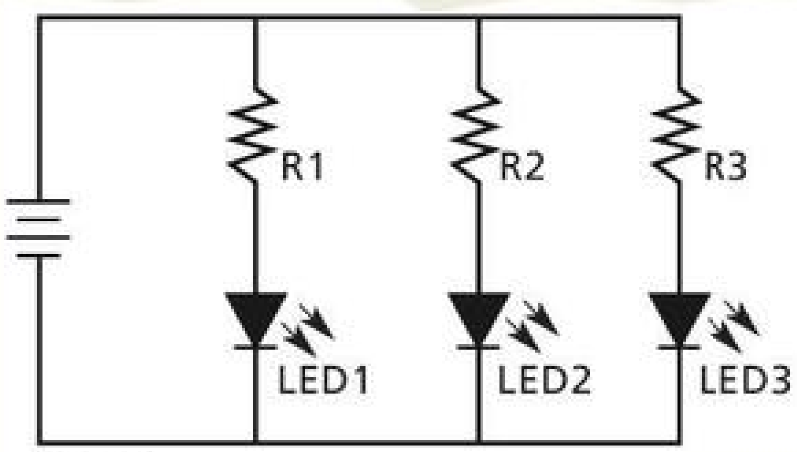


Figure 1

The position of the components in the final circuit is shown in Figure 1.

2

Ohm's law states that the amount of electric current passing through two points in an electrical circuit is directly proportional to the potential difference, or voltage, across two points, and inversely proportional to the resistance between them …

3

Since the LEDs dimmed progressively as we continued to decrease the voltage, this suggests that voltage determines the brightness of the LEDs. However, this result may …

4

The results for the trial at 8 *V* are given in the following table:

Circuit voltage		8V	Total circuit current		50.1mA
Measured LED Voltage		Measured Resistor Voltage		Calculated Current	
V_{LED1}	2.18 V	V_{R1}	5.76V	I_{LED1}	17.5 mA
V_{LED2}	2.20 V	V_{R2}	5.70V	I_{LED2}	25.9 mA
V_{LED3}	1.58 V	V_{R3}	6.30V	I_{LED3}	6.3 mA

5

The results seem to verify Ohm's law, although not perfectly. These differences may not be significant, however. It is possible that the use of imperfect equipment may explain the largest portion of this discrepancy, because …

6

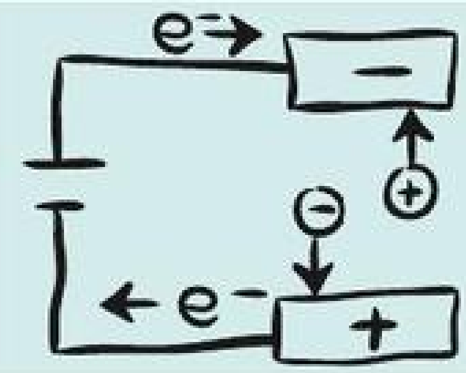
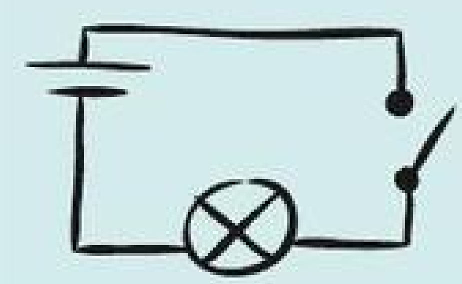
For a circuit voltage $E = 6$ V, $V_{LED} = 3.87$ V; therefore $I_{LED} = V_{LED} / R = 3.87 / 330 = 11.7$ mA.

Vocabulary bank

Understanding technical terms

You will often find that explanations of technical terms and concepts can be difficult to follow. It is a good idea to find and draw simple diagrams to help you to understand and remember. It is also a good idea to find several explanations of a term or concept (on the Internet, for example) and then try to write a definition in your own words.

Examples:

anode/cathode	Anodes and cathodes are electrodes which current passes through to complete a circuit. The electrode where the current flows out and oxidation takes place is called the *anode*, or positive electrode. The current flows in at the *cathode*, or negative electrode. Here electrons are gained in a process known as *reduction*.	
open circuit	An open circuit exists when a break occurs in the conducting pathway of the circuit, usually in one of the components or in the wire. This happens when a switch is used to turn off a circuit, although it can also be the result of damage to the circuitry.	

Linking ideas in a text: Using pronouns to refer back in a text

Text cohesion can be improved by using pronouns to refer back to previously mentioned nouns. This avoids repeating the same noun immediately or soon after the first mention.

Example:
When an electron and a hole meet, they recombine and the electron falls into a lower energy level. (they refers back to 'an electron and a hole')

It is important, however, to make clear which noun a pronoun refers back to. It is better not to use a pronoun when the meaning becomes ambiguous or unclear.

Example:

Unclear	*A typical problem for electrical engineers is how to choose the best light source for a given situation. It includes domestic and industrial lighting as well as product design.* (What does *it* refer to?)
Clear	*A typical problem for electrical engineers is how to choose the best light source for a given situation. Typical situations include domestic and industrial lighting as well as product design.*

Using words with similar meanings to refer back in a text

Text cohesion can be improved by using different words or phrases to refer back to previously mentioned information. Often the connection may be *implied* within the context rather than direct.

Examples:

First mention	Second mention	Third mention	Fourth mention
lighting engineers	the field (of lighting engineering)	lighting-related studies	this branch of engineering
those wishing to specialize	graduate students		

Skills bank

Structuring a laboratory report

A laboratory report is a formal account of a practical experiment completed in a laboratory to test a theory. The report presents data from the experiment and demonstrates understanding of the principles or theory behind the experiment; it reports on observed results. But a good laboratory report goes further: it demonstrates understanding of the results and the reason for any differences between expected and observed results.

Most laboratory reports follow a similar general format. However, you may be required to use different headings or to present your data in a different order to the one presented in this unit.

Introduction	a concise description of relevant background information; a brief discussion of the objectives and motivation for the experiment
Theory	key assumptions, theories, equations and variables used in the experiment
Experimental procedure	simple but complete list of apparatus; diagram(s) of apparatus; procedures used in obtaining the experimental data in chronological order
Results	mostly calculations, tables, figures; draw readers' attention to key points in each graphic
Discussion	analysis and interpretation of results; issues arising from findings; explanation and significance of any experimental errors
Conclusions	definite results from the experiment; recommendations for further study or improvements in the experiment's design or procedure, if appropriate
References	sources of information used

Talking about known facts

Always use the present tense to talk about known facts.

Examples:

Engineers need to know how to maximize and adjust the brightness of an LED.

Oxidation is the loss of electrons and takes place at the anode.

Talking about laws, theories, equations, formulae and hypotheses

Always use the present tense to talk about theories.

Examples:

Ohm's law states that the amount of electric current passing through a metal conductor in an electrical circuit is directly proportional to the potential difference, or voltage, across two points.

Joule's law expresses the relationship between power, current and voltage.

Talking about experimental procedures

Use the past tense to talk about methods and procedures followed.

Examples:

The circuit <u>contained</u> a power supply, a 330-ohm resistor and an LED.

The voltage across the resistor <u>was measured</u> using an analogue multimeter.

5.3 Symbols and abbreviations for notes

Symbols

&, +	and, plus
–	less, minus
±	plus or minus
=	is, equals, is the same as
≈	is approximately equivalent to
≠	is not, is not the same as, doesn't mean, does not equal, is different from
>	is greater than, is more than, is over
<	is less than
→	gives, produces, leads to, results in
←	is given by, is produced by, results from, comes from
↑	rises, increases, grows
↓	falls, decreases, declines
"	ditto (repeats text immediately above)
∴	therefore, so
∵	because, as, since
@	at
C	century, as in 20th C
§	paragraph
#	number, as in #1
?	this is doubtful

Abbreviations

e.g.	for example
c.	approximately, as in c.1900
cf.	compare
Ch.	chapter
co.	company
ed./eds.	editor(s)
et al.	and the other people (used when referring to a book with more than two authors)
etc.	and all the rest
ff.	and the following as in p.10ff.
fig.	figure (used when giving a title to a drawing or table)
i.e.	that is, that means, in other words
ibid.	in the same place in the source already mentioned
NB	important
n.d.	no date given
No., no.	number
op. cit.	in the source already mentioned
p.	page
pp.	pages, as in pp.1–10
re.	concerning
ref.	with reference to
viz.	namely
vol.	volume

Additional material

7.4 Student A Types of power station	**1 Nuclear** **Advantages** • Relatively cheap power • Low carbon emissions • One plant can produce large amounts of electricity • Provide good 'base load' – unvarying over time **Disadvantages** • Lengthy process to design and build • Expensive to build and run • Safety issues if there is an accident • Disposal of waste material • Locations difficult to find • Technology related to arms development • Uranium is not renewable and may only last 60 more years

9.3

Speech/voice recognition systems

Speaker verification

This system uses voice as a way of securely identifying an individual by matching their spoken voice with a pre-recorded sample. Only a few words are needed to establish this match, and these have been pre-recorded by the individual in question. However, the matching algorithm has to be extremely reliable since a high level of security depends on it.

An example of speaker verification is a system called SpeakerKey from ITT, which at the moment is still at the trial stage. It aims to verify whether convicted prisoners who have been allowed out of prison but required to stay inside their homes are actually at home. In this system, a computer contacts the prisoner by home telephone and asks them to say a certain series of numbers. The numbers are then matched to the previously recorded versions.

Another application of speaker verification is banking, in which customers use their bank cards, with the voice print stored on the card itself. Other uses include security for gaining access to computer systems or to buildings.

7.4 Student B Types of power station	**2 Oil-fired** **Advantages** • Fossil fuels are available for the moment • One plant can produce large amounts of electricity • Location of plant can be anywhere (as long as oil can be delivered there) • Quick response time – good for 'topping up' when there is extra demand **Disadvantages** • Very high carbon emissions (carbon dioxide) – polluting the atmosphere and contributing to the greenhouse effect • Oil transport over long distances is expensive • Oil is not renewable so one day will run out • Price of oil is not stable

9.3

Speech/voice recognition systems

Natural language processing

This is the idea that a computer listens to someone speaking naturally giving it a series of tasks to do, and the computer then carries out those tasks. Obviously, this would be a considerable achievement. It would require, on the part of the computer, a lot of background knowledge about how the world works and how language works. In reality, natural language processing is only possible when used in a restricted context, using particular tasks that have been pre-selected.

One common application of natural language processing involves database searching. The researcher gives a spoken request and this is translated into a formatted request that the computer can understand. For example, if you want to know the flights available between two cities, you can ask the computer: 'Show me the flights between London and Rome.' Then, you can filter the results by stating, for instance: 'Only show me economy flights.'

This technology is being developed commercially and, if successful, could become very popular and be very profitable.

7.4 Student C	3 Hydroelectric
Types of power station	**Advantages** • A renewable source of power • Free/cheap • No pollution • No fuel transportation costs • Often little environmental impact • Good, if not enormous, level of energy production **Disadvantages** • Depends on rainfall and level of water in rivers • Damming rivers can have a big environmental impact • Variable 'base load'

9.3

Speech/voice recognition systems

Speaker-independent voice recognition

This involves the use of a technique known as 'keyword spotting', where a small number of words in a spoken sentence – such as numbers, or 'yes' and 'no' – are identified. This recognition procedure is useful for detecting words spoken by people who have never used the system before. It can take place during a telephone call, although the quality of the line obviously influences the success rate.

Keyword spotting techniques can be used in recording equipment so that it starts only when certain words are detected. This would be useful in spying situations or for monitoring communications in certain work situations, such as air traffic control transmissions.

5.4

Group B

3D TV technology using active lenses

With this technology, a scene is filmed with two separate cameras (Picture 5), just like with other 3D techniques. The images from the two cameras are then put on a single strip of film, in alternate frames, one after the other. The screen shows first the image from the left-hand camera, followed by the image from the right-hand camera, and so on. The glasses that the viewer wears use liquid crystal in the lens. These shutter glasses can open one lens and close the other in very quick succession, one after the other (Picture 6). The glasses receive radio signals from the projection system, which tells the glasses which lens to open and when. In this way, each eye sees only one of the different images, and the central cortex of the brain combines the two images into the sensation of seeing one 3D object. This is a very effective technique and the result is very lifelike. However, it is a very expensive system to set up and the technology is rather complicated, for example, the glasses need to be connected to the television, either by a wire or by an infrared beam. Another problem is that each eye sees a separate image at a different time. There needs to be a fast refresh rate of images, otherwise the viewer can notice a 'jumping' sensation, especially during fast motion scenes.

7.4
Student D

Types of power station

4 Solar

Advantages

- Renewable resource of power
- Silent
- No pollution
- Little maintenance required
- Free source of power
- Easy to install
- Technology is improving all the time

Disadvantages

- Expensive to set up
- Cannot provide constant 'base load': no power at night or on cloudy days
- Requires large surface area for energy collection

9.3

Speech/voice recognition systems

Speaker-dependent voice recognition

The idea here is to create a system in which the speaker's words are displayed on a computer screen. For this to be possible, the system needs to be personalized for the particular voice of the user. Details of the user's voice are stored, which makes the recognition process much [illegible] reliable.

n
d

Until recently, this sort of voice-to-text system required the speaker to allow a longer tha normal pause after each spoken word so that the computer could detect where one wo ended and the next one began. Nowadays, however, some software developers are claiming better results with words spoken at normal speed.

This recognition technique also involves making a digital audio recording of the speech, which the user can refer to if there are any pieces of text that do not make sense. This is not ideal, perhaps, but a good working arrangement nonetheless.

Review

Notes

1 Manufacture of MEMS:

Materials: similar to other microelectronic products, e.g., silicon

(a) Deposition stage: thin layers of material deposited on base

(b) Etching: pattern transferred onto layers. Photosensitive layer → masked → exposed to radiation → properties of exposed parts change → dissolved in acid/gas/gases: 3-dimensional surface

2 Applications of MEMS:

(a) Car crash sensors

MEMS = accelerometer (measures changes in car's speed)

Mechanism: central inertial mass attached to spring/cantilever. Car slows down/speeds up → mass moves. Electrical sensors send data about movement of mass → microprocessor. Microprocessor monitors information: rapid ↓ in acceleration (= crash) → critical level reached = airbags open very rapidly.

Advantages of MEMS = sensors more reliable = safer/cheaper.

(b) Video projectors

MEMS = actuator

Mechanism: small mirrors attached to hinges. Mirror moves towards light source (= light reflected) or away (= blocked). 1 mirror = 1 pixel of image. Time mirror reflects light = brightness of pixel → many different shades of colour possible.

Advantage of MEMS = ↑ image quality

Summary:

Wordlist

Note: Where a word has more than one part of speech, this is indicated in brackets. The part of speech given is that of the word as it is used in the unit. So, for example, *convert* is listed as *convert (v)*, although it can also be a noun.

	Unit
discrete value	9
dish	1
display (n)	5
dissolve	11
distribution	2, 7
document	4
domestic (adj)	12
drawback	11
droop (n)	6
drop (n and v)	5
duplex (adj)	8
E	
echo (n)	9
economical	5
editing	9
efficient	7, 12
electrode	12
electroluminescence	12
electromagnet	1
electromechanical	11
electron	1, 2
electronic	4
electronics	2
element	2, 8
eliminate	6
emit	12
empirical	3
energy loss	7
enormous	10
equalization	9
equation	3
etching	11
exceed	6
exhaust pipe	10
exit (v)	4
expensive	5
extract	9
F	
fall (v)	5
feedback (n)	6
fibre-optic cable	8
fibre-optics	1
field	1, 12
filament	2, 3, 12
filter (n and v)	9
fixed-line phone	8
fixture	12
flat (adj)	5
flow (v)	12
fluctuate	6
fluorescent lamp	12
forward-biased	12
fossil fuel	10
foundation	2
fraction	11
frequency domain	9
frequency modulation	8
fundamentally	5
G	
generate	7
generator	2
gigabyte	1
glow	3
glue	11
gradual	5
grid	2, 7
ground	1
growth	5
H	
halogen	12
hearing aid	11
heat	3
heater	6
heavy	5
hidden	10
hinge	11
hit (v)	12
hold (v)	9
holes	12
hydroelectric power	7
hyperlink	4
I	
image	5, 9
imbalance	7
immovable	5
impact (n)	8
imperfect	12
improve	5
in series	1
incandescent	2, 3, 12
increase (n and v)	2, 5
independent variable	9
index	4
induction	3
inductor coil	1
infrared	1, 12
input	6
insignificant	10
installation	12
instantly	11
insulated	2
integral	6
integrated	2
intensity	1
interference	9
intranet	4
invent	2
involved	5
isolate	8
item (n)	5
K	
keyword	4
kilowatt	1
kind (n)	5
L	
lab-on-a-chip	11
last (v)	10
latter	12
law	1

Transcripts

Unit 1, Lesson 2, Exercise B 1.1

Part 1

Good morning, everyone. In this lecture, we are going to look at exactly what is included in the field of Electrical Engineering. This is an important topic because it will show you a wide variety of career paths that are possible for students of this subject. This lecture might help you choose your future job!

OK. There are many different branches within Electrical Engineering. Practising electrical engineers work in a variety of areas, doing very different things. Today we are going to look at some of the most important branches. Some electrical engineers work in only one of these branches, but many deal with a combination of them. As we will see, many branches are closely linked to each other. This is particularly true in the case of electronics. As well as the different branches, I will also mention a few of the applications and devices related to electrical engineering.

Unit 1, Lesson 2, Exercise C 1.2

Part 2

So what are the different branches of Electrical Engineering? What activities are involved in these branches? Well, let's start with the first branch of Electrical Engineering – the one concerned with computing. This branch deals with the design of both hardware and software for computers. When designing computer hardware, an engineer can be involved in the design and interconnection of very small electronic devices for use in an integrated circuit. This is known as *microelectronics*. Of course, the range of applications of the computer is huge. Computers vary from those used to control an industrial plant, down to desktop computers and computer-like devices such as DVD players and video game consoles. This is perhaps the largest of the branches of Electrical Engineering.

Another very important branch is the one that concerns electric light and power – the generation, transmission and distribution of electricity. Related applications include transformers, turbines, electric generators and electric motors. This field often involves the use of high voltages in an electrical network called a *power grid*. The grid covers a wide area – often a whole country – connecting generators with users, who buy the electrical energy for their homes and businesses.

A third major branch is communications. This involves telephony, but also satellite communications and the transmission of laser signals through optical-fibre networks. This branch is closely connected to computer engineering since computers can communicate with each other by sending digital data via wires, microwaves and satellite circuits.

Control engineering is another branch of Electrical Engineering. It involves the design of electronic controllers that make a wide range of dynamic systems behave in a particular way. Applications include the flight systems of aircraft and automation systems in factories.

The last area I want to talk about today is signal processing. This involves the analysis and manipulation of signals – both analogue and digital. An engineer can amplify or filter analogue signals, for example for audio equipment. He or she can also compress and correct errors of digitally sampled signals. This field of Electrical Engineering has a very wide range of applications, from radios and mobile phones, to missile guidance and radars.

So, as you can see, electrical engineering covers a wide range of subjects. Several of the areas are closely connected to each other, particularly by their use of computers and microelectronics. Now perhaps we should ask the question a little differently: 'What does a practising engineer do?' In other words, we are asking: 'What exactly are the typical work activities of a practising electrical engineer and what knowledge is required?'

Unit 1, Lesson 2, Exercise D 1.3

Part 3

As we have seen, electrical engineering is involved in the development of a wide range of technologies. So practising electrical engineers design, develop, test and supervise all sorts of electrical systems and devices. Physics and mathematics are key subjects for electrical engineers, and most engineering work now uses computers.

Circuit theory is a requirement for most engineers, but other theories may be used by some engineers and not others. Take, for example, engineers who design integrated circuits. They will need to have knowledge of quantum mechanics and solid state physics. However, these theories may not be relevant to engineers working in areas such as power transmission or telecommunication systems.

Apart from technical work, practising electrical engineers also spend time on other tasks. They prepare project schedules and meet clients. At higher levels they manage other engineers in a team. So, as you can see, the job of an electrical engineer can be very varied and stimulating and can also involve working in a variety of environments.

Unit 1, Lesson 2, Exercise E 1.4

Part 4

One thing I want to mention is the relationship between electrical engineering and electronic – or electronics – engineering. Are they different subjects? Or are they related, and if so, how? The answer is that, to some extent, it depends on where you are in the world. In the United States, Electrical Engineering is the main subject that is studied at university and it contains all the other branches, including electronics.

In Europe, however, it's a little different. A distinction is made between electrical and electronic engineering. Electrical engineering deals with large-scale electrical systems. Here, electrical engineers are generally involved with using electricity to transmit *energy*. Examples of applications of electrical engineering would be power transmission and motor control. Electronic engineering, on the other hand, deals with small-scale systems, and electronic engineers use electricity to transmit *information*. Examples would be computers and integrated circuits.

So let's summarize. In America, *Electrical* Engineering covers all electrical disciplines and so includes electronics. In Europe, *Electronic* Engineering is often considered a subject in its own right, and there may be separate university departments for Electrical and Electronic Engineering.

Unit 1, Lesson 3, Exercise E 1.5

Introduction 1

Hello, everyone. Today I'm going to talk about the different sorts of electrical engineering systems that you can find in a standard modern car. What electrical systems does it contain and what are they for? I think the answer really shows us what a wide range of areas are included in the subject of Electrical Engineering. To show this, I will briefly describe some of these systems.

Introduction 2

Shall I start? OK. As students of Electrical Engineering, you need to know all about the systems of units that are used. So, in this lecture, we are going to look at these different units and their symbols. These appear in the formulas and laws that electrical engineers need and use every day in their jobs.

Introduction 3

Good morning, everyone. This week I'm going to talk about the earliest accounts of electricity and its very first developments. In particular, we'll look at important terms such as *charge* and *current*. We'll also learn about *Kirchhoff's current law*, and how it helps in the design of large electrical circuits.

Introduction 4

Good afternoon. I think we can start now. In my lecture this week, I want to look at some of the measuring devices that are such an important part of an electrical engineer's work. I'll be looking at three of these devices, their characteristics and how they are used.

Introduction 5

Right. Let's have a look at the process that most electrical engineers go through in order to become recognized practising professionals. As you will find out, there are two main stages in this process. Most of you here today are at the beginning of the first stage, so there's quite a long way to go yet!

Unit 1, Lesson 4, Exercise D 1.6

Lecture 1

It's not just modern cars that have electrical systems – even older cars had them. They used an electric circuit to start the engine. This was achieved by using a starting handle to trigger the ignition phase. In this circuit, an inductor coil generates a high voltage and sends a spark across the gap in the spark plug. This spark then ignites the air and fuel mixture. The coil is supplied with a DC voltage by a battery. However, in modern cars, this traditional electrical ignition system has been replaced by electronic ignition with transistors. This device lasts much longer and is more reliable.

The car battery is a self-contained electric power system. But, like all batteries, it gradually loses its power. In order to make it last as long as possible, the car has a charging system, involving an alternator. First we have the inductor coil, then there is the battery which supplies power to other electrical components such as the lights and radio. The radio is yet another electrical system. It receives electromagnetic waves via the antenna and decodes these signals to reproduce the original sounds, sent from a long way away.

More recently, computer systems have been used in cars. Computer systems are used, for example, to control exhaust emissions. Let's look at this control system in a little more detail. A microprocessor receives signals from sensors and these contain information about things such as the composition of gases in the exhaust. From the processed information, the computer in the car can decide how to make the engine work as cleanly as possible. The use of computer systems in cars is becoming more and more common in all sorts of ways. Examples of recent uses of on-board computers are electronically controlled suspension, electronic cruise control and anti-lock braking. In the future, fibre-optic networks may replace traditional wire systems.

Unit 1, Lesson 4, Exercise D 1.7

Lecture 2

The main system electrical engineers use is the International System of Units – also known as SI units. These are used by all engineering professional bodies. SI units are based on six fundamental quantities, which are length, mass, time, electric current, temperature and luminous intensity. I'll repeat those slowly – length, mass, time, electric current, temperature and luminous intensity.

The unit of length is the metre, and the symbol is a small *m*. The unit of mass is the kilogram, with the symbol *kg*. The unit of time is the second, as I'm sure you know, and the symbol is a small *s*. Electric current is measured in amperes, and the symbol is a capital *A*. In everyday life, we usually measure temperature in degrees Celsius, but as electrical engineers we need to use the Kelvin, and the symbol for that is a capital *K*. The last SI unit is the one for luminous intensity and its unit is the candela. Its symbol is small *cd*. All other units can be derived from these six fundamental units. For example, a coulomb is the amount of electric charge transported in one second by one ampere of current.

The other thing we need to look at is the prefixes we can use to denote different powers of ten of SI units. We will also discuss the other units that can be derived from these. These prefixes are very useful because we often need to describe quantities that occur in large multiples or small fractions of a unit. In engineering, units are usually expressed in powers of ten that are used in multiples of three.

Let me give you an example. If we are talking about weight, we can talk about a kilogram. *Kilo* is a prefix to describe ten to the power of three, so a kilogram is one thousand grams. We write it with a small *k* before the symbol for grams – which is *g* – so that makes *kg*. *Mega* means ten to the power of six, so a megawatt is one million watts. Its symbol is a capital *M*. *Giga* is ten to the power of nine, with a capital *G* as the symbol. That's a very large number!

We can also use prefixes to describe very *small* numbers of units. This is particularly important for engineers working with microelectronics. For example, the prefix *milli* – with the symbol small *m* – is ten to the power of minus three, whereas *nano* is ten to the power of minus nine. Its symbol is a small *n*.

Unit 1, Lesson 4, Exercise D 1.8

Lecture 3

First, let's look at the term 'charge'. It's been known for over 2,000 years that it is possible to create a static charge on certain objects, for example on a piece of amber – that's a piece of fossilized tree resin. A charged object is capable of attracting very light objects, for example small feathers. This is an example of static electricity – an electric charge on the surface of an object. But what exactly is this charge?

Alessandro Volta invented the battery using copper and zinc metals. He showed that electricity flows through the wires attached to the battery. This is an example of current, or moving charge, electricity. Initially it wasn't clear what the connection was between static and current, but Volta showed that they were both part of the same fundamental mechanism. And this mechanism involves the atomic structure of matter, in other words a nucleus – made up of neutrons and protons – surrounded by electrons. Charge is measured in a unit called the *coulomb* – with a capital *C* as its symbol. The two main particles that carry a charge are the *electron*, with a negative charge, and the *proton*, with a positive charge. Electrons and protons are known as *elementary charges*.

The next quantity we need to look at is *current*. Electric current is defined as the rate of change of charge passing through an area – usually the cross-sectional area of a metal wire – per unit of time. It is therefore measured in terms of *coulombs per second*, and one coulomb per second is known as an *ampere*, symbolized by a capital *A* as mentioned in the last lecture. In metallic conductors, current is carried by negative charges – these are the *free electrons*. The free electrons are only weakly attracted to the atomic structure in metallic elements. As a result, they can move easily in the presence of electric fields.

In order for current to flow, there must be a *closed circuit*. An example of a simple closed circuit is a battery connected to a light bulb. The German scientist Kirchhoff observed that the current flowing from the light bulb to the battery is equal to the current flowing from the battery to the light bulb. This means that no charge is lost around the closed circuit. Kirchhoff's current law states that because charge must remain constant, the sum of currents at a node must equal zero. A node is a junction of two or more device terminals or conductors. Thanks to Kirchhoff's law, it is possible to express currents in a circuit in terms of each other. For example, it is possible to express the current leaving a node in terms of all other currents at the node. This makes it possible to write equations and this can help in designing and understanding large electrical circuits.

Unit 1, Lesson 4, Exercise D 1.9

Lecture 4

The three devices I'm going to talk about today measure three basic electrical parameters: current, voltage and resistance.

The first practical measuring device is the ohmmeter. When the ohmmeter is connected across a circuit element, it can measure the resistance of the element. However, you need to remember one important rule here: we can only measure the resistance of an element when it is disconnected from any other circuit.

The ammeter is the second device I want to mention. When the ammeter is connected in series with a circuit element, such as a resistor, it can measure the current flowing through the element. There are two important things to remember if you want an accurate reading. First, as I just mentioned, the ammeter must be placed in series with the element, and not across it as in the case with the ohmmeter. Secondly, the ammeter should not affect the flow of current in any way. If it does this, it will cause a voltage drop and the measurement will no longer be the true current flowing in the circuit. Therefore, we can say that an ideal ammeter has zero internal resistance.

The last device I want to look at today is the voltmeter. This can measure the voltage across a circuit element. Voltage, as you probably remember, is the difference in potential between two points in a circuit, so the voltmeter needs to be connected across the element. There are a couple of points you need to remember about the voltmeter. First, as I just mentioned, the voltmeter needs to be placed in parallel with the element, and not in series with it. Secondly, the voltmeter should not take any current away from the element whose voltage it is measuring. Otherwise, it won't be able to measure the true potential difference. So, the voltmeter should have an infinite internal resistance. This, of course, is the complete opposite of what we said about the ideal ammeter.

So for both the ammeter and the voltmeter, we need to consider the practical limitations of the devices we use. There will always be some series resistance to the circuit because of the presence of the ammeter. Similarly, a voltmeter will always draw some current away from the measured circuit. This is simply part of the difference between a perfect world, and the world as we know it!

Unit 1, Lesson 4, Exercise D 1.10

Lecture 5

The first step in becoming a recognized electrical engineer is to study for an academic degree in Electrical Engineering. As you know, it can take four or five years to get a bachelor's degree. This involves studying a range of subjects, including physics, mathematics, computer science and other specific topics. At the beginning of a university programme, students take courses in all the branches of Electrical Engineering. They can then choose to specialize in one or more branches in the final years.

Having completed an undergraduate degree programme, some electrical engineers decide to take a postgraduate degree such as an MSc in Engineering or a PhD in Engineering. The MSc can consist of either research or coursework, while a PhD involves a significant research component. Getting an MSc or PhD is, however, optional for most engineers. The important thing in the process of becoming a practising engineer is obtaining a bachelor's degree.

After graduation, the next step is to obtain certification by a professional body. For this, a set of requirements must be satisfied. These usually include work experience, and there is often a written exam too. After certification, engineers are given the title of Professional Engineer or Chartered Engineer, depending on the part of the world where they live and work. Obtaining certification is an important step because in many countries only certified engineers can do certain important jobs. In some countries, if you are not certified, you cannot work as an engineer at all.

There are several important professional bodies for electrical engineers. One of these is the Institute of Electrical and Electronics Engineers, abbreviated as IEEE or 'I triple E'. Another is the Institution of Engineering and Technology, or IET. These bodies have members worldwide and publish literature for the profession, such as journals. They also help practising electrical engineers keep up to date with new skills and new information, which changes more and more rapidly each year. These are therefore very important reasons for being a member.

Unit 3, Lesson 2, Exercise B 1.11

Part 1

Good morning, everyone. Shall we start? OK. Today we will look at some of the basic concepts of electricity and circuit theory. I realize that some of you may already be familiar with these concepts, but I think it's important to revise them before we consider more complicated topics. In this lecture, I want to concentrate on simple circuits and how current, voltage and resistance are related. Ohm's law gives the relationship between these quantities, but as we will see later, this is not a law in the strictest sense. It's actually derived from empirical data, which means it relates to experiment and observation rather than theory. The law holds true in most situations, but there are exceptions and it is important to be aware of these, so I'll be discussing them in my next lecture. Today, though, we'll see how Ohm's law can be used to perform calculations for a simple circuit. Later on in the course, we'll be examining more complicated circuits, but the principle is basically the same. That's why I think it's important to make sure that we all feel completely confident with the basic terminology and equations now – before it's too late!

Unit 3, Lesson 2, Exercise C 1.12

Part 2

Georg Ohm was born in Bavaria (now Germany) in 1789. He was a teacher of science and mathematics and did some important research on resistance, publishing his first results in 1827 in a book called *The Galvanic Circuit Investigated Mathematically* – except it was written in German, not English! Historically speaking, Ohm's law is one of the most important, if not *the* most important, early quantitative descriptions of the physics of electricity. However, when Ohm first published his work, critics were very hostile and voiced their disagreement very angrily.

So, what is Ohm's law? Well, Ohm's law describes the relationship between current, voltage and resistance. Ohm discovered that the amount of electric current through two points of a metal conductor in an electrical circuit is directly proportional to the potential difference or voltage across those two points. I'll say that again, because it's a very important point. Ohm discovered that the current through most materials is directly proportional to the potential difference applied across the material. Moreover, the current is inversely proportional to the resistance between the two points, meaning as one goes up the other goes down. This law can be expressed by the simple algebraic equation V equals I times R, as we can see in the first slide. In this equation, V is the potential difference measured across the resistance in units of volts; I is the current through the resistance in units of amperes; and R is the resistance of the conductor in units of ohms. I'll repeat that – V is measured in volts, I in amperes and R in ohms. Ohm's law states that the quantity R in this relationship is constant, independent of the current.

It might be useful to describe Ohm's law in terms of the analogy of water. Think of water flowing through pipes and this might make the concept a bit easier to understand. Let's consider a horizontal pipe, where the rate of water flowing through the pipe corresponds to current. If we do something that restricts the flow of the water, for example if we make the diameter of the pipe smaller, then this behaves just as a resistor does in an electric circuit. In this analogy, the difference in water pressure between two points of the pipe, for example before and after the restriction, corresponds to electrical voltage in a circuit. Ohm's law would say that the rate of water flow through the restricted part of the pipe is proportional to the difference in water pressure across the restriction. You can see this in Slide 3.

Now let's see how Ohm's law can help us analyze simple circuits. In a very simple circuit, the source of voltage is the battery. Ohm's law states that if we know the values of any two of the three quantities – voltage, current and resistance – we can use the law to calculate the value of the third quantity. For example, here we have a voltage of 3 volts and a resistance of 6 ohms. This means that the amount of current passing through the circuit is equal to *V* divided by *R*, which works out to be 0.5 amperes.

Unit 3, Lesson 2, Exercise D 1.13

Part 3

OK. So far, we've talked about Ohm's law, which involves current, resistance and voltage, but there is another measurement in circuits we need to look at now and that is *power*. First, we need to define power, then we can analyze it in an electric circuit.

Power is a measurement of how much *work* can be performed in a certain amount of time. The electric power associated with a complete electric circuit or a circuit component represents the rate at which energy is converted from the electrical energy of the moving charges into some other form, for example heat, mechanical energy or energy stored in electric fields or magnetic fields.

The equation that expresses the relationship between power, voltage and current is *P* equals *I* times *V*. So, for a resistor in a DC circuit, the power is given by the applied voltage multiplied by the electric current. You can see this in Slide 4. This is known as *Joule's law*. Joule was an English physicist who lived in the 19th century, and this was just one of his discoveries. In Joule's law, power, written as the capital letter *P*, is exactly equal to current – capital *I* – times voltage – capital *V*. The unit of measurement of power is the *watt* and its symbol is a capital *W*.

Unit 3, Lesson 2, Exercise E 1.14

Part 4

So let's summarize what power means in terms of electrical circuits. Joule's equation says that power equals current times voltage. It's clear, then, that we aren't talking about a proportional relationship here. And we can see that neither voltage nor current alone constitutes power. Power is a combination of both voltage and current – it is the voltage multiplied by the current, or in other words the product of the two quantities.

In practical terms, a circuit with a high voltage and a low current may involve the same amount of power as a circuit with a low voltage and a high current. Let's think about an open circuit – this is where the circuit is incomplete. In an open circuit, where a voltage is present between the terminals of a battery but there is no current flow, the power is equal to zero. And this is true even if the voltage is very high.

OK, I think that's enough for now. Do you remember me saying at the beginning of the lecture that Ohm's law isn't a real law? Well, next time, we'll have a look at some of the limitations of the law. We'll also see how the law can be applied to electromagnetism. So don't forget to do some research on this topic before then. Thank you and see you next time.

Unit 3, Lesson 2, Exercise F 1.15

1 Ohm's law is always true.
2 In the hydraulic analogy, current is the rate of flow of water through the pipe.
3 A resistor helps current flow more easily through a circuit.
4 Power is the amount of work done in a given time.
5 A circuit with a high voltage has more power than a circuit with a low voltage.

Unit 3, Lesson 3, Exercise A 1.16

1 'compass
2 incan'descent
3 appli'cation
4 'linear
5 re'lationship
6 'circuit
7 'zero
8 su'pply
9 electromag'netic
10 'terminal
11 'increase
12 re'sistor
13 'temperature
14 po'larity
15 em'pirical
16 'constant
17 'filament
18 'magnet

Unit 3, Lesson 4, Exercise C 1.17

Part 1

In the last lecture, we talked about Ohm's law and its application to simple electrical circuits. Today, we are going to continue looking at Ohm's law, but I want to do this in a little more depth. In the first half, I'll explain the limitations of the law. Then, in the second half of the lecture, I'll look at the very important influence Ohm's law has had in various fields, particularly in electromagnetics.

So, in the first part of this lecture, we will look at an example of a resistor that does not behave as Ohm's law suggests. A resistor can be defined as a circuit element that makes the passage of electric charge around the circuit more difficult. If you remember, in my last lecture, I used the analogy of water flowing through a pipe to illustrate Ohm's law. According to this analogy, a resistor corresponds to a restriction of the flow of water – for example, a narrowing of the pipe. If Ohm's law is to work, a resistor must have a specific resistance R – and this value should be constant. A resistor that restricts the passage of electric charge according to Ohm's law is known as an *ohmic resistor*. An ohmic resistor therefore has a single value of resistance over a range of operating conditions. I now want to show you that ohmic resistors are not part of the real world! This can create all sorts of problems, and I want to give you an example and look at the consequences of these problems.

Unit 3, Lesson 4, Exercise D 1.18

Part 2

As I said in my last lecture, Ohm's law is not a real law – it is an empirical observation. This means that it seems to be true in most situations. I now want to look at situations when it is no longer true. The main problem is that the resistance of the materials used in an electrical circuit tends to change with temperature. For example, in an incandescent lamp, a thin filament of metal wire is connected in an electric circuit and this wire offers resistance to the current flow. As a result of this resistance, the wire heats up to the point that it glows white-hot and emits light. The resistance of this wire increases dramatically as it warms up from room temperature to working temperature. This has an unusual consequence. It means that we could increase the supply voltage to the lamp circuit, and the increase in current would cause the filament to get even hotter. But this would increase its resistance and in reality prevent any further increases in current. This is clearly a very different relationship between current, voltage and resistance than the one described in Ohm's law. The resistance of the incandescent lamp's filament does not remain constant or stable for different currents.

This is not an isolated problem. Resistance changing with variations in temperature is common to nearly all metals. And, of course, wires are made of metal. Often these changes in resistance are very small and can be ignored when making calculations. However, in some cases, such as metal lamp filaments, the change is very large. If you look at the first slide, this shows the graph of the current in a lamp circuit for different values of battery voltage. As you can see, the graph is no longer a straight line. As the voltage increases from zero, the graph rises sharply. Then it begins to flatten out, as the circuit needs more and more voltage to achieve the same increase in current. Clearly, if we try to apply Ohm's law to find the resistance of this lamp circuit, we arrive at many different values depending on the temperature. The resistance is *non-linear* and it increases with current and voltage. The effects of high temperature on the metal wire in the lamp filament cause this non-linearity.

Therefore we can say that Ohm's law is true for a conductor at a constant temperature. But, as we have seen, the resistance, or *resistivity*, of materials is usually affected by temperature.

Unit 3, Lesson 4, Exercise E 1.19

Part 3

OK, so much for the limitations of Ohm's law. Now let's look at the application of Ohm's law to electromagnetics.

As I'm sure you remember, the orientation of the magnetic field produced by an electric current is always perpendicular to the direction of the current flow. This magnetic field is usually very weak in most situations – it can make a compass needle move, but not much else. To produce a stronger magnet with the same amount of current, we need to make the wire into a coil. The magnetic fields around the wire join together and create a much larger field with a clear north and south polarity.

The amount of magnetic field force generated by this coil is proportional to the current through the wire, multiplied by the number of turns of wire in the coil. Magnetic field force is known as *magnetomotive force* and it has the symbol *mmf* – written in lower case letters. It's very similar to the idea of electromotive force *E*, or *emf*, in an electric circuit. Magnetomotive force is just one important quantity associated with magnetism – there are several more quantities that you need to know about. We don't have time to look at all of these in detail, but on Slide 2 you will see a useful list. The ones we need today are field flux and reluctance. *Field flux* is the quantity of total field effect or 'substance' of the field. This is similar to electric current. *Reluctance* is the opposition to magnetic field flux through a given volume of space or material. Reluctance is therefore similar to electrical resistance.

So, to summarize, let's look at Slide 3. Just as Ohm's law describes the relationship between voltage, current and resistance in electric circuits, a very similar equation describes the relationship between field force, field flux and reluctance in magnetic circuits. This is a good illustration of how important Ohm's law has proved to be and I think Ohm himself would be very surprised!

Unit 5, Lesson 2, Exercise B 1.20

Part 1

Good morning, everyone. Shall we start? OK. Today we're going to look at television technology. Everyone nowadays, or nearly everyone, has a television set. In fact, many families have more than one. And, as you are probably aware, this is a very interesting time for television set design. After about 60 years of a more or less standard model based on the cathode ray tube, there are now several new types of television on the market. These take advantage of new technology in all sorts of ways, but particularly in terms of transmission and display.

So ... er ... let's see – yes – to start with, I'll look at a traditional cathode ray tube TV and how it works. Secondly, I'll examine the plasma screen – you may have heard of this but probably don't have one at home. Then we'll look at liquid crystal displays, or LCDs. After that, I want to analyze the changes which digital technology has brought to the field of television. I'll finish by mentioning one of the most exciting developments in this field – 3D television. I hope we have time to cover all these topics, so let's start straight away!

Unit 5, Lesson 2, Exercise D 1.21

Part 2

Actually, the basics of analogue television transmission have been more or less standard for the last 60 years. A video camera films a scene at a rate of 30 frames per second. The camera then turns the picture into rows of individual dots, or picture elements, called *pixels*. Each pixel is given a colour and intensity. The rows of pixels are then combined with horizontal and vertical synchronization signals so the electronics inside a TV set will know how to display them. The final signal, containing the colour, intensity and position of each pixel, is known as a *composite video signal*. A TV signal requires 6 megahertz of bandwidth frequency when a sound signal is added – you can see an example in Slide 2. The tuner in your TV extracts the correct video signal from the waves transmitted to the antenna.

Fundamentally, the big problem with analogue TV is resolution. An analogue TV screen displays 525 lines of resolution every 30th of a second. That's something like 512 by 400 pixels. With digital transmission, TV channels carry a 19.39 megabit per second stream of digital data on a separate frequency from analogue signals. A digital TV can receive and decode much more data, and it follows that digital screens can display more pixels than a traditional analogue TV. Naturally, that makes a big difference. I saw a tennis match on a digital screen and it was just amazing – such detail! Anyway, er ... to return to the main point, digital TVs offer a wide range of advantages over analogue TVs and will soon replace them completely.

Unit 5, Lesson 2, Exercise E 1.22

Part 3

There are two main types of digital screen – the *liquid crystal display*, or LCD, and the *plasma screen*. Let's look first at plasma. A plasma display panel, or PDP, has a much flatter screen than a cathode ray tube television. The panel is made up of tiny plasma cells situated between two panels of glass. Each cell contains a mixture of gases and mercury, and acts rather similarly to a fluorescent lamp. When an electric current is applied, the cell emits light, and different cells can be made to emit light of different colours by changing the type of phosphors painted on the inside of the cell. Each pixel consists of three cells which emit the primary colours of light – red, green and blue. Varying the voltage of the signals to the cells allows us to see different colours on the screen.

LCDs are arguably very similar to plasma screens – they are also light and thin. But they are actually very different. What I mean is, they are based on very different technology, and it's essential that we understand this difference. The general public doesn't seem to understand this so they go and buy a new screen and get the wrong one for their needs, wasting money. Er ... where was I? Oh yes. Perhaps the most important difference is that LCDs do not produce light of their own. They need a source of background light, which each pixel can block or allow to pass. A pixel of an LCD consists of a cell of liquid crystal, which is an unusual substance that consists of twisted molecules. They respond to an electric current by untwisting themselves. The amount they untwist depends on the voltage, and when they untwist, the amount of light that passes through the layer changes. In this way, the passage of light through each cell can be controlled electronically. In colour LCDs, each individual pixel consists of three cells with red, green and blue filters.

Unit 5, Lesson 3, Exercise B 1.23

Part 4

Finally, let's quickly look at the idea of 3D television. As you probably know, 3D films in the cinema have been around for some time. There have been various technologies developed, but the more successful ones have used *stereoscopy*. Basically, two film cameras are needed, which take two similar but slightly different images, just as our eyes see an object from similar but different angles. Each image is directed to one eye only and our brain combines them in such a way that we see a three-dimensional object. The problem here is how to ensure that one eye only sees one of the images projected on the screen. This is solved by a pair of glasses that the viewer has to wear. However ... oh, dear ... sadly, I see that we've run out of time. This means that I'll have to ask *you* to do some research. I'd like you to find out about these different types of glasses and the technology behind them, that is, coloured, polarized and active shutter lenses. We'll discuss what you've found out next time I see you.

Unit 5, Lesson 3, Exercise C 1.24

1 'seminar
2 'molecules
3 a'ssignment
4 reso'lution
5 dis'play
6 'overview
7 'analyze
8 'analogue
9 hori'zontal
10 fluo'rescent
11 de'vice
12 trans'mission

Unit 5, Lesson 3, Exercise D 1.25

Fundamentally, the big problem with analogue TV is resolution.

A digital TV can receive and decode much more data, and it follows that digital screens can display more pixels than a traditional analogue TV.

Naturally, that makes a big difference!

LCDs are arguably very similar to plasma screens – they are also light and thin.

But they are actually very different.

What I mean is, they are based on very different technology, and it's essential that we understand this difference.

Anyway, er ... to return to the main point, digital TVs offer a range of advantages.

Unit 5, Lesson 4, Exercise B 1.26

Extract 1

LECTURER: Right, Leila and Majed, what did you find out about 3D TVs?

LEILA: Well, first of all, we looked at the website 'How stuff works' to get an overview of the topic.

MAJED: I bought a new TV last week.

Extract 2

LECTURER: And what else did you do?

LEILA: We talked to my flatmate. He works for Sony.

MAJED: That was a waste of time!

Extract 3

LECTURER: Leila, can you give us an explanation of how passive lenses work in 3D technology?

LEILA: Well, yes, there are two different types of lens – coloured and polarized.

LECTURER: What do the rest of you think? Do you agree? Evie, what about you?

EVIE: Well, erm ... I'm not sure really.

Extract 4

LECTURER: Majed, can you explain how the coloured lenses work?

MAJED: OK. Right, the screen shows two different images. Each image has a sort of coloured tint to it, and this corresponds to the colour of the lenses.

JACK: So it's anaglyphic.

Extract 5

LECTURER: What do you mean by 'anaglyphic', Jack?

JACK: I mean using coloured lenses for 3D television is an example of anaglyphic technology. That's what …

EVIE: Actually, it's called stereoscopy.

Unit 5, Lesson 4, Exercise C 🎧 1.27

Extract 6

LECTURER: Let's go back to this idea of wearing coloured glasses – what we call anaglyphic technology. First of all, tell us about the choice of colour for the lenses.

LEILA: Well, all the information we've read talked about blue and red lenses for the glasses. Didn't it, Majed?

MAJED: Yes. Those were the only colours they used – and it's a special type of blue called cyan.

Extract 7

MAJED: The picture on the screen shows two different images that have been filtered differently.

JACK: Sorry, I don't follow. Could you possibly explain how they are filtered?

MAJED: Well, basically they colour one image blue and one image red.

Extract 8

EVIE: I don't understand how we see a 3D object from these two images.

LEILA: Well, imagine the screen shows a banana. Our left eye sees the banana slightly differently from our right eye. For example, it will see a part of it that is hidden from our right eye. The two images on the screen correspond to these different views.

Extract 9

MAJED: Yes, the visual cortex of the brain combines these two images into the perception of a three-dimensional object.

JACK: If I understand you correctly, you're saying that our brain sees these two images and believes it is looking at one real object in space.

MAJED: Yes, that's correct.

Extract 10

LECTURER: This is all very interesting, isn't it?

EVIE: Yes, but if we just go back to the idea of 3D TV, this method of using coloured lenses in glasses is now rather old-fashioned.

LEILA: That's right!

Extract 11

JACK: I think the whole idea is silly. I mean, it would be really expensive. And anyway we can't sit at home watching TV wearing strange glasses!

MAJED: I'm not sure that's true. I think the 3D effect could be so effective that we might find normal TV a bit boring in comparison.

Extract 12

LECTURER: So what do you think is the most effective 3D TV technology available?

LEILA: As Evie said earlier, the idea of coloured glasses was popular some years ago.

Extract 13

LECTURER: Any other ideas?

EVIE: I'm sorry. Has anybody made the point that 3D TVs are really expensive. Maybe no one will buy one because of that.

LECTURER: Yes, actually. Jack did say that earlier, but it's an important point.

Extract 14

LECTURER: So any other points about 3D TV?

EVIE: I don't know if this is relevant but 3D technology might be more appropriate for computer games than for normal television.

LECTURER: Yes, that's interesting.

Unit 7, Lesson 2, Exercise B 🎧 2.1

Part 1

Good morning, everyone. What I'm going to talk about today is *electric power transmission*: how electric power is carried from the power stations that generate it, to substations situated near towns and cities. This is only part of the process. What I mean is that from these substations, electricity is then distributed to individual customers in private houses, or factories and commercial buildings. This is the end of the distribution process. But this second step is known as *electricity distribution*, and is quite a different field in many ways from transmission. Plus, transmission and distribution lines are usually owned and operated by different companies. So I will deal with it later – I mean, in a future lecture.

Today, I want to look at how electricity is transmitted through high-voltage transmission networks, known as the *grid*. We will also look at a number of different types of current that can be used when transmitting electrical energy, including three-phase alternating current. Energy loss is a big problem here, so I want to show you a variety of ways that energy companies use to try to reduce this. We will then look at different sorts of generating power plants, and how supply and demand for electricity needs to be balanced. Bearing in mind that an imbalance can cause a major regional blackout, this is a very important area.

So, er ... in my next lecture, we'll look at the location of power lines that make up the grid – overhead and underground. Today, however, let's start by looking at electrical transmission.

Unit 7, Lesson 2, Exercise C 2.2

Part 2

The important thing about power transmission is the use of very high voltages. Joule's law states that energy losses in a power line are directly proportional to the square of the current passing through it. If the current is halved, the energy lost will be quartered. In other words, increasing the voltage in the line reduces the current, and this in turn reduces energy losses. So high voltages are used in order to keep losses to a minimum.

However, generating plants produce electricity at a relatively low voltage – between 3 and 30 kV. This voltage is increased using a step-up transformer to between 200 and 1200 kV for transmission over long distances to make it efficient from the point of view of costs. But we cannot use this sort of voltage in our homes, so, at substations, step-down transformers take the voltage back to a lower level for distribution. At the point of use, the electricity is transformed to an even lower voltage in such a way that it is suitable for commercial and domestic users.

These different steps in regulating the voltage level are the best way to keep the transmission process efficient and cheap, as well as safe.

Unit 7, Lesson 2, Exercise E 2.3

Part 3

Now, an important concept in electric power transmission is three-phase alternating current. // As you know, single-phase alternating current fluctuates. But in some situations it is useful to have a current with constant power and this is actually possible from a three-phase alternating current system. What do I mean by *three-phase*? Well, instead of only one power line with alternating current, there are three separate power lines running in parallel. // As you can see in the graph I'm handing out now, in each curve the current phase is shifted one-third of the cycle, so one curve is running a third of a cycle behind the second one, which is behind the third one. This is *three-phase alternating current* and it offers constant power. // Looking at it another way, if you consider the horizontal axis in the graph, we can see that the sum of the three voltages is always zero, and that the difference in voltage between any two phases oscillates as an alternating current. // In mathematical terms, since a full cycle lasts 20 milliseconds in a 50 Hertz grid, each of the three phases differs by 6⅔ milliseconds. //

However, three-phase alternating current is not the only option. Say, for example, electric power needs to be transmitted over very long distances. It is cheaper to use direct current than alternating current because fewer losses and lower construction costs are involved. // The point is that transmitting direct current is cheaper for very long distances – and by this I mean 600 kilometres or more – even though there are extra costs associated with converter stations at each end of the line. // In this way direct current can offer an efficient alternative when transmitting electric power over the length of a country or continent.

Unit 7, Lesson 2, Exercise F 2.4

Part 4

Now ... er ... let's see ... oh dear, I see we're running short of time ... but perhaps I should say something about load balancing.

A major problem with power transmission is that it is difficult to store electric energy. So this energy needs to be generated more or less as it is required. This idea of matching supply and demand creates all sorts of problems. If there is an imbalance, the whole power system can fail, causing blackouts. When these blackouts occur, large areas of the country are left without electricity for several hours. This sort of failure can be avoided by joining electric transmission networks together in nationwide or continent-wide grids.

There are two main benefits of this sort of grid. First, there are a range of alternative power routes available. What's important about alternative routes is that if some lines stop working, power can be directed through other lines. In this way it can still arrive at the required destination. Second, using a long-distance network means that it is easier to balance the demand for electricity with production. What's interesting is that demand may not be distributed evenly over a country. Imagine one region is experiencing extremely hot weather. Demand for electricity will increase because everyone is using air-conditioning. There may not be enough electricity produced locally to satisfy this demand, so transmitting electrical energy from another part of the country will help ensure that system failure does not occur.

In this way we can see that creating wide power grids covering large areas makes a lot of sense. However, there is more to load balancing than simply moving electricity from one area of the grid to another. Demand can increase at certain times of day throughout the whole grid, and these variations of load need to be carefully planned for. This is done by using a combination of different types of electric power stations.

Now ... oh dear, I was going to mention the different sorts of power station that exist and their advantages and disadvantages, but ... ah ... I see that time is moving on. So instead, I'm going to ...

Unit 7, Lesson 3, Exercise A 2.5

1 trans'mission
2 gener'ation
3 distri'bution
4 'pylons
5 'network
6 'station
7 'alternating
8 de'mand
9 im'balance
10 con'ductor
11 'energy
12 'power

Unit 7, Lesson 3, Exercise B 2.6

Part 5

The fact of the matter is, transmitting electricity always involves some sort of energy loss due to resistance. I'm going to finish with some comments about voltage-regulating transformers – in other words, how the voltage in power lines is stepped up and stepped down during the transmission process in order to reduce losses. As we have seen, for a given amount of power, it's raising the voltage that reduces current and resistive losses. This is why long-distance transmission uses high voltages – not to mention the fact that high voltages also mean that thinner copper conductors can be used, which reduces costs.

However, there is a limit to how high the voltage can be made, and how thin the conductors can be. The reason for this is that there are physical limits and financial considerations. Let's take overhead power lines as an example. If the conductor is made too thin, it has difficulty supporting itself on a purely mechanical level. So extra supports, or pylons, are needed, as well as more pole insulators, maintenance, et cetera. It's all these extra costs that make the transmission of electricity much more expensive. Plus there's the fact that higher voltages have consequences in terms of safety – so this is another important limitation.

You've probably heard of how transformers work to regulate voltage, with two coils turned around a ferromagnetic core? Please take another look at the diagram I gave out earlier in the lecture. The varying current in the primary winding creates a varying magnetic flux in the core, and this in turn creates a varying magnetic field, which induces a voltage in the secondary winding. And this second voltage depends on the number of turns in the winding. It's these basic principles that all transformers follow. But, in practice, they are very flexible electrical devices. Let me put it another way. Transformers can range from tiny items found in small electrical devices such as microphones, to huge, incredibly heavy units used to interconnect sections of a continental power grid. Their use in transmission substations is what interests us today – for stepping up and stepping down the voltage of power lines as they cross the country.

Oh, I almost forgot to mention your research topics. OK, well, what comes after the transmission process is distribution of electricity to customers. So I'd like you to find out how this takes place and what are the main features of electricity distribution.

Unit 7, Lesson 4, Exercise B 2.7

Extract 1

Now, as we know, the distribution of electricity comes after the electric power has been transmitted to the substations and the voltage reduced using step-down transformers.

Distribution involves supplying electricity to all the different customers who need it – and that includes you and me at home as well as here at university. However, don't forget, we are not talking about the retail of electricity – in other words, how it is sold. So the distribution process stops at the electricity meter. Once a customer is connected, the measurement and pricing of electricity is another matter entirely. Now … what sorts of customer are there and what sorts of electricity do they need? Let's have some ideas.

Unit 7, Lesson 3, Exercises C and D 2.8

Extract 2

JACK: Well. I'd like to make two points. First, different customers need electricity at different voltages.

LEILA: Can you expand on that, Jack?

JACK: Sure, Leila. Factories and heavy industries need around 50 kV.

LEILA: So?

JACK: So the point is that that's very different from the sort of voltage we need in our homes – that's around 240 V.

LECTURER: OK. So, what's your second point, Jack?

JACK: I was coming to that! My second point is that different customers need different kinds of current.

LEILA: Yes, but that's not important. They can all use the same alternating current if necessary.

MAJED: Well, I don't agree with that, Leila, because from what I've read, some customers need a three-phase service – which is how electricity is transmitted over the grid.

EVIE: Sorry, but who are we talking about, exactly? What sorts of customers are these?

LEILA: Yes, we need to be clear here. We certainly don't need three-phase alternating current in our homes. That would be ridiculous!

EVIE: In what way?

LEILA: Well, you only need three-phase current if you've got heavy equipment.

EVIE: I don't get that. Some people have big equipment in their homes too.

LEILA: What I'm trying to say is, only factories with big machinery need three-phase current. For the other customers, single-phase is enough.

EVIE: I still don't understand. Can you give me an example, Leila?

LEILA: OK. Look at it this way. A printing press is a really big piece of machinery. It needs three-phase alternating current at 50 kV. But light industry and residential customers don't need so much electrical power. Single-phase is enough for them.

MAJED: Yes, and single-phase is much cheaper to deliver. So it's much more suitable.

LECTURER: Absolutely. Cost and safety are the key factors when deciding what is the best way to distribute electricity.

MAJED: Yes, and I'd just like to say that I've read about a system called *single-wire earth return* – that's S-W-E-R for short – and this can be used for rural distribution. It's really cheap to set up so makes sense when there are only a few customers spread over a wide area.

Unit 9, Lesson 2, Exercise B 2.9

Part 1

Good morning, everyone. I'm going to talk to you this morning about signal processing, and in particular, the two main approaches: analogue signal processing and digital signal processing. I'm going to look at some of the key advantages of each of them, and also mention the idea of using a mixed approach. As we shall see, a mixed approach is perhaps the best for several reasons, and I want to look at how this works in practice.

First of all, however, let me define some important terms. We talk about signal processing, but what do we mean by the term 'signal'? A formal definition of a signal is as follows. It is a function of – or we could say a variable that depends on – one or more other variables, called independent variables. This is written as shown on Slide 1. Examples of independent variables are temperature, distance, time, et cetera.

As electrical engineers, we are mainly interested in an electrical signal carried by a wire, or perhaps a radio wave. This signal is a function of just one independent variable, which is – time. We can plot this function against the time variable, and we get a graph of a waveform. This waveform is the signal, or rather the form that the signal takes.

Now, there are two main types of signal. There are continuous time signals and discrete time signals. In digital signal processing, time can only take discrete values – for example, 1 second, 5 milliseconds, et cetera – and to show this we use a small *n* as a symbol. In this course, we will mainly be looking at signals involving discrete time. But just because the time variable consists of discrete numbers, this does not automatically make the signal digital. If the amplitude of the signal does not consist of just discrete values, then it is still an analogue signal, not a digital one. It is only when the amplitude is coded in some form – usually in a binary form – that it becomes a digital signal. So it should be clear that analogue and continuous time signals are not two ways of saying the same thing. It all depends on whether or not the value of the amplitude is coded into discrete values. This is an important point, and one which can sometimes cause confusion.

It's very important to study signals, because they may carry information. It's true to say that sending and receiving information, and then reacting to the information we have received, is fundamental to human life.

I have a little story to tell you. This morning, as I was driving here on my way to this lecture, I received a phone message on my hands-free set from my wife. She told me that she couldn't get to work because the car wouldn't start. So I had to go back home, take her to work and then come on here to the university. That's why I was a little bit late for this lecture! But the point of this story is that it illustrates, in a very small way, how important messages and signals are in our everyday life. We really couldn't do without them – they're an integral part of living together in groups or as a society.

So ... to get back to the main part of my lecture: what about 'processing'? What does processing involve and why is it so important? Well, we process signals in order to change them into a better form. 'Better' means more useful or convenient. For example, consider the electrocardiogram – or ECG – waveform. The first picture on Slide 3 shows what this waveform usually looks like. It's very important that the signal is clear, so doctors can analyze the trace for any problems or malfunctions. But research has shown that the signal can easily be corrupted by 'noise'. For example, the trace can be corrupted by 50Hz power line pickup from the normal electricity supply. To eliminate this noise, we can use a band-elimination filter when the signal is processed. In this way, we can see how signal processing can give a clearer ECG trace. It has changed the signal into a 'better' and more useful form, as seen in the second picture on Slide 3.

There are three basic ways of processing signals. The first way is analogue processing. Here, the signal is received and processed in analogue form. This was the most common form of processing up until the 1970s. The second way is digital processing. In terms of convenience and accuracy, digital processing is a much better option thanks to the invention and use of microprocessors. It is usually much cheaper too.

The third type of processing is what we call 'mixed', and this means a combination of analogue and digital processing. It could be argued that analogue processing is out of date and no longer needed. After all, we have seen that digital processing is much more effective and economical. But it's not that simple. From the point of view of the real world, most of the signals we meet are analogue in form, and most of the output that we need is analogue. For example, think about telephony: we speak into the phone and generate an analogue signal. This can then be converted into a digital signal and processed in various ways. It can then be transmitted and received by another phone in digital form. But we can't listen to a series of zeros and ones – this is the big problem with digital forms! So we need to convert the digital signal back into an analogue one – in other words back into speech. So increasingly we find that engineers use mixed processing for the best, most useful results. And that's what I want to look at in the next part of the lecture ...

Unit 9, Lesson 2, Exercise C 2.10

Part 2

Let's turn now to filters and have a look at them in a little more detail. We have already mentioned one type of filter – the band-elimination filter, which reduces the level of noise in the ECG graph. From this example, we can see that filters can do two different jobs. First, they can remove the unwanted components of a signal, such as random noise; and second, they can extract and keep the useful parts of a signal, such as the components lying within a particular frequency range.

Just like signals, filters can be analogue or digital. Let's first look at analogue filters. In this type of filter, the signal is an electronic voltage or current which is a representation of the physical quantity that is being processed. It could be, for example, a video signal representing moving images. Analogue filters are made up of electronic circuits and consist of components such as resistors and capacitors. There are clear procedures for designing these sorts of circuit, and exact instructions for arranging the components in such a way that they achieve the desired filtering effect.

Digital filters, on the other hand, are processors that process a digital signal by performing numerical calculations on the discrete values of the signal. The signal in a digital filter is represented by a sequence of numbers, usually in binary code, instead of a voltage or current.

But before the digital filter can begin its work, the analogue input signal must be converted into a digital signal. How is this done? Well, an ADC, or analogue to digital converter, contains a device that analyzes the analogue input in two ways. The device first samples the input signal and then holds the signal constant until it takes the next sample. In this way the analogue input is converted to a digital output using binary code. Once we have a binary digital signal, this can then be processed using numerical calculations.

After it has been processed in some way, the digital output needs to be converted back into an analogue signal. In other words, we need to convert the discrete values in the digital signal to the continuous variation of an analogue signal. However, when the amplitude value changes rapidly, the conversion can result in a series of rapid steps, which can be a problem.

That reminds me of an experiment I did some time ago, when computers had very little processing capability and were very slow. Using a record of a song by Elvis Presley, we used an ADC and then converted the digital signal back to analogue again – just to see what would happen. Well, the sampling was very slow, because the computer simply couldn't hold very much information, and the resulting output was very, very strange. It certainly didn't sound anything like Elvis Presley – more like a robot singing! A very funny experiment – although modern equipment would be able to do this extremely easily and quickly of course ...

Now where was I? Oh yes, right, I was talking about the problems of converting from digital to analogue. Well, to smooth out these steps, or sudden changes in value, we can use a low-pass filter. This conditions the signal by reducing the amplitude of signals with high frequencies. At this point, we now have a useful analogue output signal.

There are many advantages of digital filters. First of all, they are programmable and can be easily changed without touching the circuitry or hardware. This is not true for analogue filters, which can only be changed by redesigning the circuits.

Secondly, analogue filters tend to be subject to something called 'drift'. This is the phenomenon that occurs when the circuit is switched on – there is an uncontrolled slow change in the way it operates. Analogue filters are also sensitive to temperature. So we can see that they tend to be rather unstable. Digital filters, on the other hand, are extremely stable.

A third advantage of digital filters is that they work very effectively with low-frequency signals – we'll look at this in a future lecture. This is an area where analogue filters have great difficulty in operating. In the past, digital filters had trouble with high-frequency signals in the radio frequency domain, but this is changing thanks to new technology. This means that digital filters are now able to operate in a very wide range of frequencies.

Unit 9, Lesson 2, Exercise D 2.11

1 As we shall see, a mixed approach is perhaps the best for several reasons.

2 So it should be clear that analogue and continuous time signals are not necessarily the same.

3 It's true to say that sending and receiving information, and then reacting to the information we have received, is fundamental to human life.

4 But research has shown that the signal can easily be corrupted by 'noise'.

5 In terms of convenience and accuracy, digital processing is a much better option thanks to the invention and use of microprocessors.

6 It could be argued that analogue processing is out of date and no longer needed.

7 From the point of view of the real world, most of the signals we meet are analogue in form, and most of the output that we need is analogue.

8 So increasingly we find that engineers use mixed processing.

Unit 9, Lesson 3, Exercise A 2.12

1 'analogue 'signal, 'binary 'code, disc'rete 'value, 'random 'noise

2 'frequency, 'processing, 'barrier, de'pendent

3 'amplitude, com'pression, con'version, ex'traction

4 modu'lation, peri'odic, 'variable, inter'ference

Unit 9, Lesson 3, Exercise C 2.13

Part 3

OK, so let's move on to look at some of the applications of signal processing and filters. There are so many applications that it's actually been quite difficult to choose just one of them, but I have chosen what I consider to be one of the most important. In fact, as Ansari and Valbonesi point out in *The Electrical Engineering Handbook*, which is one of your core texts – the 1st edition was published in 2004 – signal processing is everywhere in everyday life, although this may not be evident to most people.

Anyway, today I'm going to focus on active noise control, or ANC. This is an extremely important application of signal processing – both analogue and digital – and has resulted in some very useful devices, as we shall see. We use the term *active* because there are also passive methods of controlling or reducing noise, which you may be familiar with – ear plugs, for instance, or soundproofing using sound-absorbing ceiling tiles. We call these *passive* because there is no added power to the noise control system.

One definition of active noise control, given by thefreedictionary.com on the web, is: 'A method of reducing unwanted sound.' So ANC is basically a way of taking an unwanted audio signal and eliminating it – or at least greatly reducing it. Let's first look at what sound is exactly. Well, as you probably already know, sound is a pressure wave. It consists of two phases: a compression phase and a rarefaction phase. Please note that while rarefaction begins with the spelling R-A-R-E, the *e* is pronounced as a separate syllable, so we say rar-e-fac-tion – I'll just write that on the board for you. In ANC, a computer analyzes the waveform of the incoming unwanted sound and then generates, and emits via a speaker, a sound wave which is identical – or directly proportional – to the original audio signal in terms of amplitude. However, the wave has an inverted phase compared to the original wave. This means that it is 180 degrees out of phase with the wave associated with the noise. We also call this *antiphase*. This means that the two waves combine and form a new wave – we call this process *interference*. The waves basically cancel each other out. This destructive interference is known as *phase cancellation* and results in an output signal which has such a small amplitude that it may not be audible.

There are three basic models of ANC, and in each one the speaker or sound / wave transmitter is placed in a different location. In one model, the speaker is located next to the source of the unwanted sound. It follows from this that the speaker must emit its cancellation signal at the same power level as the source – probably quite a high level. In another model, the speaker is located where the sound reduction is required – and that means near the listener's ear. Of course, in this case, we can use a much lower power level. However, it does mean that each listener needs his or her own speaker – so the situation becomes a little more complicated in that sense. Sometimes the speaker is put in a third position – neither at the source nor at the ear. However, this can work only with a stationary listener, because as soon as he or she moves, the sound and cancellation signals will no longer match, and the interference will no longer be effective.

By the way, I see that some of you are using the Cornell note-taking system. That's very good. Do you all know about this? No? Right, well, if you want to know more about it, I suggest you look at *How to Study in College* by Walter Pauk, the 10th edition, published in 2010. It's very good, and it should be in the university library. I'm sure that you all know the importance of taking good notes – and this system is particularly useful.

So to get back to the main topic ... as you can imagine, active noise control works much better than passive methods. And this is particularly true at low frequencies, for which passive soundproofing is less successful. ANC also works best when the sound is periodic. Don't forget that when we use *periodic* in electrical engineering we mean *repetitive* – this is different from the general English meaning of *periodic*, to mean something that happens not very often. And the fact that ANC works well with periodic signals holds true even if the signal is quite complex. It also follows from this that random sounds – by which I mean non-periodic sounds – create more of a problem in terms of cancellation.

Let's now look at a specific application of ANC: noise-cancelling headphones. These consist of a pair of headphones which completely cover the ears and form a physical barrier that can help block high-frequency sound waves. They therefore use classic passive noise cancellation methods. But they combine these with active methods too, and it's this concept that interests us today. A microphone inside the headphone cup picks up the external sounds that cannot be blocked passively. An electronic device located next to the microphone analyzes the amplitude and frequency of the external sound signal to generate a new wave in antiphase to the original. Circuitry feeds this new wave into a speaker located in the headphones and destructive interference erases the noise. All this is powered by a rechargeable battery. The great thing about these headphones is that ANC can be used in parallel with a normal audio signal coming through the speaker, such as when we are listening to the radio or watching a video. The speaker simply emits the *anti-sound* wave created by the ANC device, together with the normal audio. And the result can be surprisingly effective – providing a reduction of up to 20 decibels in addition to the passive noise control that the headphones provide.

Now, I think that's all I'm going to say for the moment on ANC. Are there any questions so far? No? OK. Now, when I see you in tutorials we'll look at how digital signal processing developed in the 1960s and 1970s, and the inventions that helped this development take place. In the meantime, I'm going to set you a research task.

Now, as I said before, it's easy to forget just how many applications of signal processing there are. To quote Ansari and Valbonesi, 'Users may be familiar with JPEG, MPEG and MP3 without recognizing that these tools are rooted in signal processing.' Right, now listen carefully … your research task is to find out about one important application of signal processing in more detail: speech recognition, otherwise known as *voice recognition*. Now, there are several different systems included under the general term of *speech recognition*. I'd like you to work in groups of four. I want each group to find out about *one* speech recognition system and report back on their findings.

Unit 9, Lesson 3, Exercise D 2.14

Extract 1

There are so many applications that it's actually been quite difficult to choose just one of them. In fact, as Ansari and Valbonesi point out in *The Electrical Engineering Handbook* (one of your core texts – the 1st edition was published in 2004), signal processing is everywhere in everyday life, although this may not be evident to most people.

Extract 2

One definition of active noise control, given by thefreedictionary.com on the web, is: 'A method of reducing unwanted sound.'

Extract 3

By the way, I see that some of you are using the Cornell note-taking system. That's very good. Do you all know about this? No? Right, well, if you want to know more about it, I suggest you look at *How to Study in College* by Walter Pauk, the 10th edition, published in 2010. It's very good, and it should be in the university library.

Extract 4

Now, as I said before, it's easy to forget just how many applications of signal processing there are. To quote Ansari and Valbonesi, 'Users may be familiar with JPEG, MPEG and MP3 without recognizing that these tools are rooted in signal processing.'

Unit 9, Lesson 4, Exercise C 2.15

Extract 1

Digital signal processing started in the 1960s with the development of digital computers. These computers were able to run the number-crunching applications which were necessary to analyze the frequency spectrum of the input signal, and to do this in real time. Before the 1960s, these techniques were simply impossible due to the lack of suitable technology.

Extract 2

… erm, I think signal processing is very important. It's possible … er … we can see how this is very important. So let's look at the chart and … oh, sorry, that's the wrong chart, just a minute … right, so this shows some of the main applications of signal processing … er you can see I think, these applications … do you have any questions about this chart?

Extract 3

Digital signal processing is usually considered to be superior to analogue signal processing – it's much more powerful and also much cheaper. However, we should not forget that analogue signal processing has capabilities that make it more suitable in certain situations. For example, if the input signal is in analogue form, it can be expensive and complicated to use an ADC. More importantly, it can result in a delay – and this may make it unusable for systems that need to operate in a real-time environment.

Extract 4

In the late 1970s, the invention of the microprocessor meant that digital signal processing became used in an extremely wide range of situations. General-purpose microprocessors led to the development of *digital signal processor* chips – or DSP chips. These are specialized programmable microprocessors which were designed specifically for the numerically intensive operations that digital signal processing requires. If we look at the chart I've prepared here, we can see some of the operations that DSPs are able to carry out. Over the last few years, faster and more powerful versions of these DSPs are appearing on the market, and their sales make up an ever-increasing share of the world market for electronic devices.

Unit 11, Lesson 2, Exercise B 2.16

Part 1

Good morning. My name is Dr Mary Myatt and I'm an electrical engineer and researcher working in the field of microsystems technology, or MST. It's a pleasure to be here today. I'm going to explain some of the main developments that are happening in the field of microelectromechanical systems, that is to say, I shall be looking at very small mechanical devices built onto semiconductor chips. To some degree, I believe that the area of microelectromechanical systems – or MEMS for short – is perhaps the most interesting sector of electrical engineering at the present time. Now, don't misunderstand me, I'm not implying that other areas of electrical engineering are boring! But it is fair to say that there is something particularly exciting about the developments in MEMS and, recently, at a nano level – NEMS.

So, in an attempt to give you an overall picture of this field, let's start with the question: What are MEMS? Well, although they are very modern, they were first predicted in 1959 by Richard Feynman. Feynman gave a description of smaller and smaller machines in his famous talk: 'There's plenty of room at the bottom.' Briefly, he explained how building and controlling devices at smaller scales would have a wide range of potential applications. And this is exactly what has happened with respect to a number of common electrical products.

MEMS consist of an electrical element and a mechanical element. The electrical element is a central microprocessor, which processes data. The mechanical element acts in response to this data. Now, there are two main types of MEMS: sensors and actuators. *Sensor* devices collect data, whereas *actuators* follow commands with highly controlled movements. The thing to remember about MEMS is their size: between one and a hundred micrometres – about the thickness of a human hair. Yes, tiny! MEMS can be found in inkjet printers, car tyre pressure sensors, video projectors, hearing aids and many, many other products.

Today, I want to look at how MEMS are manufactured, and explore two uses of MEMS in more detail: in car crash sensors and in the latest video projectors.

Unit 11, Lesson 2, Exercise C 2.17

Part 2

Let's first look at how MEMS are made. The manufacturing process is similar to that of typical microelectronic products, and uses the same materials – silicon, for example. Extremely thin layers of various materials are deposited onto a base. This is the *deposition* stage. After this, a pattern, or design, is transferred onto the layers. This is usually done using a photosensitive material – a material which changes its physical properties when exposed to a radiation source, such as an electron beam or X-rays. The important point here is that the material is not uniformly exposed to the radiation. Some of it is masked, and, so ... we've got two parts. The properties of the two parts become different. I mean, the parts of the material which were exposed develop different properties from the parts which were hidden. These differences can then be exploited, and exposed parts removed by dissolving them in a chemical solution, such as an acid, or by allowing them to react to a gas or a combination of gases. This process of removing parts of a layer is known as *etching*. Etching leaves a microscopic three-dimensional surface. In this way, both electrical and mechanical components are constructed.

Now let's look at some applications of MEMS. First, I want to talk about car crash sensors. The MEMS that are used here are a form of accelerometer – they measure changes in the car's speed. Inside the tiny device, there is a weight attached to a spring or hinge, and this mass moves as the car slows down or speeds up. The MEMS contain electrical sensors that can send data about the movement of the mass to a microprocessor, which monitors this information. In a crash, there is a sudden negative acceleration – a deceleration – and when this reaches a certain critical level, the airbags open. All this happens in a fraction of a second. Now, airbags in cars have been around for some time, so you might wonder what's so special about using a MEMS for this. Well, I have a colleague who's been directly involved in the development of these new sensors, and she has no doubt that the use of MEMS has meant a huge improvement on earlier versions, making the sensors more reliable – and this means safer – as well as cheaper.

Another product that has been greatly improved by the use of MEMS is the video projector. Do you remember I talked about some MEMS being actuators? Well, this is a case in point. These actuators use micro-mirror devices to improve image quality. Micro-mirror devices consist of extremely small mirrors attached to hinges. The mirror can move on the hinge in two directions: towards the light source, which means the mirror will reflect the light, or away from the light source, which means the light will be blocked. Each mirror corresponds to one pixel of the projected image, so if the mirror reflects the light source there will be a tiny point of light on the screen. Not only that, but the amount of time the mirror reflects light will also give the perception of brightness: the longer it reflects, the brighter the point. In this way, up to sixteen million different shades of colour can be achieved. Now this is a massive improvement on previous technology, to the extent that it is now being used in cinemas, and replacing old film projectors.

Some people say that MEMS don't bring anything new to electrical engineering – it's simply a case of making existing devices smaller. But the evidence shows that this is not really the whole story. In my view, both the examples I have presented today show how MEMS can *improve* existing products, making them more reliable and more accurate, and sometimes doing the task more cheaply. If we don't recognize the benefits that MEMS can bring, and act on them, we could get left behind and that would be a disaster. As Feynman said in his excellent talk, the whole of technology benefits as a result of developing smaller-scale devices. Actually, MEMS are destined to become more and more important in the future, in all sorts of different ways. Now, I'm going to stop at this point and ...

Unit 11, Lesson 2, Exercise F 2.18

Some people say that MEMS don't bring anything new to electrical engineering – it's simply a case of making existing devices smaller. But the evidence shows that this is not really the whole story. In my view, both the examples I have presented today show how MEMS can *improve* existing products, making them more reliable and more accurate, and doing the task more cheaply. If we don't recognize the benefits that MEMS can bring, and act on them, we could get left behind and that would be a disaster. As Feynman said in his excellent talk, the whole of technology benefits as a result of developing smaller-scale devices. Actually, MEMS are destined to become more and more important in the future, in all sorts of different ways.

Unit 11, Lesson 2, Exercise G 2.19

Extract 1

I'm going to explain some of the main developments that are happening in the field of microelectromechanical systems, that is to say, I shall be looking at very small mechanical devices built onto semiconductor chips.

Extract 2

To some degree, I believe that the area of microelectromechanical systems – or MEMS for short – is perhaps the most interesting sector of electrical engineering at the present time.

Extract 3

Now, don't misunderstand me, I'm not implying that other areas of electrical engineering are boring!

Extract 4

But it is fair to say that there is something particularly exciting about the developments in MEMS and, recently, at a nano level – NEMS.

Extract 5

So, in an attempt to give you an overall picture of this field, let's start with the question: What are MEMS?

Extract 6

Feynman gave a description of smaller and smaller machines in his famous talk: 'There's plenty of room at the bottom.'

Extract 7

Briefly, he explained how building and controlling devices at smaller scales would have a wide range of potential applications.

Extract 8

And this is exactly what has happened with respect to a number of common electrical products.

Extract 9

Well, I have a colleague who's been directly involved in the development of these new sensors, and she has no doubt that the use of MEMS has meant a huge improvement on earlier versions ...

Extract 10

Do you remember I talked about some MEMS being actuators? Well, this is a case in point.

Extract 11

Not only that, but the amount of time the mirror reflects light will also give the perception of brightness ...

Extract 12

Now this is a massive improvement on previous technology, to the extent that it is now being used in cinemas, and replacing old film projectors.

Unit 11, Lesson 3, Exercise A 2.20

'building blocks

'carbon nanotubes

'car crash sensor

chemical 'properties

'current density

digital 'switch

electromechanical de'vice

integrated 'system

manu'facturing processes

'weighing device

Unit 11, Lesson 3, Exercise B 2.21

Part 3

So, now we've seen what MEMS are, let's look at something even smaller! We will move from the microscale to the nanoscale. And, just as we had *microelectromechanical* systems, we can have *nanoelectromechanical* systems, or, in other words, NEMS. The principle is the same: a combination of electrical and mechanical devices working together, but this time measuring from one to a hundred nanometres. To give you an idea of this size, a human hair is around 100,000 nanometres wide!

If you recall, earlier today I spoke about the two main uses of MEMS for sensors and actuators. Well, NEMS seem to have a lot of potential as sensors. Research has shown that they are highly sensitive detectors of various quantities such as mass, charge, energy and displacement. To give an example, do you remember the MEMS used as a car crash sensor? Well, imagine that sort of device consisting of a mass attached to a hinge, but now imagine it much, much smaller. At this scale, the electrical circuit measuring the deflection of the hinge is capable of sensing the weight of an individual atom or molecule which is resting on it. It becomes a tiny weighing device!

This sort of device would need to be built in a very similar way to how MEMS are built. The question is: How small can we go? Some people claim that there is no limit in terms of size, and that the same manufacturing processes used in MEMS can be used to produce NEMS: deposition and etching. I'm afraid that just isn't true. It's quite clear that the main problem in the development of NEMS is with the transduction element of the system. A transducer converts mechanical energy – for example, a vibration – into electrical energy. Research has concluded that making transducers at a nanoscale level is not at all easy. The evidence lies in the fact that as electromechanical devices are made smaller and smaller, it becomes very difficult to create an efficient and finely controlled integrated system.

However, there is another approach available for creating NEMS, using the chemical properties of single molecules. Perhaps the most exciting materials are *carbon nanotubes*. These are molecules of carbon allotropes – allotropes are different forms which a chemical element can take. Carbon nanotubes look like very long thin cylinders. Their diameter is only a few nanometres, but they can be up to several centimetres in length. They are extremely strong and have interesting electrical characteristics, acting as semiconductors in some circumstances. This means that they can be used to create nanotube-based transistors – one of the key building blocks in any electronic device. For example, a carbon nanotube can be employed as a digital switch, using a single electron. Some carbon nanotubes can also conduct high current densities, so can be seen as a type of wire – another fundamental component of any electrical system.

We need to remember, however, that there are problems regarding the use of carbon nanotubes. First of all, when they are exposed to oxygen, their electrical properties change significantly. As a result, new environments will need to be developed for these electronic devices. Their conductivity also seems to be extremely variable, depending on various factors in the production process that have not been completely understood and which are not easy to control. Finally, carbon nanotubes may be extremely toxic, causing lung cancer when inhaled.

But let's finish by looking at some of the potential of NEMS. Since NEMS are built so very small, their potential is huge. It is expected that they will make a significant impact on many areas of technology. And, since they will be even more efficient, smaller and cheaper to run and manufacture, they will one day perhaps even take the place of MEMS. So, all in all, I hope you agree with me when I say that MEMS and NEMS are very exciting fields of electrical engineering!

Now, I'm going to set you a task which will involve investigating some of the points I've raised. I want you to do some research into some of the most common applications of MEMS. I've chosen three of these. The first one is a very common device and I'm sure many of you have one at home: an *inkjet printer*. The second is a *gyroscope*. And the last application I want you to investigate is a *portable blood pressure sensor*.

Unit 11, Lesson 3, Exercise E 2.22

This sort of device would need to be built in a very similar way to how MEMS are built. The question is: How small can we go? Some people claim that there is no limit in terms of size, and that the same manufacturing processes used in MEMS can be used to produce NEMS: deposition and etching. I'm afraid that just isn't true. It's quite clear that the main problem in the development of NEMS is with the transduction element of the system. A transducer converts mechanical energy – for example, a vibration – into electrical energy. Research has concluded that making transducers at a nanoscale level is not easy at all. The evidence lies in the fact that as electromechanical devices are made smaller and smaller, it becomes very difficult to create an efficient and finely controlled integrated system.

Unit 11, Lesson 4, Exercise E 2.23

Extract 1

MAJED: The lecturer we listened to last week introduced a number of interesting issues. In my part of the seminar, I would like to build on what he said and talk about a subset of MEMS called *lab-on-a-chip*, or LOC. I'd like to start by explaining what a lab-on-a-chip is. In common with other MEMS, a lab-on-a-chip is very small: ranging from a few square millimetres to a few square centimetres. As the name suggests, a lab-on-a-chip is an analytical tool involving a semiconductor microchip, and it combines typical semiconductor processing with the control and manipulation of very small quantities of fluids. The idea is that a lab-on-a-chip is able to analyze the composition of these fluids. Clearly, this will have a wide range of applications. I think this is what Evie wants to talk about.

Extract 2

EVIE: Actually, I'm going to give an example of a lab-on-a-chip and how it works. One of the main applications of LOCs is analyzing, for medical purposes, the fluids that are in a person's body. The example I want to talk about involves one of these fluids: blood. Usually, when we have a routine blood test in a hospital, we have to give quite a lot of blood. A lab-on-a-chip only needs a drop of blood to do the same thing. The process is quite complicated and entails creating a micro-emulsion, which is a drop of fluid – blood in this case – inside a layer of another substance. The emulsion can then be positioned very accurately on the chip, and tests can be carried out, with the results transmitted immediately to a computer. OK then. Does anybody have any opinions or anything they would like to add?

Extract 3

JACK: Yes, well, following on from what Evie has said, I'd like to mention some of the advantages of LOCs. As you can see from Evie's example of a blood test, a lab-on-a-chip requires a much smaller quantity of fluid, so it's much easier and quicker for the patient. The analysis is faster than with conventional fluid testing, and this, of course, is a very important factor, meaning that there is better process control. Finally, a lab-on-a-chip is obviously very small, and this compactness can have clear advantages, not least in terms of lower manufacturing costs.

Extract 4

LEILA: OK, to continue then, I'm going to look at some of the various applications of LOCs. Evie talked about blood tests, and tests of this sort are one really important application of a lab-on-a-chip. Apart from blood, other bodily fluids are saliva and urine. LOCs can be used with these fluids to detect bacteria, viruses and even cancers. For example, a lab-on-a-chip can be used to diagnose and manage HIV infections in a cheap and simple way – a very important requirement, especially in the developing world. LOCs can also be used to test for allergies by exposing a person's white blood cells to potential allergens and recording their reaction. Yet another application is the testing of new drugs to see if they are safe and effective. Obviously, this would be at the start of the testing process, but using LOCs is cheaper and quicker than conventional laboratory methods. So, to sum up, we can say that a lab-on-a-chip has a lot of potential, particularly in terms of improving global health.

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