Engineering Terms and Vocabulary

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Engineering

Engineering is based principally on physics, chemistry, and mathematics, and their extensions into materials science, solid and fluid mechanics, thermodynamics, transfer and rate processes, and systems analysis. Engineering as a profession involves different tasks. It can refer specifically to the manufacture or assembly of engines, machine tools and machine parts. It is also used more generally to describe the creative application of scientific principles to design, develop, construct and forecast the behavior of structures, apparatus, machines, manufacturing processes and works. The function of scientists is to know, while that of engineers is to do they must solve specific problems

Different *branches of engineering* require different *equipment* and are based on different *processes*.

Branches of engineering

The following words/phrases are all followed by 'engineering'

chemical • civil • electrical • electronic • highway • hydraulic • industrial
mechanical • mining • petroleum production • production • structural

Equipment in engineering

boiler • crane • gas engine • machine tool • pump • turbine

Processes in treating metals

anneal • anodize • electroplate • forge • found • galvanize • grind
harden • mint • plate • roll • soften • temper • tinplate

Notice the following adjective endings:

-al • chemical • mechanical • physical • structural
-ial • industrial
-ic • electronic • hydraulic

Notice the following verb endings:

-en • harden • soften
-ize • anodize • galvanize

Notice the following nouns which are a plural form but are normally used with a singular verb

mathematics • mechanics • physics • thermodynamics

TASKS

1 **Match the following verbs with the correct definition.**

anneal	to melt metal and then pour it into a form, e.g. iron components
anodize	to make thin sheets of metal by passing it between large rollers, e.g. steel
electroplate	to shape metals by heating and then hammering, e.g. horse shoes
forge	to make materials tough by cooling them slowly, e.g. glass
found	to make something softer, e.g. fibres
galvanize	to heat and then cool metals to obtain the required hardness and elasticity, e.g. steel
grind	to cover with a thin layer of metal using electrolysis, e.g. car components
roll	to protect from rusting by coating in zinc, e.g. food cans
plate	to give a metal a protective coat by using it as an anode in electrolysis, e.g. car components
soften	to polish or sharpen by rubbing on a rough surface, e.g. stone
temper	to cover one metal with a thin layer of another, e.g. silver plate

2 **Complete the following sentences with a form of the word in brackets.**

1 In the _____ industry, _____ develop processes for producing plastics, fibres, medicines, etc. from simple chemicals. (chemistry)

2 Producing steel using the Bessemer process is one of the best-known _____ processes. (industry)

3 Most _____ devices need oil as a lubricant. (mechanics)

4 Following the earthquake, every building had to be inspected to see whether it had suffered any _____ damage. (structure)

5 Certain chemicals are added to glue to _____ it. (hard)

6 Excavators and power shovels are two types of _____ equipment used by _____ when they are removing rocks from the ground. (mine)

3 **Here is an extract from a speech made by a careers advisor to a group of students choosing their future courses of study at university. Complete the speech by choosing one of the words from the box.**

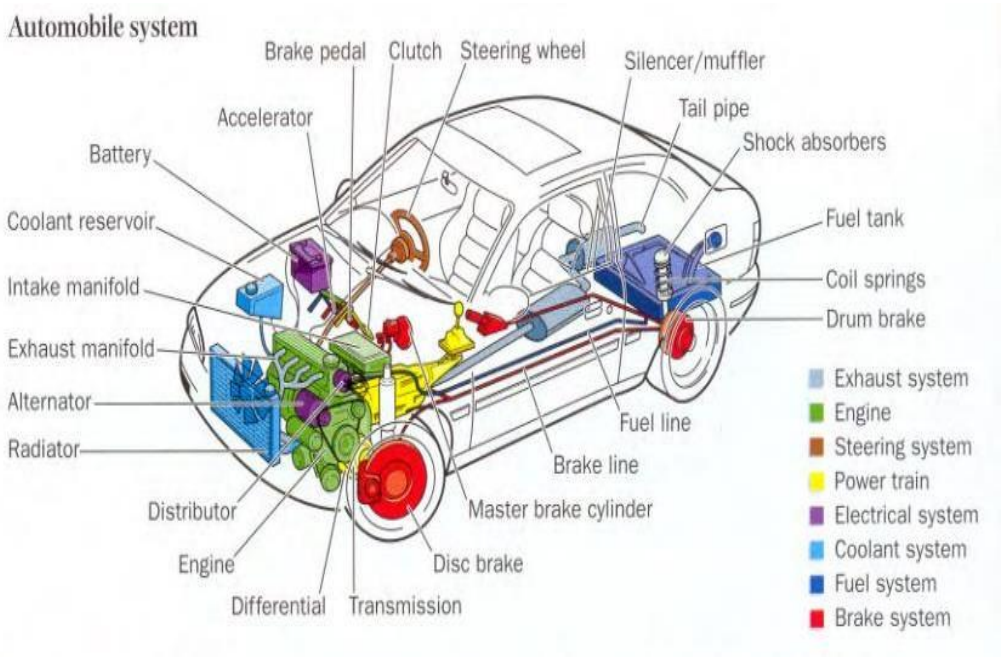
machines • highway • mechanical • chemical • civil • physics
electrical • develop • production • electronic

Engineering students should have an understanding of maths, (a) _____ and chemistry. Working with pharmaceuticals, food, mineral processing and chemical manufacturing, a (b) _____ engineer is trained to understand, design, control, and investigate material flows. If you enjoy problem solving and find projects such as the Channel Tunnel and the Three Gorges Dam interesting, (c) _____ engineering may be for you. You will produce creative designs at an economical price while paying due concern to the environment. If your interest is in road building then you may decide to follow a specialized course in (d) _____ engineering. By studying (e) _____ and (f) _____ engineering you learn about the design of complete systems, such as computers, controllers, power and transport systems. (g) _____ engineers plan, design and (h) _____ a wide range of things: washing machines, cars and spacecraft. (i) _____ engineers work very closely with mechanical engineers, to make new products at the right price, on time and in the correct quantity. As well as designing and selecting (j) _____ and materials, they also organize people and finance.

Automotive

Building a car takes a long time- from research, through design to final development. First, researchers need to determine what consumers want, and then suggest what kind of automobile to make, During the design phase, new ideas are converted into tangible parts or products, At the same time engineers modify existing parts and features for the new model and draft new plans for the prototype (a working example of a new design). Then manufacturers begin to construct a few prototypes. These are extensively tested in wind tunnels and dust tunnels, factory tracks, water-proofing bays, desert heat, Arctic cold, and crashes. At the next stage a plant is set up to build the new model and the necessary components. Product planners monitor the process to ensure that the new car programme finishes on time and within budget. Managers must also coordinate different activities, including producing the cars, purchasing materials, and training the workers. Marketing teams must then sell the car. Every year the major car manufacturers launch their new models, but a single car design can take several years from the drawing board to the showroom floor. A typical company will therefore have several new designs in various stages of development at any given time

Automobiles have developed over the years, both in terms of mechanics and designer Today's automobile system is more efficient and safer, and the range of models more varied. A central part of car manufacture is the workshop where car bodies are shaped and painted (the bodyshop).



TASKS

1 There are several steps in the process of developing a car. Put the following steps in the correct order.

a A plant is set up to build the new model.

b Marketing teams work to promote the new model and the new car is launched.

c Researchers analyse the answers and suggest the type of car to be built.

d Engineers work to modify existing parts for the new model.

e Customers are asked questions about the sorts of features they would like in a car.

f Product planners make sure that the new car is ready on time.

g Tests are carried out in different conditions.

h A prototype is built.

i Designers work to design a new car based on these suggestions.

2 Match the part of the car with its function.

steering wheel	holds brake fluid
exhaust manifold	provides the power
radiator	stores electricity
fuel tank	ensures that the rear wheels turn at a different speed to each other when a car corners
brake line	produces electricity
silencer/muffler	sends an electric current to the spark plugs
battery	carries waste gases to the exhaust pipe
clutch	makes the car go faster when it is pressed
differential	used by the driver to turn the car
engine	holds fuel
brake cylinder	cools water from the engine
accelerator	connects the brake cylinder to the brakes
distributor	reduces the exhaust noise
alternator	disconnects the engine from the gearbox while the gears are changed

Chemical

The chemical industry covers the business that uses chemical reactions to turn raw materials, such as coal, oil, and salt, into different products. Technological advances in the chemical industry have dramatically altered the world's economy. Chemical processes have created pesticides and fertilizers for farmers, pharmaceuticals for the health care industry, synthetic dyes and fibers for the textile industry, soaps and beauty aids for the cosmetics industry, synthetic sweeteners and flavors for the food industry, plastics for the packaging industry, chemicals and celluloid for the motion picture industry, and artificial rubber for the automotive industry. The chemical industry includes makers of more than 70,000 different chemicals, with global sales worth more than €l.l trillion.

Chemicals can be broken down into:

- basic and intermediate chemicals
- agricultural chemicals
- paints and coatings
- specialty chemicals.
- petrochemicals.
- Plastics and fiber

Some basic and intermediate chemicals

acids • alcohols • alkalis • aromatics • benzene • carbonates
chlorides • ethylene • fluorides • industrial gases • methanol
nitrates • olefins • oxides • polyethylene • polypropylene

Agricultural chemicals

fungicide • herbicide • insecticide • nutrient management
pest management • pesticide • soil management • sustainable production systems

Notice the following endings and their meanings,

ending	meaning	example of use	meaning
-cide	something that kills	herbicide	a chemical that kills weeds
-ide	group of related chemical compounds	oxide	any of various oxides
-anol	denotes alcohol	methanol	colourless, toxic, flammable liquid used as an antifreeze, a general solvent, and a fuel
-ate	a derivative of a specified chemical compound or element	carbonate	a derivative of carbon
-ene	organic compound, especially one containing a double bond between carbon atoms	propylene	a flammable gas derived from petroleum hydrocarbon cracking and used in organic synthesis
-fin	making	olefin	oil forming gas

TASKS

1 **Match the chemical with the correct description**

benzene	an alcohol with the formula CH_3OH
aromatics	compound of oxygen and another element
ethylene	compounds that react with acids to give off carbon dioxide
olefins	contains six carbon atoms in a ring
fluorides	made from propene and often used for kitchen tools for example
carbonates	the simplest olefin, it is a sweet-smelling gas that is used to make plastics
chlorides	a group of compounds made by cracking alkanes and used to make plastics and antifreeze
methanol	chemicals that contain the benzene ring
nitrates	compounds containing chlorine and another element
oxides	inorganic compounds of fluorine that are added to toothpastes
polypropylene	contain NO_3 and a metal cation

2 **Fill in the blanks with a word from the opposite page.**

1 Farmers use this to kill insects: _____

2 These fibres are made from chemicals: _____

3 Farmers use these to make plants grow: _____

4 This describes a paint which dries quickly: _____

5 This describes a paint that doesn't have a shiny appearance: _____

6 This industry makes soaps and beauty aids: _____

7 These give food a good taste: _____

8 This describes a plastic that doesn't bend: _____

3 **Here is the first part of a speech about the chemical industry. The letters of the missing words in brackets are mixed up. Complete the text with the missing words.**

Huge quantities of chemicals are used today. Products of the chemical industry include (a) _____ (sposa), fibres and explosives. The starting point in the manufacture of chemical products is (b) _____ (bicsa) chemicals and these include (c) _____ (adics), for example sulphuric acid, and (d) _____ (akillsa), for example sodium hydroxide. Sulphuric acid is one of the best-known acids and is used to make (e) _____ (fizterriles), plastics, (f) _____ (ptaisn), dyes, detergents and many other chemicals. Alkali mixtures containing sodium and potassium are used to manufacture (g) _____ (gslas), soap and textiles and are also used in refining crude (h) _____ (lio). (i) _____ (lmeditterane) chemicals such as synthetic resins are made from these basic chemicals, and then used in further chemical (j) _____ (peecorsss).

The modern chemical industry began towards the end of the 19th century. William Perkin discovered (k) _____ (dsey) from coal. These were soon being used by the (l) _____ (tlextie) industry. Shortly after, Alfred Nobel invented dynamite which was the start of the (m) _____ (epsolxevis) industry. The discovery of celluloid by Hyatt and bakelite by Baekeland led to the creation of the (n) _____ (piltascs) industry. The (o) _____ (pchemlacetori) industry grew rapidly after 1950 when petroleum became very important in the production of organic chemicals.

Plastics have different properties: strong and (p) _____ (tugho), (q) _____ (tpentrasarn) or heat (r) _____ (ritessant).

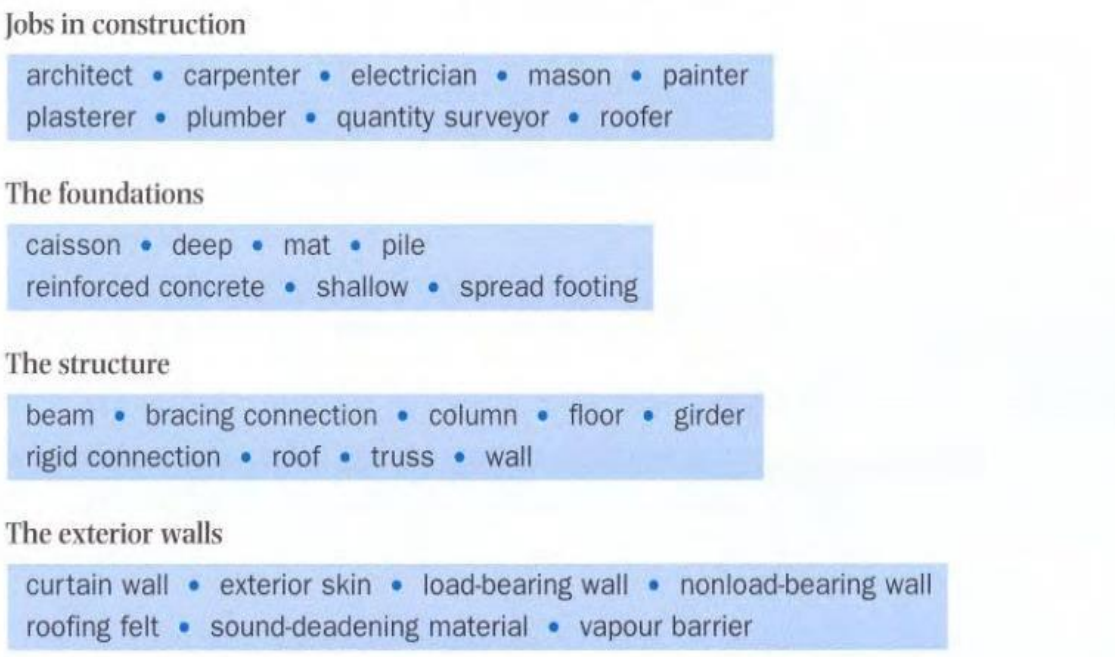
Construction

A Construction means the erection or assembly of large structures, primarily those which provide shelter, such as commercial and residential buildings. It also includes major works such as ships, aircraft, and public works such as roads, dams, and bridges.

The major elements of a building include:

- the foundation, which supports the building and gives it stability
- the structure, which supports all the imposed loads and transmits them to the foundation
- the exterior walls, which may or may not be part of the primary supporting structure
- the interior partitions, which also may or may not be part of the primary structure
- the environmental-control systems, including the heating, ventilating, air conditioning, lighting, and acoustical systems.
- the power, water supply, and waste disposal systems

Jobs in construction are many and varied, ranging from architects to painters. However, every building needs a solid foundation on which the structure can be erected, paying special attention to the exterior walls which will need to withstand the elements.



TASKS

1 **Choose the correct word in the following sentences.**

1 A flat roof is usually covered in roofing **felt/skin** for protection against the weather.

2 Rooms in a building are divided by interior **supports/partitions**.

3 To prevent water entering the cavity of the wall, moisture barriers are used on the external surface and **vapour/insulating** barriers are used on the internal face.

4 The **assembly/structure** of a building transfers all the loads acting on the building to the ground.

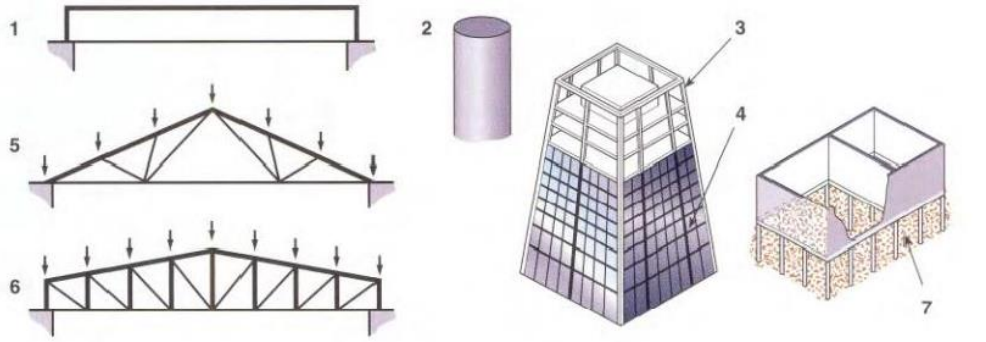
5 The **ventilating/acoustical** system provides fresh air.

6 Sound-**deadening/-barrier** material is used to reduce sound passing from one room to another.

7 The foundations for a skyscraper building must be **deep/shallow**.

8 A **spread footing/caisson piers** is/are used when the soil is weak.

2 **Label the following diagrams using words from the opposite page.**



1 _____ 4 _____ 7 _____ foundations

2 _____ 5 roof _____

3 steel _____ 6 lattice _____

3 **Here is part of a text about house building. Complete the text with words from the opposite page.**

There are two main methods of building houses. In one, solid walls known as (a) _____ walls are constructed. They support the floors and the roof of the building. In the other, a framework of steel, timber or concrete is constructed. The frame can be covered or filled in with lightweight material.

When building a house, the (b) _____ first of all examines the site and makes a plan of the size and shape of the plot of land. Next, an (c) _____ makes a detailed drawing of the building, and gives information about the materials which are to be used. A (d) _____ calculates exactly how much of these materials will be needed for the building. Then, the ground is dug out and the (e) _____ laid. During building, (f) _____ make the wooden structures, (g) _____ cut and place stone, (h) _____ construct the roof and (i) _____ cover walls and ceilings with plaster. Once the building has been completed, (j) _____ lay meters of electrical cable, and (k) _____ install pipes for heating and water. Finally (l) _____ paint the walls and ceilings of the building.

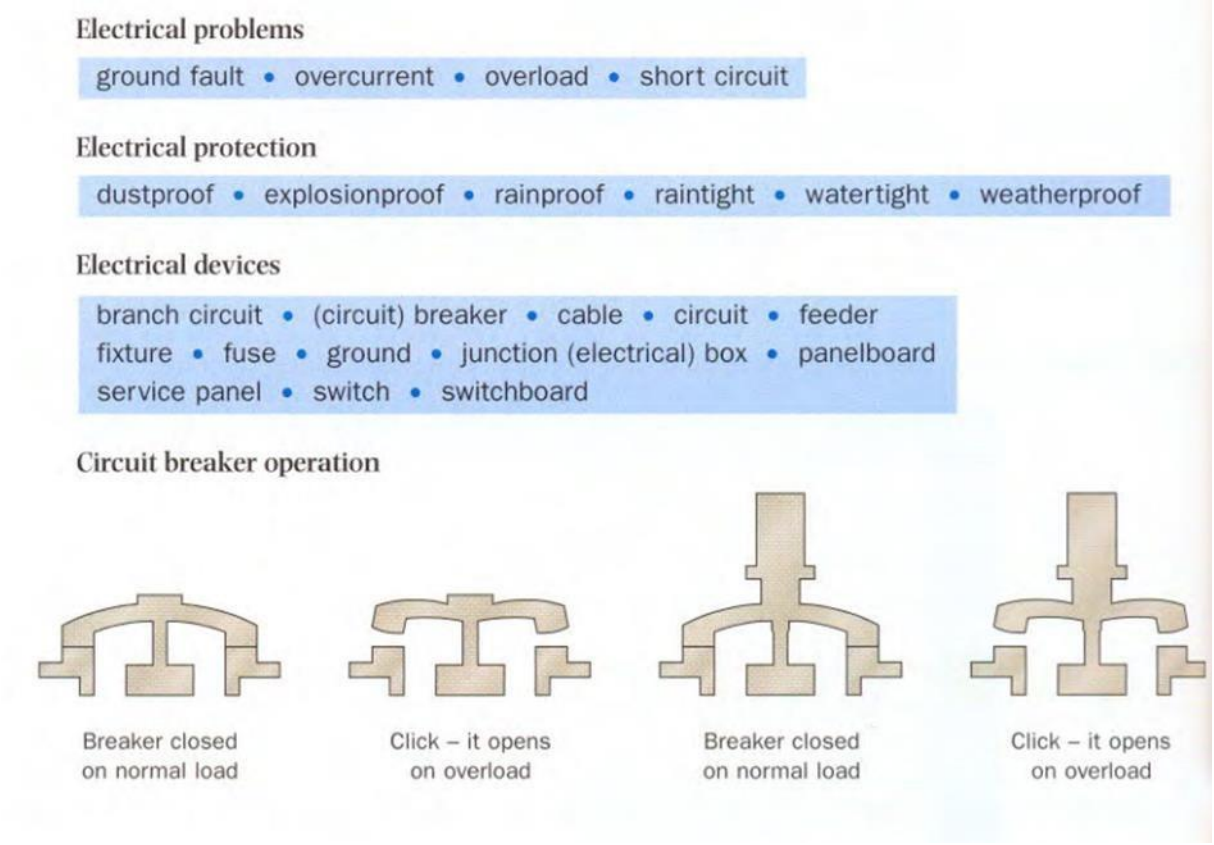
Electrical

Electrical engineering deals with the practical application of the theory of electricity to the construction and manufacture of systems, devices and assemblies that use electric power and signals. Electrical engineering can be divided into four main branches:

electric power and machinery ∗ communications and control ∗ electronics ∗ computers

Electrical applications are used in many industrial areas including:
electric power and machinery ∗ superconductors ∗ electronic circuits ∗ solid-state electronics ∗ control systems ∗ medical imaging systems ∗ computer design ∗ robotics ∗ lasers ∗ radar ∗ consumer electronics ∗ fiber optics.

In recent years, the electronic computer has emerged as the largest application of electrical engineering. However, another very large field is concerned with electric light and power and their applications. Specialties within the field include the design, manufacture, and use of turbines, generators, transmission lines, transformers, motors, lighting systems, and appliances. Electrical problems can be avoided by always using the right devices and taking appropriate measures for electrical protection.



Compounds are short ways of giving information. They are used to express complex ideas economically:

- noun + noun, e.g. panel board (or panelboard) =a board consisting of several panels.
- noun + adjective, e.g. explosionproof =material which cannot be damaged by explosions.
- adverb + noun, e.g. overload =current which is greater than the load for which the system OI, mechanism was intended

TASKS

1 **Express each of these ideas as a compound.**

1 a board consisting of a number of panels
2 material that does not allow water to get into it
3 material that doesn't allow rain to get into it
4 a board consisting of a number of electrical switches
5 conductors which are perfect, conducting a current without a battery
6 material that will not be damaged in an explosion
7 current which is greater than the load for which the system or mechanism was intended
8 material that does not allow dust to get into it

2 **What is being described? Find a word or phrase from the page opposite.**

1 It produces a narrow beam of light and can be used to read barcodes in a supermarket, play compact discs, etc.
2 A word to describe any piece of equipment made for a specific purpose.
3 A pulse of light, current or sound that is used to convey information.
4 A device that uses electromagnetic waves to calculate the distance of an object.
5 Glass fibres that are used for data transmission.
6 The study of how robots are made and used.
7 A circuit where the current has a choice of paths.
8 A situation where the electrical current takes an easier path than the one intended.
9 A piece of equipment that stops an electrical current if it becomes dangerous.
10 A connection point where several cables are connected.

3 **Complete the text below with words from the page opposite. The first letter of the missing words has been given.**

In power stations, high pressure steam, gas, water or wind is used to drive (a) t_____ which turn huge (b) g_____. Large power stations generate electricity at 25,000 volts. This is then stepped up to 275,000 or 400,000 volts using (c) t_____ before being fed into a network of (d) c_____ known as the Grid. Electrical (e) p_____ is then carried across the country by overhead (f) t_____ _____. The Grid voltage is reduced by stepping down (g) t_____ at substations before it is used in homes and factories. Some industrial plants take electrical energy from the Grid system at 33,000 or 11,000 volts, but for use in homes and offices it is stepped down to a lower level.

In the home, supply from the mains (h) c_____ passes through a main (i) f_____ and then to a fuse box. The fuse box is a distribution point for the electricity supply to the house. Most houses have two or three ring main (j) c_____ connecting electric sockets. There are also two or three (k) l_____ circuits and separate circuits for (l) a_____ such as cookers and hot water heaters.

Electronics

Electronics is a branch of engineering and physics. It deals with the emission, behaviour, and effects of electrons for the generation, transmission, reception, and storage of information. This information can be audio signals in a radio, images (video signals) on a television screen, or numbers and other data in a computer. Electronic systems are important in communication, entertainment, and control systems. Electronic circuits consist of interconnections of electronic components, at the heart of which are semiconductors. Transistors, which are made of silicon or germanium, are made from semiconductors. Commercial products range from cellular radiotelephone systems and video cassette recorders to high-performance supercomputers and sophisticated weapons systems. In industry, electronic devices have led to dramatic improvements in productivity and quality. For example, computer-aided design tools facilitate the design of complex parts, such as aircraft wings, or intricate structures, such as integrated circuits. The development of microelectronics has had a major impact on the electronics industry. Electronic components are expected to deliver ever higher performance, while electronic circuits continue to benefit from miniaturization.

Function of electronic circuits

amplification • demodulation • electronic processing • generation
information extraction • modulation • radio wave • recovery (of audio signal)

Electronic components

absorb • active • battery • capacitor • diode • energy • generator • inductor
passive • resistor • transducer • transistor • vacuum tube (AmE) • valve (BrE)

Impacts

device size • digitization • fidelity • high speed • increased reliability
manufacturing cost • storage capacity • storage system • ultrahigh image definition

One way of increasing your vocabulary is to learn the associated words from a key word. Look at the word table below, which shows words related to the key words presented above:

Noun	Verb	Adjective
activation	activate	active
amplification	amplify	amplified
emission	emit	emitted
entertainment	entertain	entertaining
extraction	extract	extracted
generation	generate	generative
integration	integrate	integrated/integrative
reception	receive	receptive
recovery	recover	recovered
reliability	rely	reliable
storage	store	stored
transmission	transmit	transmittable/transmissible

TASKS

1 Choose the correct word in the following sentences.

1 **Transistors/inductors** are the key component in electronics.

2 They consist of three layers of silicon **semiconductor/superconductor.**

3 All **electronic/electrical** systems consist of input, a processor and output, and usually memory.

4 The input **receives/resists** and converts information while the output converts and supplies electronically processed information.

5 The memory may not be present in simple systems, but its function is the **storage/transmission** of information for the processor.

6 Continual developments in electronics give us increased **reliability/recovery** in electronic devices.

7 Electronic equipment controls **microprocessors/microwaves** in, for example, weapons systems, cellular radiotelephone systems and domestic appliances.

8 Electronic devices have improved our lives by providing high quality **communication/combination** and entertainment.

2 Use the word in brackets to form a word which fits in the sentence.

1 The weak audio signal entering a radio is _____ by the _____ thus making it audible. (amplify)

2 Computer games are just one example of electronic systems being used for _____. (entertain)

3 Due to developments in mobile telecommunications systems, a new _____ of mobile phone is now available. (generate)

4 IC stands for _____ circuit. (integrate)

5 Computer software is _____ if it does what the manual says it should. (rely)

6 One area of electronics is concerned with the _____ of information. (store)

7 The _____ of signals to satellites is made by microwaves. (transmit)

8 A computer chip is capable of holding vast amounts of _____ information. (store)

9 _____ of speech was first carried out through _____ of the amplitude of a radio signal. (transmit, modulate)

10 In a laser, energy is released in the form of _____ light. (emit)

3 Complete the text about electronics by choosing a word from the box.

diodes • semiconductor • electrons • devices • germanium • transistors
integrated circuits • capacitors • silicon • integrated • resistors

Electronic circuits are built from basic components. (a) _____ are the most important components. They can be used to amplify the strength of a signal by converting a weak signal into a stronger one or to switch other circuits on or off. (b) _____ reduce the flow of (c) _____ through the circuit, adding resistance to that circuit. (d) _____ function as electronic valves allowing current to flow in only one direction. (e) _____ store electricity in order to smooth the flow. They can be charged and discharged. The two most common capacitors are ceramic and electrolytic.

Most electronic devices use (f) _____ _____ (IC) or microchips. Inside an IC is a very small piece of (g) _____ with circuits built in. Today, semiconductors are usually made of (h) _____ which is cheaper and easier to manufacture than (i) _____.

Researchers are constantly trying to reduce the size of transistors in order to reduce the size of (j) _____.

Energy

The UK's energy system has changed dramatically over the last century.

In the first half of the twentieth century:

- **coal** was the dominant **fuel** in industry and electricity **power plants**, and in houses and businesses
- **town-gas** networks existed in larger towns, with the **gas** derived from coal

In the second half of the 20th century:

- coal continued to be of central importance for electricity **generation**, although its importance elsewhere fell substantially
- **nuclear power plants** began to be **commissioned** from the mid-1950s
- the electricity industry was combined into state-owned monopolies, during the 1950s
- the **high voltage** electricity **transmission network** was created in order to transport electricity over long distances from big power plants
- electricity **distribution networks** shrank in importance and activity
- during the 1960s and 1970s there was a move to an extensive **natural gas** network for **heating** (industry, commerce and domestic)
- demand for **transport fuel** increased dramatically
- **gas-fired central heating** largely replaced **open coal fires** in homes
- the use of **electrical appliances** in commerce and the domestic sector increased hugely

Today we are seeing increasing interest in those renewable *sources of energy* which can deliver clean and cheap *types of energy*, using environmentally-friendly processes and *equipment*.

Sources of energy

renewable	non-renewable
sun • water	fossil fuels: coal, oil, natural gas, petroleum
wave • wind	biofuel • plutonium • uranium

Types of energy

electrical energy • fire • fossil fuels • gas power • geothermal energy
greenhouse effect • hydraulic power • hydroelectric energy • kinetic energy
magnetic energy • nuclear energy • solar energy • steam power • tidal power
water power • wave power • wind power

Equipment to produce energy

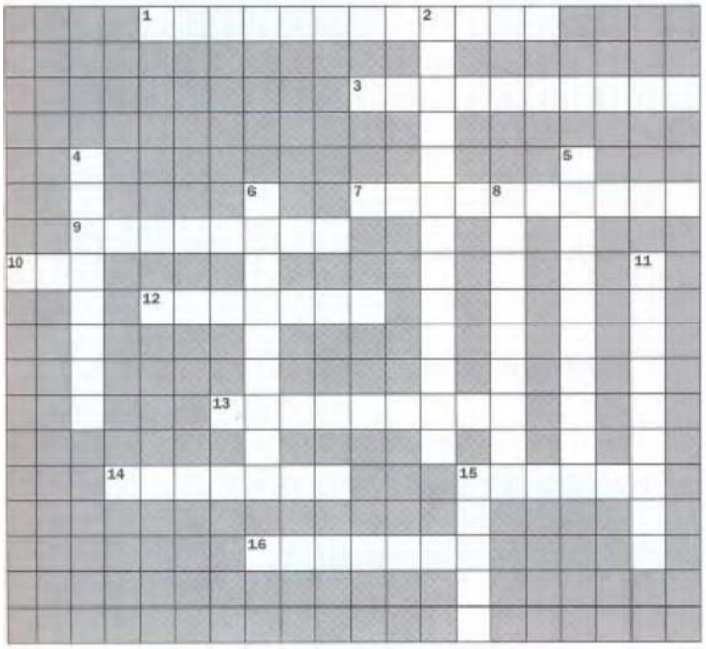
atomic energy plant • gas station • gasworks • generating station • generator
heat exchanger • hydroelectric scheme • motor • nuclear plant • power station
powerhouse • solar cell • solar panel • tidal barrage • tide mill • turbine
waterfall • waterworks • wind farm • windmill

TASKS

1 Rearrange the letters to name six sources of energy.

1 uns 2 fbielou 3 dwni 4 piumutoln 5 weva 6 peumroetl

2 Complete the crossword with words from the opposite page.



Across

1 When a nuclear plant is put into action it is _____.
3 The flow of electrons produces this type of energy.
7 This heat comes from the earth itself.
9 This is where gas was made from coal in the past.
10 Almost all the energy we use comes from this.
12 The reactor in nuclear power stations contains a nuclear fuel such as _____.
13 These turn the energy in sunlight into electricity.
14 This kind of energy is in things that are moving, e.g. a moving turbine.
15 This is a hydroelectric power station together with its dam and reservoir.
16 This is made from plant or animal matter.

Down

2 The main way of heating homes in the UK before central heating.
4 This energy is associated with electric current.
5 Exhaust gases from vehicles and power stations, methane from oil and gas rigs and CFCs in refrigerators all contribute to this effect.
6 This type of fuel is used to power all sorts of vehicles.
8 This power comes from the pressure or movement of a liquid.
11 Another word for oil.
15 This type of energy comes from the sun.

3 Complete the following text about power using the words from the box.

barrage • gas • non-renewable • produce • water • wave • fossil fuels
power stations • generators • renewable • tidal • coal • turbines

Most large power stations burn (a) _____ which were formed from the remains of plants and animals that lived on the earth millions of years ago. The first type of fossil fuel to be used in large quantities was (b) _____. Today, it is increasingly expensive to mine, however, many (c) _____ still burn it to (d) _____ electricity. Oil and natural (e) _____ have now largely replaced coal. These fuels are all (f) _____ and will eventually run out. Wood is used by 2 billion people in the developing world and unlike fossil fuels, it is a (g) _____ energy source. Alternative energy sources include (h) _____ power technology. In hydro schemes, water from a reservoir or from a river powers (i) _____ which drive (j) _____. (k) _____ power systems use the energy from wind and sea or take mechanical energy from wave movement. The UK offers a good position to exploit wave energy. The movement of the sun, moon and earth combine to produce (l) _____ power. Electricity can be generated when tidal water passes through turbines positioned in a (m) _____.

Civil Engineering

The term civil engineering describes engineering work performed by civilians for non-military purposes. In general it describes the profession of designing and executing **structural works** for the general public and the **communal environment**. Civil engineering covers different areas of engineering, including the design and construction of large buildings, **roads, bridges, canals, railway lines, airports, water-supply systems, dams, irrigation, harbours, docks, aqueducts,** and **tunnels.**

The civil engineer needs a thorough knowledge of **surveying**, of the properties and mechanics of construction materials, of the **mechanics** of **structures** and **soils**, and of **hydraulics** and **fluid mechanics**. Today civil engineering includes the production and distribution of **energy**, the development of **aircraft** and airports, the construction of **chemical process plants** and **nuclear power stations**, and **water desalination.**

A range of *civil engineering tools and equipment* is used in the construction of *roads, bridges* and *waterways.*

Roads

camber • crown • culvert • kerb/curb • macadam
main • manhole • metal • pavement • pedestrian crossing
pothole • sewer • soft shoulder • tarmac • underdrain

Bridges

arch • bascule • cable • cantilever • clapper • crossover • lift
footbridge • span • suspender • suspension • swing • viaduct

Canals, rivers and other waterways

aqueduct • barrage • dam • dike • drainage
flume • lock • paddle • pier • sluice
watercourse • water main • weir • well

Civil engineering tools and equipment

bulldozer • dredger • earthmover • excavator
plate girder • pylon • road roller • shovel

Read the list of the *essential duties and responsibilities* of a civil engineer below:

- to provide detailed fact finding, research and analysis
- to provide support for less experienced staff
- to develop computer models, including detailed and potentially complex spreadsheet analyses
- to assist with engagement planning activities including the development of **draft work plans** and budgets
- to prepare client communications for senior level review

TASKS

1 **Match the following words and phrases with their definitions.**

feasibility study	building or installation which is built, supplied, or installed complete and ready to operate
site investigation	activities carried out after the project to ensure problems are solved
maintenance	detailed plan of proposed structures
soil mechanics	dimensions and measurements
specifications	extensive investigation to evaluate the load-bearing qualities and stability of the ground
technical drawings	investigation to assess both financial and engineering aspects of a project
commission a project	offer of a bid for an engineering contract
costing system	procedure to monitor the costs of a project so that management can get information on development
tender	study of the proposed location to assess geology of the area
turnkey project	to order a plan to be carried out

2 **What is being described? Choose from the words on the opposite page.**

1 This structure is built across a river to hold back the water to produce power, improve navigation or control flooding.
2 This structure is built along the banks of a river or along the coast to hold back water and prevent flooding.
3 This carries a road or railway across water.
4 This carries water (canal or river) across land, usually over a valley.
5 The section of a canal where the water level changes to raise boats from one level to the next.
6 These allow water to flow in or out in order to change the water level in a canal.
7 A deep hole in the ground where people can get water.
8 These are dug underground for roads and railways.
9 This is the process of removing salt from sea water.
10 This large powerful vehicle uses a large blade to move earth and rocks.
11 This machine or ship is used for removing sand and mud from the bottom of a river or a harbour.
12 This machine is used for rolling tarmac or asphalt flat on a road surface.

3 **A civil engineer is showing an international visitor around. Complete the text with words from *Roads* from the opposite page.**

Here we are on one of our town streets. As you can see the road is not flat, it has a (a) _____. This is to allow rain water to run off the surface and into the drains at the side. The highest part of the road is the (b) _____ in the centre. A (c) _____ carrying waste water runs below the surface of the road. At certain points along the road you'll find large (d) _____ which allow engineers to go down and inspect electricity and telephone cables which also run below the road. On either side of the road there is a raised (e) _____ for pedestrians which is edged with (f) _____ stones. The black surface we use nowadays is a variety of (g) _____. It was invented by a man of that name whose company was later called Tarmac. As you can see this road needs to be resurfaced. There are a number of (h) _____ following the heavy rain we had last month.

Now, here we are on a (i) _____ road out of town. There are no pavements here. Grass is allowed to grow along the edges and provides a (j) _____ _____. Over there you can see a (k) _____ carrying a small stream under the road.

ROADS

Mining

Mining is the process of **extracting** useful **minerals** from the **earth's crust** – the land and the seas. The process involves the physical **removal** of **rock** and **earth. Excavations** take place in different types of mines. **Underground** mines are constructed when any **ore** lies deep below the surface. There are several types of **surface** mining, but the three most common are **open-pit** mining, **strip mining**, and **quarrying**. These differ from one another in:

- their structure
- the mining techniques employed
- the minerals produced.

There are typically four stages to mining:

- **prospecting** – looking for mineral **deposits**
- **exploring** – assessing the size, shape, location, and economic value of the deposit
- developing – preparing **access** to the deposit so that the minerals can be **mined**
- **exploiting** – extracting the minerals

Mining is an extremely dangerous activity. The health and safety of mine workers and the protection of the public are achieved by regular mine safety **audits** and mine site **inspections**.

Various *professionals* are employed in mining to extract minerals. The output from mines can be divided into *metalliferous*, *nonmetalliferous* and *building and ornamental stones*.

Professionals in mining

drill supervisor • environmental engineer • geochemist • geologist • geophysicist
hydrogeologist • miner • mining engineer • prospector • safety engineer

Minerals: metalliferous ores

copper • gold • iron • lead • manganese • tin • zinc

Minerals: nonmetalliferous ores

asbestos • bauxite • borax • coal • feldspar
phosphate rock • quartz • talctrona

Building and ornamental stones

granite • limestone • marble • slate • traprock • travertine

What's in a mine?

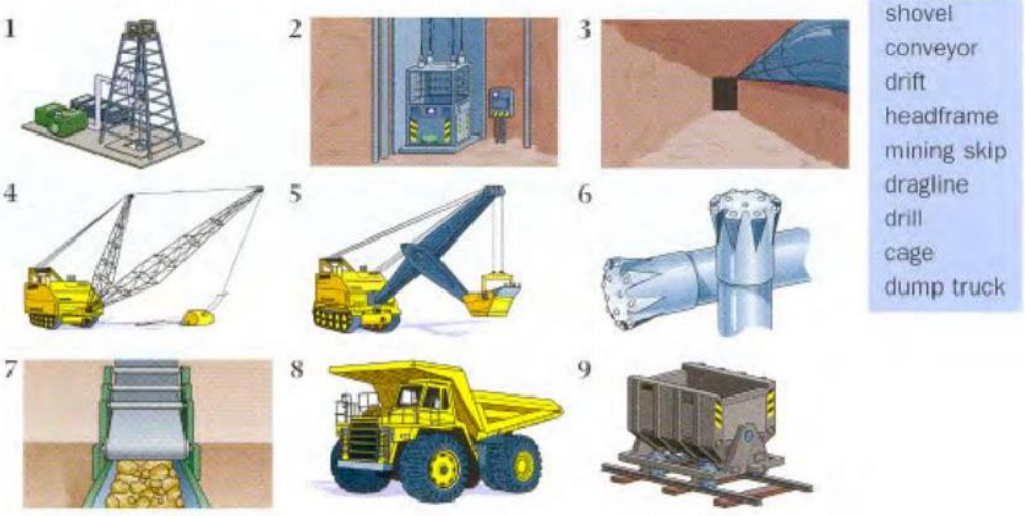
cage • chute • conveyor • dragline • drift • drill • dump truck
explosive • headframe • mechanical loader • mine car • pump • raise
shovel • skip • stope • stripping machine • sump • ventilation shaft

TASKS

1 Match the following words and phrases with their definitions.

deposit	a natural occurrence of a useful mineral in sufficient quantities for exploitation
excavate	a natural resource extracted from the earth for human use, e.g., ores, salts, coal, or petroleum
explore	an open or surface mineral working, usually for the extraction of building stone, such as slate and limestone
extract	examine a territory for its mineral wealth
mineral	remove coal or ore from a mine
mining	remove soil and/or rock materials from one location and transport them to another
ore	search for coal, minerals, or ore
prospect	the naturally occurring material from which a mineral or minerals of economic value can be extracted
quarry	the science, technique, and business of mineral discovery and exploitation

2 Label the following items of mining equipment with words from the box.



shovel
conveyor
drift
headframe
mining skip
dragline
drill
cage
dump truck

3 Rearrange the letters to complete the short descriptions of the activities of different mining professionals.

There are two main activities in my job. Firstly to make holes in rock so that samples of the rock can be taken and to insert (a) _____ (leoivsxspe) for blasting.

I make evaluations of conditions at a (b) _____ (ienm) and check air pollution, waste disposal, and previously mined areas.

My job is to study the chemistry of (c) _____ (htare) materials. I specialize in the study of the planet and the materials of which it is made. This information helps us to discover (d) _____ (nlriames) and fuels.

I study and investigate phenomena which cause movement of the earth's surface. Through my studies I help others to locate petroleum and mineral (e) _____ (tseopids).

I specialize in various branches of work, including (f) _____ (goespnrctip), surveying, and technical underground management.

My job is to inspect all possible danger spots in the mine, prepare (g) _____ (sutdai) and cooperate with committees to prevent unnecessary dangers.

Petroleum

Petroleum is an **oily**, thick, **flammable**, usually dark-coloured liquid that is a form of **bitumen** or a mixture of various **hydrocarbons**. It occurs naturally in various parts of the world and is usually obtained by **drilling**. **Offshore** drilling for oil takes places in oceans, seas or large lakes from **platforms** standing on the bed; **onshore** drilling takes place on land. Because petroleum is found underground, it must be **extracted** by means of **wells**. To check whether there is any oil at a site, an **exploratory** well, or **wildcat**, is **dug**. Scientific methods and technical equipment, such as gravimeters, magnetometers, and seismographs are used to find **subsurface rock formations** that might hold **crude oil**. The petroleum from a new well will usually come to the surface under its own **pressure**. Later the crude oil must be **pumped** out or forced to the surface by **injecting** water, gas, or air into the **deposits**. The oil and gas industry distinguishes between:

upstream – oil and natural gas exploration and production activities; plus gas gathering, processing and marketing operations
downstream – all activities from the processing of **refined crude oil** into petroleum products to the distribution, marketing, and shipping of the products. (➳ 24)

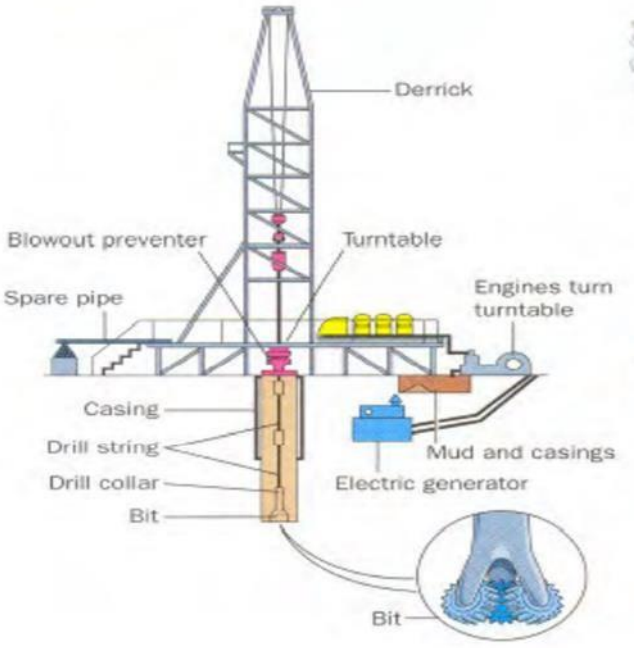
Accurate *forecasting and measuring* always precedes *drilling and pumping*.

Forecasting and measuring

downhole • flow rate • layer • pressure • reserves
reservoir • rock mapping • wellbore • wildcat well

Drilling and pumping

blowout • casing • (drill) collar • cuttings • derrick • drill bit • drill pipe
drill string • drilling mud • inject • kelly • licence • oil field/gas field • permit
platform • pump • recover • rig • trap • turntable/rotary table • well



TASKS

1 Match the following words and phrases with their definitions.

derrick	a hole drilled into the earth to recover oil or gas
drill	a pyramid of steel erected over a bore hole to drill for oil
extract	a structure that contains all the necessary equipment for drilling
flammable	an offshore structure from which wells are drilled
offshore	burns easily
platform	exploration and production activities for oil and natural gas
reservoir	places in oceans, seas or large lakes
rig	rock formation containing oil and/or natural gas
upstream	to cut through rock
well	to take out a solid or liquid

Telecoms

Telecommunications technology **transmits** information by **electromagnetic** means over media such as telephone **wires** or radio **waves**. The information may be voice, facsimile, data, radio, or television signals. The electronic **signals** that are transmitted can be either **analogue** or **digital**. The advantages of digital transmission are high reliability and low cost. Digital **switching systems** are much cheaper than analogue systems.

In analogue **modulation**, the signals are transmitted directly (without **converting** them to digital form) by **amplitude modulation** or **frequency modulation.** For digital transmission the analogue signals must be converted to a digital form. Then the digitized signal is passed through a **source encoder**, which reduces redundant **binary** information. After source encoding, the digitized signal is processed in a **channel encoder**, which introduces **redundant** information that allows errors (**degradation** by **noise** or **distortion**) to be detected and corrected. The encoded signal is made suitable for transmission by modulation onto a **carrier wave**. When a signal reaches its destination, the device on the receiving end converts the **electronic** signal back into an understandable message – sound on a telephone, images on a television, or words and pictures on a computer.

There are three main methods of electromagnetic signal transmission: *wire*, *radio* and *optical*.

wire transmission

amplify • attenuation • coaxial cable • copper wire • metallic-pair circuit
multipair cable • open-wire pair • repeater • restore • retransmit • single-wire line

radio transmission

antenna • dish • electromagnetic wave • microwave • radio wave • receiver
reflected propagation • satellite • surface propagation • transmitter • transponder

optical transmission

fibre optic cable • high bandwidth • interference immunity • laser • lightweight
light-emitting diode (LED) • low attenuation • low cost • wavelength

A wide variety of information can be **transferred** through a telecommunications system, including **voice** and **music**, **still-frame** and **full-motion** pictures, computer **files** and **applications**, and telegraphic **data**.

The telephone is an **instrument** used for **sending** and **receiving** voice **messages** and data. Most phone **calls** involve two people, but the phone **network** can also be used to pay bills and **retrieve** messages from **answering machines**. Private individuals will usually have their own **phone line**; a large business will usually have its own **switching machine**, called a **Private Branch Exchange (PBX)**, with many lines, all of which can be reached by **dialling** one number.

Radio **transmission broadcasts signals** that are intended for general public **reception**. With an **omnidirectional antenna**, radio signals are **transmitted** over a wide area. In a point-to-point radio **channel**, a **directional** transmitting antenna focuses the wave into a narrow **beam**, which is directed toward a single receiver. Broadcasts may be **audible** only, as in radio, or **visual** or a combination of both, as in television.

Two applications of telecoms are *telephony* and *television*.

Telephony

A **videophone** is a personal **video camera** and **display**, a **microphone** and **speaker**, and a **data-conversion device**.

A **cordless** telephone is a **device** which plugs directly into an existing telephone **jack**, allowing limited **mobility** within the home, garden or office.

Telephony has been revolutionized by **cellular** (**cell** or **mobile**) telephones, which are personal **portable** devices.

Facsimile, or **fax**, refers to the **transmission** of print: text, fixed **images** or **drawings** by wire or radio channels or undersea **cable**.

Television

aerial • antenna • broadcast • cable television • dish
relay station • television set • television station • visible

TASKS

1 Match each of the following words with its definition.

wire	a device which maps the binary strings into coded bits or waveforms for transmission
wave	a device which maps the source into a set of binary strings
analogue	a system in which data is represented as 0 or 1
digital	a system in which data is represented as a continuously varying voltage
amplitude modulation	a thin piece of metal for conducting electrical current
frequency modulation	a wave suitable for modulation by an information-bearing signal
source encoder	an electric, electromagnetic, acoustic, mechanical or other form whose physical activity rises and falls as it travels through a medium
channel encoder	the deterioration in quality, level, or standard of performance
degradation	to fail to reproduce accurately the characteristics of the input
distort	where audio signals increase and decrease the amplitude of the carrier wave
carrier wave	where voltage levels change the frequency of a carrier wave

2 Match a word in the left-hand column with a word on the right to form ten phrases from the field of telecommunications.

answering	antenna
radio	camera
video	jack
relay	machine
cable	messages
television	phone
retrieve	set
transmitting	signal
cordless	station
telephone	television

Now complete the following sentences using phrases from the table opposite.

1 The telephone can be used to pay bills and _____ from _____.

2 With an omnidirectional antenna, _____ can be transmitted over a wide area.

3 A videophone incorporates a _____ and display, a microphone and speaker.

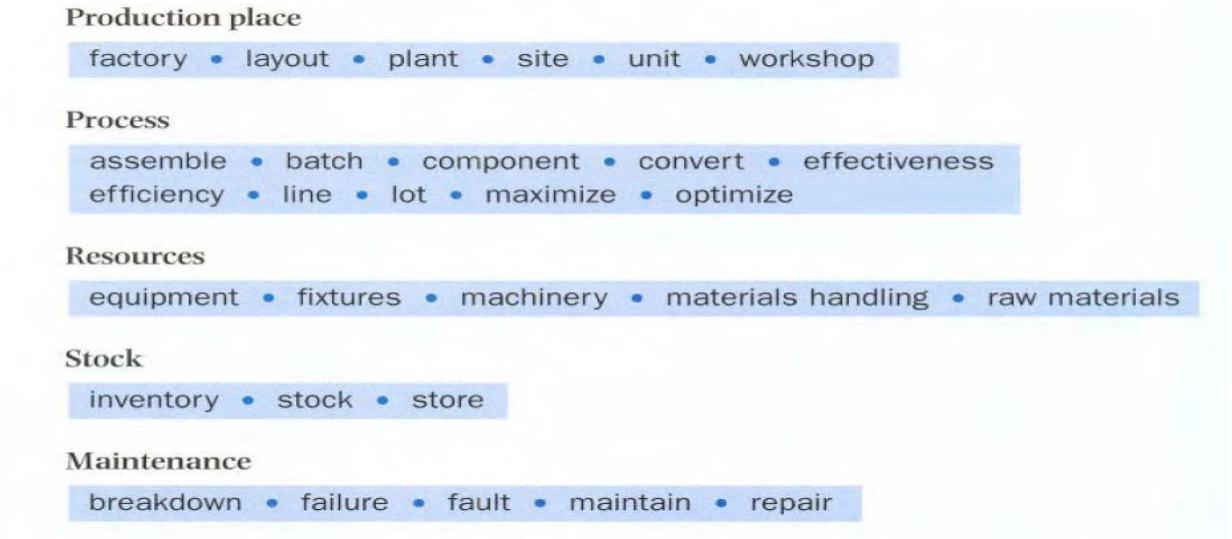
4 A _____ allows limited mobility in and around the home.

5 _____ allows access to many television stations.

Production

Production management is concerned with planning and controlling industrial processes which produce and distribute products and services. Techniques of production management are also used in service industries: here they are called operations management. During production processes, inputs are converted into outputs. These processes take many forms: from basic agriculture to large-scale manufacturing. Much manufacturing takes place in factories, where assembly lines allow a steady flow of raw materials (inputs) and finished products (outputs). People in production focus on efficiency and effectiveness of processes in order to maximize productivity. To achieve overall success, it is important to measure, analyses and evaluate these processes. However, other activities also contribute to success: purchasing, inventory control. quality control. storage, logistics.

Production varies according to the inputs, *processes* and outputs. Other important factors are the *place* of production and the *resources.* In addition, *stock,* a major cost, needs to be carefully controlled, and the equipment must be regularly *maintained* to remain productive and prevent breakdowns.



TASKS

1 Match the words that go together and then complete the sentences below.

quality	material
finished	manager
industrial	lines
production	process
large-scale	levels
assembly	control
raw	products
productivity	manufacturing

1 Improved _____ _____ has led to higher efficiency in production.
2 The manufacture of paper is an _____ _____.
3 Crude oil is the basic _____ _____ for the plastics industry.
4 Increased _____ _____ have reduced the number of manufacturing workers.
5 The large warehouse is used to store _____ _____ waiting for delivery.
6 Large car manufacturers use _____ _____ in production.
7 The company began in a single room but has now developed into _____ _____.
8 The manufacturing process is the responsibility of the _____ _____.

2 Complete the sentences below. The first letter of the missing word has been given.

1 A quantity of goods prepared at the same time is known as a b_ _ _ _.
2 To put parts together to produce the final product is to a _ _ _ _ _ _ _.
3 Production processes convert inputs to o _ _ _ _ _ _.
4 The process of buying inputs is known as p _ _ _ _ _ _ _ _ _.
5 A part which is used in the final product is called a c _ _ _ _ _ _ _ _.
6 To get the best possible level of production is to o _ _ _ _ _ _ _.

Drawings

Drawing types and scales

In engineering, most design information is shown on **drawings**. Today, drawings are generally not drawn by hand. They are produced on computer, using **CAD** (**computer-aided design**) systems.

A key factor on a drawing is the **scale** – that is, the size of items on the drawing in relation to their real size. When all the items on a drawing are shown relative to their real size, the drawing is **drawn to scale**, and can be called a **scale drawing**. An example of a scale is 1:10 (**one to ten**). **At 1:10**, an object with a length of 100 mm in real life would measure 10 mm on the drawing.

Most engineering designs consist of **a set of drawings** (a number of related drawings):

- **General arrangement** (**GA**) drawings show whole devices or structures, using a **small scale**. This means objects on the drawing are small, relative to their real size (for example, **a 1:100 drawing** of an entire building).
- **Detail** drawings show parts in detail, using a **large scale**, such as 1:5 or 1:2. Small parts are sometimes shown in a **detail** as **actual size** (1:1), or can be **enlarged** to bigger than actual size (for example, 2:1).

For electrical circuits, and pipe and duct networks, it is helpful to show designs in a simplified form. In this case, **schematic drawings** (often referred to as **schematics**) are used. An everyday example is the map of a train network.

Notes: When written, **drawing** is often abbreviated to **dwg**.
CAD is pronounced as a word: /kæd/.

Types of views used on drawings

Technicians are discussing different **views** shown on drawings (looking at components from above, from the side, etc.), as they search for the information they require.

We need a view from above showing the **general arrangement** of all of the roof panels - a **plan** of the whole area.

According to this list, there are **elevations** of all four sides of the machine on drawing 28. So one of those should show the front of the machine.

There should be a **section** through the pipe, showing the valve inside, on drawing 36.

We need an **exploded view** of the mechanism, showing the components spaced out.

It's hard to visualize this assembly, based on **two-dimensional** elevations and sections. It would be clearer if we had a **three-dimensional** view, as either an **oblique projection** or an **isometric projection**.

.1 Complete the sentences. Look at A opposite to help you.

1 Enlarged drawings show components larger than their ....
2 For engineering drawings, 1:5 is a commonly used ..... .
3 Whole machines or structures are shown on .... drawings.
4 Electrical drawings don't usually show sizes. They're shown as ..... .
5 A ..... of drawings for a large project can consist of hundreds of pages.
6 Most drawings are produced on computers, using ..... software.

.2 Match the descriptions (1–6) with the names of views used on drawings (a–f). Look at B opposite and Appendix I on page 98 to help you.

1 a 2D view of the side of an object
2 a 2D view inside an object, as if it is cut through
3 a 2D view, looking down on top of an object
4 a 3D view, showing an assembly taken to pieces
5 a 3D view, with the 2D face of the object at the front
6 a 3D view, with a corner of the object at the front

a a plan
b a section
c an isometric projection
d an oblique projection
e an exploded view
f an elevation

.3 Write the full forms, in words, of the abbreviations and shortened terms below. Look at A and B opposite and Appendix I on page 98 to help you.

1 GA ....
2 CAD .....-..... .....
3 dwg .....
4 3D .....-.....
5 section .....-.....
6 1:50 ....

4 Complete the sentences, taken from conversations about drawings, using the words and abbreviations in the box. Look at A and B opposite and Appendix I on page 98 to help you.

3D	detail	elevation	GA	plan	scale	schematic	section

1 We need a ..... through the bridge, showing the profile of the deck.
2 The only drawing we have is the ..... , which is 1:100, so it obviously doesn't show things in detail.
3 On drawing 12, there's a large ..... of the entire top deck of the ship.
4 This is the ..... showing the front face of the tower.
5 Modern CAD systems can produce ..... drawings that look almost as realistic as photographs.
6 We don't need dimensions and positions at this stage. We just need a ..... showing how many branches come off the main supply pipe.
7 We don't have a proper drawing. We've just got a rough sketch, which is not to ..... .
8 The fixings aren't shown on the 1:50 general arrangement. But there's a ..... , at 1:5, on drawing 42.

Numbers and calculations

Decimals and fractions

A manufacturer is thinking about giving both **metric** measurements (for example, millimetres) and **imperial** measurements (for example, inches) in its product specifications. One of the company's engineers is giving his opinion on the idea in a meeting.

'One problem is, when you convert from metric to imperial you no longer have **whole numbers** – you get long **decimal numbers**. For example, one millimetre is **nought point nought three nine three seven** inches as a **decimal**. So to be manageable, decimals have to be **rounded up** or **down**. You'd probably round up that number **to two decimal places**, to give you **zero point zero four**. Now, you might say the difference is **negligible** – it's so small it's not going to affect anything. But even if it's just a tiny **fraction** of a unit – **one hundredth of** an inch (1/100), or **one thousandth of** an inch (1/1000) – and those numbers are then used in calculations, the **rounding error** can very quickly add up to give bigger inaccuracies.'

Note: See Appendix III on page 100 for a list of metric and imperial units.

1 mm = 0.03937 inches ≈ 0.04 inches

Addition, subtraction, multiplication and division

During a TV programme about garden design, the presenter is explaining the calculations required to make a large setsquare which can be used for setting out.

To make one of these, you need to use Pythagoras's Theorem. So, a quick geometry lesson. Measure a length of timber for one of the sides adjacent to the right-angle. I've made this 3 feet long. Then **square** that number – 3 **multiplied by** 3 **equals** 9. Then do the same with the other side adjacent to the right-angle. I've made this one 4 feet long. Work out **the square of** that. So, 4 **times** 4 **is** 16. Then work out **the sum of** those two numbers – so if I **add** 16 **to** 9 ... 16 **plus** 9 is 25. Then, calculate **the square root of** that. The square root of 25 is 5. That means the longest side – the hypotenuse – needs to be 5 feet long. And it doesn't matter what length you make the two adjacent sides – if the square of the hypotenuse is **equal to** the square of each of the adjacent sides, **added together**, you'll have a perfect right-angle.

A large setsquare for setting out

Now you can also start by making the hypotenuse, square the length of that, then make one of the other sides, square the length of that, and then **subtract** one **from** the other. For this example, that would be 25 **minus** 16. So, 25 **less** 16 is 9. And the square root of 9 is 3, which gives me the remaining side. Alternatively, you can make both the adjacent sides **equal** – make them the same length. So, take the square of the hypotenuse, which is 25, **divide** that **by** 2, which is 12.5, then work out the square root of 12.5, which ... requires a calculator! That's why it's easiest to use a 3-4-5 triangle, like this, which conveniently works with whole numbers. And that's also why I'm measuring **in imperial**, because 3 feet by 4 feet by 5 feet is a practical size to work with.

1 Write the numbers in words. Look at A opposite to help you.

1 1.793 ....
2 1/100 mm .... millimetre
3 1/1000 mm .... millimetre
4 0 ..... or .....

2 Complete the descriptions of the numbers using words from A opposite.

1 0.25 = ¼ — The first number is a decimal, and the second is a ..... .
2 0.6368 ≈ 0.637 — The second number is .... to three ....
3 7.5278 ≈ 7.5 — The second number is .... to one ....
4 8, 26, 154 — The numbers aren't fractions or decimals. They're ..... numbers.
5 Error: 0.00001% — The error is so small that it's ..... .
6 0.586 kg × 9,000 = 5,274 kg
0.59 kg × 9,000 = 5,310 kg — This difference is the result of a ....

3 Complete the calculations using the words in the box. Sometimes there is more than one possible answer. Look at B opposite to help you.

divided	minus	plus	square root	subtract	times
less	multiplied	square	squared	sum	

1 14 + 8 = 22 — Fourteen ..... eight equals twenty-two.
2 100 × 20 = 2,000 — One hundred ..... twenty is two thousand.
3 7 × 11 = 77 — Seven ..... by eleven equals seventy-seven.
4 400 ÷ 8 = 50 — Four hundred ..... by eight equals fifty.
5 95 + 2 = 97 — The ..... of ninety-five and two is ninety-seven.
6 8^2 = 64 — The ..... of eight is sixty-four.
7 50 – 30 = 20 — If you ..... thirty from fifty, it equals twenty.
8 $\sqrt{100}$ = 10 — The ..... of a hundred is ten.
9 11^2 = 121 — Eleven ..... is a hundred and twenty-one.
10 48 – 12 = 36 — Forty-eight ..... twelve equals thirty-six.

4 Use your knowledge of basic geometry to complete the sentences. Use one or two words from B opposite to fill each gap.

1 The ..... of the three angles in a triangle equals 180 degrees.
2 The area of a circle is equal to the ..... of its radius ..... 3.14.
3 The area of a right-angle triangle is equal to the length of one adjacent side, ... the length of the other adjacent side, ... two.
4 The length of each side of a square is equal to the ..... of the square's area.
5 If each angle in a triangle is 60°, then the lengths of its sides are ..... .

Weight, mass, volume and density

In everyday language, the term **weight** means how heavy things are (how much they **weigh**), and **grams** and **kilograms** are used as units of weight. But in physics and in engineering, grams and kilograms are units of **mass**. Whether an object is on earth – where it is subjected to **gravity** (the pull of the earth) – or floating **weightless** in space, its mass is always the same. The mass of an object depends on:

- the **volume** of the object, measured in **cubic metres** (m^3) – as an object's volume increases, its mass increases
- the **density** of the object, measured in **kilograms per cubic metre** (kg/m^3) – as density increases, mass **per unit of volume** increases.

The mass of an object is the object's volume multiplied by its density. The weight of an object is the force exerted on the object's mass by gravity.

Some materials are very **dense**, and therefore very heavy. An example is lead (Pb), which has a density of 11,340 kg/m^3. Other materials, such as expanded polystyrene (which can have a density as low as 10 kg/m^3), are very **lightweight**.

Material types

Metals and non-metals

Engineering materials can be divided into:

- **metals** – examples of **metallic** materials are iron (Fe) and copper (Cu)
- **non-metals** – examples of **non-metallic** materials are carbon (C) and silicon (Si).

As iron is such a widely used material, metals can be divided into:

- **ferrous metals** – those that contain iron
- **non-ferrous metals** – those that do not contain iron.

Elements, compounds and mixtures

With regard to the **chemical composition** of materials – the chemicals they contain, and how those chemicals are combined – three main categories can be used:

- **Elements** are pure materials in their most basic form. They cannot be broken down into different **constituents** ('ingredients'). Examples of elements widely used in engineering materials are iron, carbon and aluminium (Al).
- **Compounds** consist of two or more elements that are **chemically bound** – that is, combined by a chemical reaction. An everyday example is water, which is **a compound of** hydrogen (H) and oxygen (O).
- **Mixtures** consist of two or more elements or compounds which are mixed together, but which are not chemically bound. In engineering, common examples are **alloys** – that is, metals which have other metals and/or non-metals mixed with them. A common example is steel, which is an **iron–carbon alloy**, and can include other **alloying metals** – metals which are added to alloys, in small quantities relative to the main metal. Examples of widely used alloying metals are chromium (Cr), manganese (Mn) and tungsten (W).

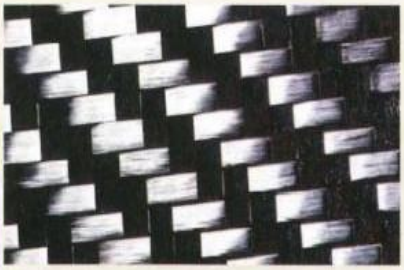
BrE: aluminium /ˌæl.jʊˈmɪn.i.əm/; AmE: aluminum /əˈluː.mɪ.nəm/

Note: For a list of chemical elements and their symbols, see Appendix IV on page 104.

Composite materials

The article below is from an engineering journal.

Materials under the microscope: composites



When you think of examples of hi-tech materials, **composite materials** come to mind – such as carbon-fibre, used in aerospace and Formula 1 cars. But although we think of **composites** as hi-tech and highly expensive, that's not always true. The earliest examples of composite materials were bricks made from mud and straw. Or, to use the correct composite terms, from straw **reinforcement** – the structural network that reinforces the material inside, and a mud **matrix** – the material surrounding the reinforcement. These terms explain what a composite material is: a matrix with a **reinforcing material** inside it. A modern, everyday example is fibreglass – correctly called **glass-reinforced plastic (GRP)** – which has a plastic matrix **reinforced with** glass fibres.

1 Complete the sentences using the words in the box. Look at A opposite and Appendix IV on page 104 to help you.

metal	non-metal	metallic	non-metallic	ferrous	non-ferrous

1 Carbon (C) is a ..... .
2 Copper (Cu) is a ..... metal.
3 Aluminium (Al) is a common ..... .
4 Steel (Fe + C) is a widely used ..... metal.
5 Although it is used in steel, carbon is ..... .
6 Aluminium is relatively lightweight for a ..... material.

2 Decide whether the sentences below are true or false, and correct the false sentences. Look at B opposite to help you.

1 The elements that make up a compound are chemically bound.
2 Alloys are chemical compounds that are frequently used in engineering.
3 Alloys can contain both metallic and non-metallic constituents.
4 In an alloy, an alloying metal is the biggest constituent, by percentage.
5 Steel is a metallic element.

3 Complete the extract about concrete and steel, using suitable forms of the word *reinforce* from C opposite. Sometimes there is more than one possible answer.

(1) ..... concrete is one of the most widely used construction materials, and one we take for granted. However, using steel bars to (2) ..... concrete structures located outdoors is only possible thanks to a fortunate coincidence: concrete and steel have practically the same coefficient of thermal expansion – in other words, as atmospheric temperature varies, the concrete and the steel (3) ..... expand and contract at the same rate, allowing uniform movement. Using a (4) ..... material with a different coefficient of expansion would not be feasible. For example, (5) aluminium-..... concrete would quickly disintegrate.

4 Read the text below and find two elements, two compounds, an alloy and a composite. Look at A, B and C opposite to help you.

Generally, the steel used in reinforced concrete will have previously been exposed to water and to the oxygen in the air. As a result, it will usually be partly corroded, being covered with a layer of iron oxide (rust). However, once the steel is inside the hardened concrete, it will be protected from air and water, which prevents further rusting. Additionally, the cement in concrete does not react aggressively with the iron in steel.

Element	Compound	Alloy	Composite

Material properties

Tensile strength and deformation

When materials are exposed to forces, such as **tension** (stretching forces ←□→) and **compression** (crushing forces →□←), they **deform** – that is, they change shape. The type of **deformation** depends on the type of force that is applied.

When a material is subjected to tension, its length will increase by a certain amount. This is called **extension** or **elongation**. It is especially important to understand the performance of materials **in tension**, as their **tensile strength** (ability to resist tension) is usually lower than their **compressive strength** (ability to resist compression).

Elasticity and plasticity

Some materials can extend significantly, but still return to their original shape. A material's ability to do this is called **elasticity**. Rubber is an example of a very **elastic** material – it can be **elastically deformed** to a considerable extent.

If a material has very low elasticity, and is strong, engineers say it is **stiff**. If a material has low elasticity and is weak, it is described as **brittle** – that is, it **fractures** (breaks, due to tension) very easily. Glass is an example of a brittle material.

Some materials can change shape significantly, but do not return to their original shape. We say these materials are **plastic**. Often, **plasticity** is described in specific terms. A material that can be **plastically deformed** by hammering or rolling – for example, lead (Pb) – is **malleable**. A material that can be drawn out (stretched) into a long length – for example, copper (Cu) – is **ductile**.

Hardness

The **hardness** of a material affects its **durability** – that is, how long it will last. Generally, **hard** materials are more **durable** than **soft** materials, because they are better at resisting **wear** – progressively worsening damage – to their surfaces. Hardness can be defined in two main ways:

- **Scratch hardness** describes a material's ability to resist being **scratched**. Materials with a high degree of scratch hardness are said to have good **abrasion resistance** – they are good at resisting damage due to **abrasion** (the action of two surfaces being rubbed together).
- **Indentation hardness** describes a material's ability to resist **indentations** – that is, compressions in the surface of a material caused by impacts.

Scratches

Indentations

Fatigue, fracture toughness and creep

The article below is from an aviation magazine.

In aircraft construction, special attention must be paid to two materials problems that are well understood by mechanical and structural engineers.

One is **fatigue**, often called **metal fatigue** in metals. This problem is caused by **cyclic loads** – forces that continually vary. In aircraft, the wings are affected by cyclic loading as they frequently **flex**, continually bending up and down due to air turbulence. The consequence of fatigue is **micro-cracking** – the formation of cracks too small to see with the eye, and which worsen over time. The speed at which **fatigue cracking** progresses depends on the material's **fracture toughness**. This is a measure of how easily cracks that have already formed continue to open up and increase in length.

Another problem is **creep** – where components become permanently deformed (stretched, for example), due to loads. Creep increases over time. The problem is made worse by heat, so is a major issue in engines, where both loads and temperatures are high.

Basic thermal properties

Some materials **conduct** (carry or transmit) heat better than others. Therefore, **thermal conductivity** varies, depending on the material. Copper, for example, is an excellent **thermal conductor**. Polystyrene, on the other hand, is an excellent **thermal insulator** (and so a very poor thermal conductor).

As temperature increases, most materials **expand** (increase in size due to heating), and as temperature falls, they **contract** (decrease in size due to cooling). The extent to which **expansion** and **contraction** occur is measured by a material's **coefficient of thermal expansion** – that is, its change in size for a given change in temperature. The coefficient for aluminium, for example, is 0.000023. This means that for an increase in temperature of one degree Celsius, a one-metre length of aluminium will increase in length by 0.000023 metres. This figure can also be referred to as the **coefficient of linear expansion**, since it describes change in length (a linear measurement).