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НАЦІОНАЛЬНА МЕТАЛУРГІЙНА АКАДЕМІЯ УКРАЇНИ

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ENGLISH FOR ELECTRICAL ENGINEERING

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Містить основні лексико-граматичні довідкові матеріали, призначені для повторення та поглиблення знань, набутих при вивченні базового курсу з англійської мови.

Пропонуються тексти на основі спеціальної термінології, а також вправи, спрямовані на розвиток навичок усного та писемного мовлення.

Призначений для студентів спеціальності 141 – електроенергетика, електротехніка та електромеханіка (магістерський рівень).

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ВСТУП

Навчальний посібник “English for Electrical Engineering” для студентів спеціальності 141 – електроенергетика, електротехніка та електромеханіка (магістерський рівень) укладено з метою поглиблення знань студентів з іноземної мови (англійська) у галузі, лексики та граматики на матеріалі автентичних текстів професійної тематики, що сприятиме розвитку їх соціолінгвістичної та лінгвістичної компетенцій.

Відповідно до Програми навчальної дисципліни «Іноземна мова професійного спрямування», навчальний посібник структуровано чотирма змістовими частинами:

1) Unit 1. ENGINEERING - WHAT’S IT ALL ABOUT?
2) Unit 2. ELECTRICAL
3) Unit 3. ENERGY
4) Unit 4. WHAT IS ELECTRICITY?
5) Unit 5. CURRENT, VOLTAGE AND RESISTANCE
6) Unit 6.ELECTRICAL SUPPLY
7) Unit 7. CIRCUIT AND COMPONENTS
8) Unit 8. MAGNETIC FIELDS
9) Unit 9.ENGINES AND MOTORS
10) REFERENCES
11) APPENDIX

Усі змістові частини містять необхідний лексичний мінімум, лексико-граматичні вправи, автентичні тексти з професійної тематики, комунікативні вправи, спрямовані на розвиток усного та писемного мовлення.

Навчальний посібник містить додатки – лексичний мінімум зі спеціальності, довідковий матеріал, що сприяє розвитку навичок професійно-орієнтованого мовлення та знімає лексичні труднощі при роботі з текстами.

UNIT 1

ENGINEERING - WHAT'S IT ALL ABOUT?

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

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

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

B. Study these illustrations. They show some of the areas in which engineers work. What kinds of engineers are concerned with these areas?

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

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

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

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

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

C. Language study *deals with/is concerned with*

What is the link between column A and column B?

A	***B***
mechanical	machines
electrical	electricity

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

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

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

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

D. Electrical Engineer

What is Involved?

As an electrical engineer, you would be largely concerned with generating and supplying electrical power, although you might branch into the closely related field of electronic engineering, where you would be more involved with designing and making machines that use electricity. Electrical engineers work mainly with large power applications, generating and harnessing electrical power. You could be researching more efficient power generation systems, developing alternative energy sources or planning the future development of the electricity supply network.

Kind of Person

Electrical engineers work in a rapidly developing environment and you would need to be creative, imaginative and prepared to keep up-to-date with changes in your field. You should have a logical and practical approach to solving complex scientific problems. In addition to your scientific skills, you are likely to need good communication skills. You would probably be working as a member of a team and may need to communicate with a wide range of people, not all of whom would have your technical knowledge and skills.

Related Occupations.

You might also consider: electronic/ electronics engineer, civil engineer, mechanical engineer, manufacturing engineer, chemical/process engineer or aeronautical/aerospace engineer, materials scientist/ engineer, metallurgist, physicist, medical physicist, biotechnologist or computer engineer/scientist.

Over to you

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

The main branches of engineering are civil, _________ , ________ and electronic. Mechanical engineering is __________ _________ machinery of all kinds. This ranch of engineering includes __________, automobile, __________, and heating and ventilating. The first three are concerned with transport: ________, ________, cars and planes. The last ________ with air-conditioning, refrigeration, etc.

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

Two branches of engineering include both _______ and _______ engineers. These are mining and _________ engineering. The former deals with mines and mining equipment, the latter with hospital ________ _________ of all kinfs.

UNIT 2

ELECTRICAL

A. 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	- lasers
- medical imaging systems	- control systems	- radar
- solid-state electronics	- computer design	- fibre optics
- consumer electronics	- electronic circuits	- robotics

In recent years, the electronic computer has emerged as the largest application of electrical engineering. However, another very large field is concerned with electrical ***light*** and power and their applications. Specialities within the field include the design, manufacture and use of ***turbines***, ***generators***, ***transmission lines***, ***transformers***, ***motors***, ***lighting systems*** and ***appliances***.

B. *Electrical problems* can be avoided by always using the right *devices* and taking appropriate measures for *electrical protection*.

Electrical problems

ground fault	overcurrent	overload	short circuit

Electrical protection

dustproof	explosionproof	rainproof	raintight	waterlight	weatherproof

Electrical devices

branch circuit	cable	feeder	fuse
(circuit) breaker	circuit	fixture	ground
junction (electrical) box	panelboard	switchboard	
service panel	switch		

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

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

TASKS

2.1. 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 does not 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.

2.2. What is being described? Find a word or phrase the page opposite.

1. It produces a narrow beam of light and can be used to read barcodes in a supermarket, play compact disks, etc.
2. A word to describe any piece of equipment made for 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 roots 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 where several cables are connected.

2.3. Complete the text below with words from parts A-C. 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 400,00 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.

Over to you

Think about electrical applications / electrical devices used in industrial areas you are familiar with. What measures for electrical protection must be used?

UNIT 3

ENERGY

A. Forms of energy

The effects of energy can be seen, felt or heard in different ways, depending on the form of energy in question. The main forms are listed below:

• ***kinetic energy***: energy in the form of movement - a type of mechanical energy

• ***thermal energy***: energy in the form of heat

• ***electrical energy***: the energy of an electric current

• ***sound energy***: energy in the form of noise

• ***light energy***: for example, light emitted from the sun or from a light bulb

• ***chemical energy***: energy within substances that can produce a chemical reaction

• ***nuclear energy***: energy from an atomic reaction.

Energy cannot be created or destroyed, only ***converted*** from one form to another. For example, in a torch ***powered*** by batteries, chemical energy ***stored*** in the batteries is converted to electrical energy, and the electrical energy is converted to light energy.

Mechanical energy can be stored as ***potential energy***. An example is a load, lifted by a crane and suspended at a high level. The weight has the potential (in the future) to be released and allowed to fall, becoming ***kinetic energy***. Energy can also be stored when a component is elastically deformed. This is called ***strain energy***. An example is the spring in a watch, which is wound up, then progressively unwinds.

B. Energy efficiency

Machines often convert an ***energy source,*** such as electricity, to another form of ***useful energy*** - in other words, energy used for a purpose. For example, a motor converts electrical energy (the energy source) into kinetic energy (useful energy). But it also converts some energy into heat and noise. As this will be ***dissipated*** into the air, and not used, it is ***waste energy***.

If a machine converts a high percentage of energy into useful energy, it is ***efficient***. For example, if a motor converts 7 5% of the electrical energy it consumes into kinetic energy, and wastes 25% as thermal and sound energy, it is ***seventy-five percent efficient***. Improving ***efficiency*** - making ***efficiency gains*** - is a key focus in engineering.

A motor: electrical energy ~ useful kinetic energy
~ wasted thermal and sound energy

C. Work and power

The amount of energy needed to do a task - for example, lifting a load to a certain height by crane - is called ***work***. The amount of energy converted in order to perform tasks – in other words, the amount of ***work done***- is measured in ***joules*** **(J).** If a force of one newton is required to keep an object moving, the work required to move that object over a distance of one meter is equal to one joule.

The speed, or rate, at which work is done is called ***power***, and is measured in ***watts (W).*** One watt is one joule per second. Power, in watts, is often referred to as ***wattage***. A powerful motor will have a higher wattage than a less powerful one.

TASKS

3.1. Make word combinations with *energy* using words from A and B opposite. Then match the combinations with the descriptions (1-8).

1. ……………… *energy* = energy stored within the liquids or solids in a battery;
2. ……………… *energy* = mechanical energy in the form of movement;
3. ……………… *energy* = potential energy stored in a deformed material;
4. ……………… *energy* = energy converted to the form required for a purpose;

5. ……………… *energy* = energy converted to a form that cannot be used;
6. ……………… *energy* = the form of energy that shines, and can be seen;
7. ……………… *energy* = the form of energy that can be heard;
8. ……………… *energy* = energy that results in an increase in temperature.

3.2. Complete the article about electric and diesel-electric locomotives using the words in the box. Look at A, B and C opposite to help you.

a) chemical,	e) efficient,	i) joules,	m) powerful,	r) useful,
b) convert,	f) electrical,	j) kinetic,	n) source,	s) waste,
c) dissipated,	g) form,	k) power,	o) stored,	t)wattage,
d) efficiency,	h) gain,	l) powered,	p) thermal,	u) work.

An electric locomotive is one that is (1) .... by an external energy (2) .... , most often via overhead electric lines. This differs from a diesel-electric locomotive, which has an onboard fuel tank and a diesel-powered generator to provide electricity for its motors. Purely electric power has numerous advantages over diesel-electric power, explaining the choice of electric locomotives for use in high-speed trains.

Firstly, an electric locomotive needs to carry neither a generator nor fuel. Its mass is therefore lower than a diesel-electric equivalent. This results in a significant efficiency (3) .... , as the electric locomotive's smaller mass means less (4) .... is done - measured as a total number of (5)................................ - on a given journey. For a comparable rate of acceleration, its motors are also required to provide less (6) .... As they use a lower (7) .... , this means less (8) .... motors can be used, making them smaller, thus further reducing weight and improving

(9) .... In addition, electric locomotives use only (10)................................ energy.

This means there is no need to (11) .... energy from one (12)................................ to another on board the train (electricity can be generated more efficiently in power stations).

In a diesel-electric unit, the energy conversion process starts with(13)............................. .. energy, which is (14) ....…. within the hydro-carbon compounds of diesel. This fuel is burned to produce (15) .... energy, and the heat is then converted by the engine into (16) .... energy, which provides the movement to drive the train. This process is a very long way from being 100% (17)................................ - only a small percentage of the initial chemical energy is converted to the (18) .... energy that is actually used to drive the train, with a significant percentage being (19) .... into the air in the form of heat, constituting (20) .... energy.

<u>Over to you.</u>

Think about some machines or appliances you are familiar with. What sources of energy do they convert? What forms of useful energy and waste energy are produced?

UNIT 4

WHAT IS ELECTRICITY?

A. All substances, solids, liquids or gases, are composed of one or more of the chemical elements. Each element is composed of identical atoms.

Each atom is composed of a small central nucleus consisting of protons and neutrons around which ***orbit shells*** of electrons. These electrons are very much smaller than protons and neutrons.

The electrons in the ***outermost*** shell are called ***valence*** electrons and the electrical ***properties*** of the substance depend on the numbers of these electrons. Neutrons have no electric ***charge***, but protons have a positive charge while electrons have a negative charge. In some substances, usually metals, the valence electrons are free to move from one atom to another and this is what constitutes as electric current.

B. There are two types of current: Direct current (DC) and Alternating current (AC). Direct current is a continuous flow of electrons in one direction and it never changes its direction until the power is stopped or ***switched off***. Alternating current constantly changes its direction because of the way it is generated. The term "frequency" is used to indicate how many times the current changes its direction in one second.

Alternating current has a great advantage over direct current because it can be transmitted over very long distances through small wires, by making energy high voltage and low current.

There are several quantities that are important when we are talking about electric current. ***Volts*** (***V***) - so named after the Italian physicist Alessandro Volta - measure the difference of electric potential between two points on a conducting wire. ***Amperes*** (***A***) measure the amount of current flowing through a conductor, that is to say the number of electrons passing a point in a conductor in one second. ***Coulomb*** (***C***) measure the quantity of charge transferred in one second by a ***steady*** current of one ampere. Power is the rate at which work is performed and it is measured in ***watts*** (***W***). A ***Kilowatt*** (***kW***), which is equal to one thousand watts, is used to measure the amount of used or available energy. The amount of electrical energy consumed in one hour at the constant rate of one kilowatt is called kilowatt-hour.

TASKS

4.1. Read the text A again and complete the sentences with the missing information.

1. Elements make up ____ .
2. Identical atoms ____ .
3. Atoms consist of ____ .
4. Inside there are __________ and __________, while outside __________ .
5. Shells ____ .
6. Valence electrons ____ .
7. Neutrons do not have ____ .
8. Electricity is generated when ____________________________________ .

4.2. Read the text B again and complete the sentences with the missing information.

Unit of measurement	What does it measure?
1)	the number of electrons passing a given point in a conductor in one second.
2)	the quantity of electricity transferred by a steady current of one ampere
3)	the amount of electric energy used
4)	the difference of potential between two points on a conductor
5)	rate at which work is done

Over to you.
Think of some semiconductors / insulators you're familiar with. Explain how they work.

UNIT 5

CURRENT, VOLTAGE AND RESISTANCE

A. Electric current

The photo on the opposite page shows a simple electric circuit (or circuit). A cell provides an electric current (or current). This flows through wires, which conduct the electricity (provide a way for it to travel). The current is used to light a lamp. So, like all circuits, the example includes:

- an ***electrical supply*** - in this case, the cell
- an ***electrical conductor*** (or conductor)- an electrical path- in this case, wires
- one or more ***electrical components*** (or components)- electrical devices (in this case, the lamp) which have a function.

Current- measured in amperes, or amps (A) -is the rate of flow of electric charge. Electric charge is carried by electrons- particles with a negative charge (-),which are normally attached to atoms. When an electric current flows through a conductor; the electrons move from one atom to another- in the case of a copper wire, from one copper atom to the next.

If the number of electrons flowing through a conductor increases, then the amperage, or ampage (current) increases. When electrons flow, carrying a current, they can be called charge carriers.

Notes:	*In everyday English,* ***cells*** *are called* ***batteries****. In technical English, a battery is a number of cells placed together.* *Lamps are often called* ***bulbs*** *in everyday English*

B. Voltage and resistance

The amount of current (in amps) flowing through a circuit will partly depend on the ***electromotive force (EMF)*** of the electrical supply. Electromotive force is measured in ***volts (V)***, and is generally called ***voltage***. The voltage depends on the 'strength' of the electrical supply. In the diagram above, adding a second cell would supply a higher voltage.

The amount of current will also depend on ***electrical resistance*** (or ***resistance***). This value - in ***ohms*** (**Ω**) - is a measure of how easily current can flow through the conductors and components in a circuit. For example, a lamp creates resistance because the ***filament***- the metal wire inside it - is very thin. This limits the amount of current that can flow. Resistance also depends on the materials used as conductors. For example, copper has a low resistance and so is a good conductor.

Materials with very high resistance, such as plastics, are called ***electrical insulators*** (or insulators). Only very high voltages cause current to flow through them. Materials that are good insulators are used to insulate conductors. An example is plastic ***insulation*** around ***electric wires***.

This stops people from touching the conductor and- if it is ***live*** (carrying current)- from getting a dangerous ***electric shock***.

C. Electric power

The text below, about ***electrical power***, is from a home improvements magazine:

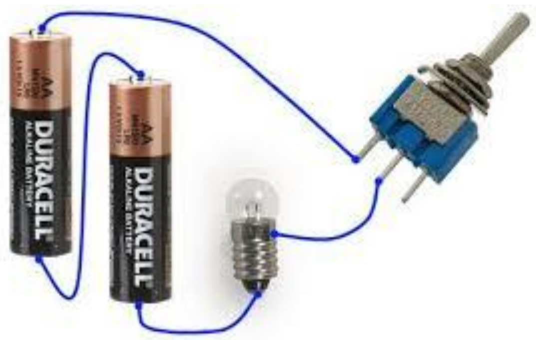
> The amount of current, in amps, required by an ***electrical appliance-*** such as a TV or an electric kettle -depends on the ***power*** of the

appliance. This number- expressed in ***watts (W)-*** will be marked somewhere on the appliance. To calculate the required current, simply take the ***wattage*** and divide it by the voltage of the electrical supply in your home- around 230 volts in most of Europe. Therefore, for an electric kettle with a ***power rating*** of 2,000 watts (as specified by the manufacturer), the current required is:

$$\frac{2{,}000 \text{ watts}}{230 \text{ volts}} = 8.\ 7 \text{ amps}$$

TASKS

5.1. Complete the word puzzle and find the word going down the page. Look at A, B and C opposite page to help you.



1 another term for amperage;

2 provided by a battery, for example;

3 measured as wattage;

4 allows current to flow through it;

5 has very high electrical resistance;

6 carried by moving electrons;

7 another term for an electrical 'device';

8 the consequence of a person touching a live conductor.

1. ELECTRIC
2. ELEC TRIC
3. E LECTRIC
4. ELECTRIC
5. ELECTRIC
6. ELECTRIC
7. ELECTRIC
8. ELECTRIC

5.2. Complete the extract about current and power calculations using the words in the box. Look at A, B and C opposite to help you.

a) amps	d) circuit	g) resistance	i) voltage	k) wattage
b) components	e) current	h) supply	j) volts	l) watts
c) conductor	f) ohms			

In electrical calculations, electromotive force is expressed by the letter E, resistance by the letter R, and current by the letter *1* (which comes from the word 'intensity').

According to Ohm's Law: I = E/R.

In other words, the (1) .... flowing through a (2)................................ , measured in (3) .... , equals the (4) .... of the electrical (5) .... , measured in (6) .... , divided by the total (7) .... , measured in (8) .... To work out the value of R, it is necessary to calculate the total resistance of all the (9) .... and connecting lengths of (1 0) .... that make up the circuit.

Once both the voltage and amperage are known, it is possible to work out the power, measured in (11) .... , that will be consumed. Power (P) can be calculated using the equation P = EI. Therefore (12) .... equals voltage multiplied by amperage.

<u>Over to you.</u>

Say how much power is required by an electrical appliance you know about, and what voltage and current are used to power it. Then use these values to calculate and state what the total resistance of the appliance is.

UNIT 6

ELECTRICAL SUPPLY

A. Direct current and alternating current

The current from a cell is ***direct current (DC)*** **-** a constant flow of electricity which travels around a circuit in one direction. The electricity supplied to homes and other buildings - called ***mains electricity*** **-** is ***alternating***

current (AC). Unlike a ***DC supply***, an ***AC supply*** flows backwards and forwards - its direction continually ***alternates***. The rate at which the current alternates- called the ***frequency***- is measured in ***hertz*** (***Hz***). For example, in the UK, AC supply is 50 Hz - it alternates 50 times per second. On a graph, the AC supply of mains electricity forms a ***sine wave***.

The current supplied to most homes is ***single-phase*** - it forms one sine wave. In factories and large buildings, which have powerful electrical equipment, the supply is often ***three-phase*** - effectively three currents, each with a different ***phase*** (timing). This provides a smoother supply as it reduces the gaps between the voltage peaks.

Note:	*The term mains electricity is not used in American English - terms like supply are used.*

B. AC generation and supply

Mains electricity is ***generated*** (produced) at sites called ***power stations***, which use large ***generators***. A generator converts mechanical energy to electrical energy. A generator rotates a magnet within an iron surround. The iron - called an ***armature*** - has coils of wire around it, called ***field coils*** (or ***field windings***). As the magnet rotates, it causes current to flow through the field coils, due to ***electromagnetic induction***.

Current from the generators leaves the power station and enters the ***power grid*** (or ***grid***) - the network of ***power lines*** (cables) which transmit it around the country. At the point where it enters the grid, the electricity flows through ***transformers*** - specifically ***step-up transformers***, which increase voltage and decrease amperage. This reduces the energy lost from the power lines over long distances, as ***high-voltage*** (***HV***) supplies flow more efficiently than ***low-voltage*** (***LV***) supplies. Before the supply is used by homes and other buildings, it passes through several ***step-down transformers***, which reduce its voltage and increase its amperage.

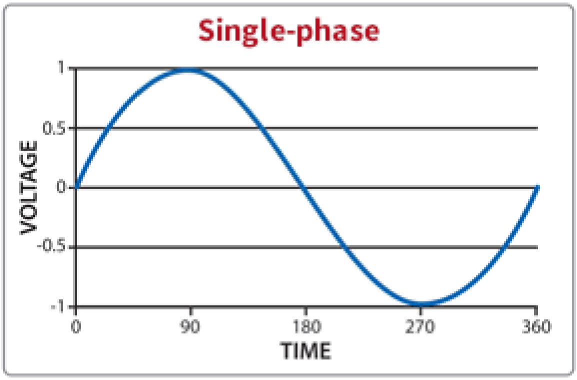
The supply may be ***stepped up*** to over 400,000 volts at the point where it enters the large ***transmission lines*** (long-distance power lines) leaving the power station. It is normally then ***stepped down*** in stages, first passing through a wider network of lower-voltage transmission lines, and finally through the small

distribution lines which supply streets and houses –in many countries at around 230 volts.

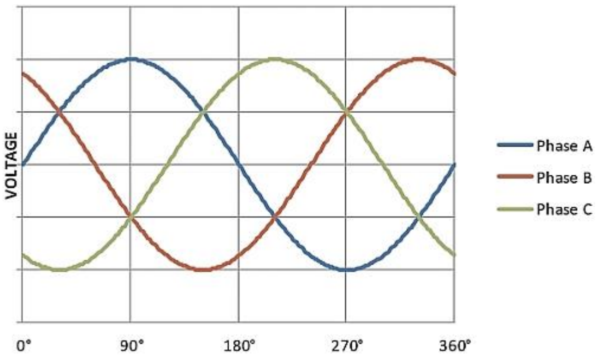
C. DC generation and use

The extract below is from a consumer magazine.

Photovoltaic cells (***PVs***) - or solar cells - are an effective way of generating your own electricity from sunlight. The current they produce can be used immediately, may be stored in ***rechargeable batteries*** (like the ones in cars), or can be fed into the power grid and sold to the electric company. But PVs produce direct current. This is fine for ***charging*** batteries, but is not suitable for powering household appliances, which require alternating current. For this, the DC supply from PVs and batteries needs to go through an ***inverter*** - a device which converts DC to AC.



A single-phase AC supply



A three phase AC supply

TASKS

6.1. Complete the text about inverters using words from A. Look at A, B and C to help you.

Inverters convert (1) .... to (2) .... If an inverter is used to supply electrical appliances in a home, it must copy the supply of (3) .... electricity produced by the generators at power stations. Most inverters can produce a current which alternates precisely at the required (4) .... - for example, 50 (5) .... (SO cycles per second). However, not all types are able to produce a current which follows the pattern of a (6) ....

.... , like that of the (7) .... -....................... AC supply used in homes. So-called 'square wave inverters' only produce a very approximate copy of this wave, which can affect the functioning of many electrical appliances.

6.2. Choose the correct words from the brackets to complete the descriptions of different stages of AC generation and supply (a-f). Then, put the stages in the correct order. Look at B opposite to help you.

a. After the step-up transformer, the current enters a (*distribution / transmission*) line.

b. Current is produced, by electromagnetic induction, in the (*magnet / field coils*) of a generator.

c. The current goes from the last step-down transformer to a (*distribution / transmission*) line.

d. The current leaves the power (*grid / station*) and enters the home.

e. Amperage is reduced and voltage is increased by a (*step-up / step-down*) transformer.

f. The current is stepped (*up / down*) from a higher voltage to a lower voltage, in stages.

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

1. Photovoltaic cells produce direct current.
2. The electricity supply from PVs can be used to charge rechargeable batteries.

3 Rechargeable batteries supply electricity as alternating current.

4 Inverters convert sunlight to alternating current.

<u>Over to you.</u>

Think of some large and small electrical appliances you’re familiar with. Explain their electrical supply requirements. What type of current is required, and how is it supplied and/or converted?

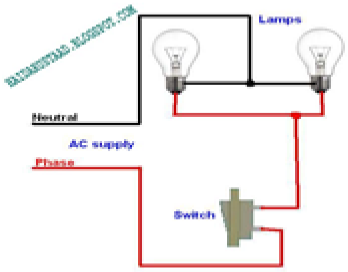
UNIT 7

CIRCUITS AND COMPONENTS

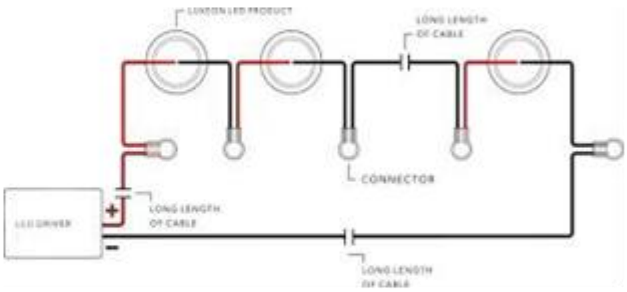
A. Simple circuits

The circuit diagrams below show lamps connected in a ***parallel circuit*** and in a ***series circuit***. The supply has live and ***neutral*** conductors. On an alternating current (AC) supply, the difference between live and neutral is that conductors on the neutral side of appliances are ***earthed*** - that is, connected to ***earth*** (the ground).

2 lamps in parallel



3 lamps in series



BrE: live; AmE: phase BrE: earth, earthed; AmE: ground, grounded

B. Mains AC circuits and switchboards

Where an AC supply enters a building, it is connected to a ***switchboard***. This has a number of switches to allow different circuits in the building to be ***switched on*** and ***off***. Circuits include ***power circuits***. These supply the ***power sockets*** (or ***sockets***) for the plugs on appliances. Usually, a ***circuitbreaker*** is fitted to each circuit. This is a safety switch that switches off automatically if there is a problem. This may happen if a person touches a live conductor, or if there is a ***short circuit***. A short circuit is when current flows directly from a live conductor to a neutral conductor -for example, due to damaged insulation. Circuit breakers also allow circuits to be switched off manually, to ***isolate*** them (switch them off safely) -for example, before maintenance work.

Note: The equipment in ***switchboards*** is often called ***switchgear***.

C. Printed and integrated circuits

The circuits in electrical appliances are often ***printed circuits***, on ***printed circuit boards*** (***PCBs***).

These are ***populated*** with (fitted with) electrical components. Many appliances also contain small, complex ***integrated circuits*** often called ***microchips*** (or ***chips***) made from silicon ***wafers*** (very thin pieces of silicon). They act as ***semiconductors***, which can be positively charged at certain points on their surface and negatively charged at other points.

This principle is used to make very small circuits.

D. Electrical and electronic components

There are many types of electrical and ***electronic*** components. These can be used individually or combined with other components to perform different tasks. For example:

- ***Sensors*** or ***detectors*** can ***sense*** or ***detect*** levels of- or changes in - values such as temperature, pressure and light.
- ***Control systems*** use feedback from sensors to control devices automatically. For example, mechanical devices such as water valves may be moved or adjusted by ***servomechanisms*** electrically powered mechanisms that are controlled automatically by ***signals*** ('messages') from sensors.
- ***Logic gates*** are widely used in control systems. They send signals, in the form of low voltages, to other devices. An output signal from the logic gate is switched on or off, depending on the input signals it receives**.**

Notes: The term electronic, rather than electrical, generally describes small but often very complex circuits and components that operate at a low voltage.

TASKS

7.1. Make word combinations with *circuit* using words from A and B opposite. Then match the combinations with the descriptions (1- 6) below.

1. a _____________
2. a _____________
3. a _____________
4. a _____________
5. a _____________
6. an ____________

circuit

1. a circuit containing one or more sockets;
2. a simple circuit where all the components are placed one after the other along the same conductor;
3. a microchip - a very small, often complex circuit;
4. what happens if live and neutral conductors touch while a current is flowing, and there is no component or appliance between them;
5. a circuit which allows different components to be controlled independently by separate switches;
6. a circuit that can be populated with a large number of components.

7.2. Complete the task from an engineering textbook. Sometimes more than one word is possible.

In an experiment, the lights in a room are connected to two types of electronic (1) .... The first is an occupancy sensor, which will (2) .... the movement of a person entering the room, and the second is some kind of photosensor, which can determine whether it's daylight or dark. These two devices are connected to an AND gate - a (3) .... that will produce an output current only if it receives two input currents - in this case, from both the occupancy sensor *and* the photosensor.

Therefore, a (4) .... will be sent to the light switch to (5) ....
.... the lights only if a person enters the room *and* if it's dark.

However, fo r this system to work, we are assuming that the type of photosensor used will be one which is designed to produce a current in the dark, and which will then (6) .... as soon as daylight appears. But such a sensor may be designed to work in the opposite way - producing a current when it detects daylight and no current in the dark.
This would cause an obvious problem. In this case, what type of logic gate could be placed between the photosensor and the AND gate in order to solve the problem?

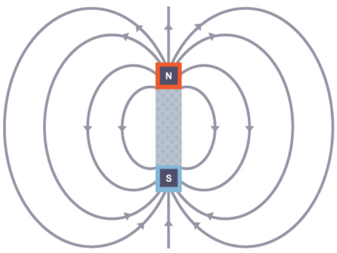
Over to you.
Think of a device or installation you're familiar with which is automatically controlled, and describe its control systems. What kinds of sensor are used? How does the control system react to different signals from the sensors?

UNIT 8

MAGNETIC FIELDS

A. Electric currents can create ***magnetic fields***. Magnetic fields are the areas where a ***magnetic force*** acts. There's proper definition of a ***magnetic field***:

A ***magnetic field*** is a region where ***magnetic materials*** (like iron and steel) and also ***wires carrying currents*** experience ***a force*** acting on them.



Magnetic fields can be represented by ***field diagrams*.**
The arrows on the field lines always point from the ***north pole*** of the magnet to the ***south pole.***

When a current flows through a ***wire***, a magnetic field is created ***around*** the wire. The field is made up of ***concentric circles*** with the wire in the centre.
The magnetic field ***inside*** a coil of wire (a solenoid) is ***strong*** and ***uniform*.** Outside the coil, the magnetic field is just like the one round a ***bar magnet***. If you stop the current, the magnetic field disappears. A magnet whose magnetic field can be ***turned on*** and ***off*** with an electric current like this is called an ***elecromagnet***.

An electromagnet must be ***constantly supplied*** with current – as that's what produces the ***magnetic field***. So, if the current ***stops***, then it ***stops*** being magnetic. Magnets you can ***switch off*** at your whim can be really ***useful***.

B. Passing an electric current through a wire produces a magnetic field around the wire. If you put that wire into a magnetic field, you have two magnetic fields combining which puts a force on the wire (generally). A current in a magnetic field experiences a ***force***. The force experienced by a ***current-carrying*** wire in a magnetic field is known as the ***motor effect***. The motor effect is used in lots of appliances that use movement.

C. ***Electric motors*** use the ***motor effect*** to get them (and keep them) ***moving*.** An **electric motor** is an electrical machine that converts electrical energy into mechanical energy. Most electric motors operate through the interaction between the motor's magnetic field and electric current in a wire winding to generate force in the form of rotation of a shaft. Electric motors can be powered by direct current (DC) sources, such as from batteries, motor vehicles, etc. or by alternating current (AC) sources, such as a power grid, inverters or electrical generators. An electrical generator is mechanically identical to an electric motor, but operates in the reverse direction, converting mechanical energy into electrical energy.

TASKS

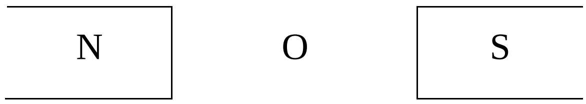
8.1. Answer the questions:

1. Name two things that experience a force in a magnetic field.
2. Describe the magnetic field around a current-carrying wire.
3. Suggest one use for an electromagnet.
4. In Fleming's left-hand rule, what's represented by the first finger? the second finger? the thumb?
5. Give three uses of electric motors.

8.2. Solve and explain some problems:

3. Iron and steel are magnetic. Electromagnets are often used in scrap yards to lift iron and steel. Explain why electromagnets are used, rather than ordinary magnets.

4. The diagram below shows an aerial view of current-carrying wire in a magnetic field. The circle represents the wire carrying current out of the page, towards you.



a) Describe the direction of the magnetic field of the magnet.

b) On the diagram, draw an arrow to show the direction of the force acting on the current-carrying wire.

c) Describe what would happen to the force acting on the current-carrying wire if the direction of current was reversed.

d) Describe how the size of the force acting on the wire would change if:

(i) the wire was at 30* to the magnetic field.

(ii) the wire ran parallel to the magnetic field.

<u>Over to you.</u>

Think of an electromagnet using a current-carrying solenoid and a core, and describe how it works. Suggest a material that would be suitable for the core.

UNIT 9

ENGINES AND MOTORS

A. Types and functions of engines and motors

The term engine usually refers to petrol engines, diesel engines and jet engines (or jets). In engineering, motor usually means electric motor - but in general language, 'motor' can also refer to petrol and diesel engines. Engines and motors power (or drive) machines by generating rotary motion- for example, to drive wheels. In jet engines, compressors and turbines rotate to generate thrust -

pushing force, produced by forcing air from the back of the engine at high velocity.

As an engine produces a couple -rotary force - the moving parts of the machine it is driving will produce resistance, due to friction and other forces. As a result, torque (twisting force) is exerted on the output shaft of the engine. Torque -calculated as a turning moment, in newton metres - is therefore a measure of how much rotational force an engine can exert. The rate at which an engine can work to exert torque is the power of the engine, measured in watts. Although engineers normally calculate engine power in watts, the power of vehicle engines is often given in brake horsepower (bhp). This is the power of an engine's output shaft measured in horsepower (hp) - a historic measurement of power.

BrE: petrol; AmE: gasoline
BrE: petrol engine; AmE: gasoline engine

B. Internal combustion engines

Petrol and diesel engines are internal combustion engines. This means they are driven by the combustion (burning) of fuel in enclosed, sealed spaces called combustion chambers. In petrol and diesel engines, the combustion chambers are cylinders surrounded by a cylinder block and closed at the top by a cylinder head. Each cylinder contains a piston. The number of piston cylinders in an engine varies - engines in small motorcycles have only one, while sports car engines may have twelve.

Fuel is supplied to each cylinder from a tank. In most engines, the flow of fuel is generated by a pump, which forces it- at high pressure - through fuel injectors. These vaporize the fuel, allowing it to mix with air. Using this mixture (of fuel and air), most engines function as four-stroke engines. This means they work on a cycle of four stages - or four strokes. A stroke is an upward or downward movement of a piston.

1. Induction or intake	2. Compression	3. Power or ignition	4. Exhaust
The intake valve opens. The mixture enters the cylinder through a port (opening) in the cylinder head while the piston moves downwards.	The intake valve closes. The piston moves upwards, compressing the mixture.	The spark plug produces a spark, which ignites (lights) the mixture. On ignition, the mixture explodes, generating a sudden pressure which forces the piston down.	The exhaust valve opens, and the piston moves upwards, forcing the exhaust gases - those produced during combustion - out of the cylinder via the exhaust port. The exhaust valve then closes and the cycle begins again.

The cycle of a four-stroke petrol engine

9.1. Complete the text about diesel engines using words from A and B.

Diesel engines differ from (1) .... engines in one key respect: they are not fitted with a (2) .... , in each cylinder, to ignite the fuel. This is because when a (3) .... of diesel and air is compressed inside a hot (4) .... , it will explode spontaneously, without the need for a spark to provide (5) .... A diesel engine must therefore work in a way which prevents the diesel from exploding before the piston is at the top of the cylinder. To achieve this, the engine takes in only air during the (6) .... stage of the cycle. Therefore, during the (7) .... stage, only air- and not an air-fuel mixture - is pressurized. It is only at that last instant, when full compression has occurred, that the (8) .... above each cylinder forces vaporized diesel into the combustion chamber, where it ignites.

Diesel engines operate at lower speeds than petrol engines, making them less suitable for high-speed applications. However, they are more able to (9) .... heavy vehicles, as they can produce greater amounts of (10) .... than petrol engines.

<u>Over to you.</u>
Think about the engine in a vehicle you're familiar with. Describe specific aspects of it – the type of fuel it uses, the number of cylinders it has, and how much power and torque it produces.

REFERENCES

MAGNETIC FIELD

A ***magnetically soft*** material ***magnetises*** and ***demagnetises*** very easily. So, as soon as you ***turn off*** the current through the solenoid, the magnetic field ***disappears*** – the iron doesn't stay magnetised. This is what makes it ***useful*** for something that needs to be able to ***switch*** its magnetism ***on*** and ***off***.

Electromagnets are ***useful*** as their ***magnetism*** can be ***turned off.***

An electromagnet must be ***constantly supplied*** with current – as that's what produces the ***magnetic field***. So, if the current ***stops***, then it ***stops*** being magnetic. Magnets you can ***switch off*** at your whim can be really ***useful***.

Example: ***cranes*** used for ***lifting iron*** and ***steel***.

1. ***Magnets*** can be used to ***attract*** and ***pick up*** things made from ***magnetic materials*** like ***iron*** and ***steel***.
2. Electromagnets are used in ***some cranes***, e.g. in ***scrap yards*** and ***steel works***.
3. If an ***ordinary magnet*** was used, the crane would be able to pick up the cars, etc., but then ***wouldn't*** let it go. Which isn't very helpful.
4. Using an electromagnetic means the magnet can be ***switched on*** when you want to and ***attract*** and ***pick stuff up***, then ***switched off*** when you want to ***drop*** it. Which is far ***more useful.***

Fields around electromagnets and bar magnets are the same shape.

Electromagnets pop up in lots of different places – they're used in ***electric bells***, ***car ignition circuits*** and some ***security doors***. Electromagnets aren't all the same strength though – how strong they are depends on stuff like the number of ***turns*** of wire there are and the ***size*** of ***current*** going through the wire.

ELECTROMAGNETIC INDUCTION

A. Electromagnetic induction: The creation of a ***potential difference*** across a conductor which is experiencing a ***chance in magnetic field***. Remember: potential difference is just another name for voltage. For some reason they use the word "induction" rather than "creation", but it amounts to the same thing.

Moving a ***magnet*** in a ***coil*** of wire ***induces*** a ***voltage***.

1. ***Electromagnetic induction*** means creating a ***potential difference*** across the ends of ***a conductor*** (e.g. a wire). If the conductor is part of a complete circuit, a current will flow.
2. You can do this by ***moving a magnet*** in a ***coil of wire*** or moving an electrical conductor in a magnetic field ("***cutting***" magnetic field lines). Shifting the magnet from ***side to side*** creates a little "***blip***" of current.
3. If you keep the magnet in the ***opposite direction*** then the ***potential difference/current*** will be ***reversed*** too. Likewise, if the ***polarity*** of the magnet is ***reversed*** then the ***potential difference/current*** will be ***reversed*** too.
4. If you keep the magnet (or the coil) moving ***backwards*** and ***forwards,*** you produce a ***potential difference*** that keeps ***swapping direction*** – and this is how you produce an ***alternating current*** (AC).

B. A magnet ***turning*** end to end in a coil also ***creates a current***.

You can also create a potential difference by ***turning*** a magnet end to end in a coil, which lasts as long as you spin the magnet.

This is how generators work.

1. As you turn the magnet, the ***magnetic field*** through the coil changes – this ***change*** in the magnetic field induces a ***potential difference,*** which can make a ***current*** flow in the wire.

2. When you've turned the magnet through half a turn, the ***direction*** of ***magnetic field*** through the coil ***reverses***. When this happens, the ***potential***

difference reverses, so the current flows in the ***opposite direction*** around the coil of wire.

3. If you keep turning the magnet in the ***same direction*** – always clockwise, say – then the potential difference will keep on reversing every half turn and you'll get an AC ***current***.

Some ***appliances*** use ***electromagnetic induction***. Electromagnetic induction is used by some appliances to generate a ***current***.

Example: ***dynamos***

1. ***Dynamos*** are often used on bikes to power the lights.
2. The ***cog wheel*** at the top is positioned so that it ***touches*** one of the ***wheels***.
3. As the wheel moves round, it ***turns*** the cog which is attached to the ***magnet***.
4. This creates an ***AC current*** to power the lights.

EM induction – works whether the coil or the field is moving. This is how most of our electricity is generated, whether it's in a coal-fired power station or a wind turbine.

TRANSFORMERS

A. ***Transformers*** use ***electromagnetic induction*** to change potential difference (p.d.). So they will only work on ***AC***.

Transformers change the ***p.d***.- but only ***AC p.d.***

There are a few different types of transformer. The ***two*** you need to know about are ***step-up transformers*** and ***step-down transformers***.

They both have two coils, the ***primary*** and the ***secondary***, joined with an ***iron core***.

STEP-UP TRANSFORMERS	STEP-DOWN TRANSFORMERS
step the voltage up. They have more turns on the secondary coil than the primary coil.	step the voltage down. They have more turns on the primary coil than the secondary.

Transformers work by ***electromagnetic induction***

1. The primary coil ***produces a magnetic field*** which stays ***within the iron core.*** This means ***nearly all*** of it passes through the ***secondary coil*** and hardly any is lost.
2. Because there is ***alternating current*** (AC) in the ***primary coil***, the field in the iron core is constantly ***changing direction*** (100 times a second if it's at 50 Hz) – i.e. it is a ***changing magnetic field***.
3. This ***rapidly changing*** magnetic field is then felt by the ***secondary coil.***
4. The changing field ***induces*** an ***alternating potential difference*** across the secondary coil (with the same frequency as the alternating current in the primary) – ***electromagnetic induction*** of a potential difference in fact.

The ***iron core*** carries ***magnetic field***, ***not current***.

1. The ***iron core*** is purely for transferring the ***changing magnetic field*** from the primary coil to the secondary.

2. No ***electricity*** flows round the ***iron core***.

B. ***Transformers*** have ***more turns*** on ***one coil*** than another.

1. The ***relative number of turns*** on the two coils determines whether the potential difference induced in the secondary coil is ***greater*** or ***less*** than the potential difference in the primary.

2. In ***a step-up transformer***, the p.d. across the ***secondary coil*** is greater than the p. d. across the ***primary coil***.

3. In ***a step-down transformer***, the p.d. across ***the secondary coil*** is less than the p.d. across the ***primary coil***.

4. If you supplied DC to the primary, you'd get ***nothing*** out of the secondary at all. Sure, there'd still be a magnetic field in the iron core, but it wouldn't be ***constantly changing***, so there'd be no ***induction*** in the secondary because you need a ***changing field*** to induce a potential difference. So don't forget it – transformers only work with ***AC.*** They won't work with DC ***at all.***

C. The ***transformer equation*** – use it ***either way up***.

You can calculate the output potential difference from a transformer if you know the input potential difference and the number of turns on each coil.

$$\frac{\text{Potential Difference across Primary Coil}}{\text{Potential Difference across SecondaryCoil}} = \frac{\text{Number of turns on Primary Coil}}{\text{Number of turns on SecondaryCoil}}$$

Well, it's just *another formula*. You stick in the number you've got and work out the one that's left.

$$\frac{Vp}{Vs} = \frac{Np}{Ns} \quad \text{or} \quad \frac{Vs}{Vp} = \frac{Ns}{Np}$$

It's really useful to remember you can write it either way up – this example's much trickier algebra-wise if you start with Vs on the bottom.

Example:

A transformer has 40 turns on the primary and 800 on the secondary.

If the input potential difference is 1000 V, find the output potential difference.

Answer: Vs/Vp = Ns/Np so Vs/1000 = 800/40 Vs = 1000 x (800/40) = 20 000V

Transformers only work with AC.

ENERGY AND POWER IN CIRCUITS

A. Electricity is just another form of ***energy*** – which means that it is always ***conserved.***

Energy is ***transferred*** from cells and other sources. Anything which ***supplies electricity*** is also supplying ***energy***. So cells, batteries, generators, etc. all ***transfer energy*** to components in the circuits:

Motion: motors Light: light bulbs Heat: hair dryers/kettles Sound: speakers

All ***resistors*** produce ***heat*** when a ***current*** flows through them.

1) Whenever a ***current*** flows through anything with ***electrical resistance*** (which is pretty much everything) then ***electrical energy*** is converted into ***heat energy***.

2) ***The more current*** that flows, ***the more heat*** is produced.
3) A ***bigger voltage*** means more heating because it pushes more current through.
4) ***Filament bulbs*** work by passing a current through a very ***thin wire***, heating it up so much that it grows. Rather obviously, they waste a lot of energy as ***heat.***

If an appliance is ***efficient*** it ***wastes less energy***.

All this energy wasted as heat can get a little ***depressing*** – but there is a solution.

1) When you buy electrical appliances you can choose to buy ones that are more ***energy efficient***.
2) These appliances transfer more of their ***total electrical energy output to useful energy.***
3) For example, less energy is wasted as heat in power-saving lamps such as ***compact fluorescent lamps*** (CFLs) and ***light-emitting diodes*** than in ordinary filament bulbs.
4) Unfortunately, they do ***cost more to buy***, but over time the money you ***save*** on your electricity bills pays you back for the initial investment.

A. ***Power ratings*** tell you how much energy a device transfers per second.

Appliances have ***power ratings***.

1) The total energy transferred by an appliance depends on ***how long*** the appliance is on and its ***power rating.***
2) The power of an appliance is the ***energy*** that it uses ***per second***.

Energy transferred = Power rating x time $\frac{E}{P \times t}$

Example:

A 2.5 kettle is on for 5 minutes. Calculate the energy transferred by the kettle in this time.

Answer: 2500 x 300 = 750 000 J = 750 kl. (5 minutes = 300 s.)

Electrical power and ***fuse ratings***.

1) The formula for ***electrical power*** is:
   Power = current x potential difference.

P = I x V $\frac{P}{I \times V}$

2) Most electrical goods show their ***power rating*** and ***voltage rating***. To work out the size of the ***fuse*** needed, you need to work out the ***current*** that the item will normally use.

Example:

A hair dryer is rated at 230 V, 1 kW. Find the fuse needed.

Answer: 1 = P/V = 1000/230 = **4.3 A.** Normally, the fuse should be rated just a little higher than the normal current, so a 5 amp fuse is ideal for this one.

Use fuses with a rating just above the usual current.

In the UK, you can usually get fuses rated at 3 A, 5 A or 13 A, and that's about it.

You should bear that in mind when you're working out fuse rating.

If you find you need a 10.73 A fuse – tough. You'll have to use a 13 A one.

B. You can think about ***electrical circuits*** in terms of ***energy transfer*** – the charge carriers take charge around the circuit, and when they go through an electrical component energy is transferred to make the component work.

Potential difference is the ***energy*** transferred per ***charge passed***.

1) When an electrical ***charge*** (Q) goes through a ***change*** in potential difference (V), then ***energy*** (E) is ***transferred.***
2) Energy is ***supplied*** to the charge at the ***power source*** to 'raise' it through a potential.
3) The charge ***gives up*** this energy when it '***falls***' through any ***potential drop*** in ***components*** elsewhere in the circuit.
4) The formula is simple:

Energy transformed = Charge x Potential difference. $\frac{E}{Q \times V}$

5) *The **bigger** the **charge** in P.D. (or voltage), the **more energy*** is transferred for a ***given amount of charge*** passing through the circuit.
6) That means that a battery with a ***bigger voltage*** will supply ***more energy*** to the circuit for every ***coulomb*** of charge which flows round it, because the charge is raised up ***"higher"*** at the start – and as the diagram shows, ***more energy*** will be ***dissipated*** in the circuit too.

Example:

The motor in an electric toothbrush is attached to a 3 V battery.

If a current of 0.8 A flows through the motor for 3 minutes:

a) Calculate the total charge passed.
b) Calculate the energy transformed by the motor.
c) Explain why the kinetic energy output of the motor will be less than your answer to b).

Answer:

a) Use the formula Q = 1x1 = 0.8 x (3 x 60) = **144 C**
b) Use E = Q x V = 144 x 3 = **432 J**
c) The motor won't be 100% efficient.

Some of the energy will be transformed into ***sound and heat.***

Ex.1 Match the questions (1-6) and answers (a-f):

1) What is the frequency of UK mains electricity supply?
2) Which of the live, neutral or earth wires is always at 0 volts?
3) Why is the case of a plug usually made out of plastic?
4) Appliances with double insulation don't need which type of wire?
5) What energy transformation occurs when electric current flows through a resistor?
6) What is the equation linking Q, V and E?

a) Earth wire
b) 50 Hz
c) Electrical energy (to kinetic energy) to heat energy.
d) The neutral wire (also accept the earth wire).

e) E (energy) = Q (charge) x V (voltage)

f) Plastic is a good insulator.

Ex. 2 Answer the questions:

1. What colours are each of the following wires in an electric plug?

   a) live b) neutral c) earth

2. What type of safety device contains a wire that is designed to melt when the current passing through it goes above a certain value?

3. A domestic appliance has a plug containing live, neutral and earth wires and a fuse. The appliance has a metal case. Describe how the earth wire and fuse work together to protect the appliance and to prevent the user getting an electric shock if there is a fault.

4. A current of 0.5 A passes through a torch bulb. The torch is powered by a 3V battery.

   a) Calculate the power of the torch.

   b) In a half an hour, 900 C of charge pass through the battery. Calculate how much electrical energy the bulb transfers in half an hour.

APPENDIX

SI UNITS FOR ELECTICITY

	Unit	Abbreviation
electromotive force	volt	V
electrical resistance	ohm	Ω
electrical conductance	siemens	S
electrical charge	coulomb	C
flow of electrons	ampere	A
frequency	hertz	Hz
capacitance	farad	F
inductance	henry	H
magnetic flux	weber	Wb
magnetic flux density	tesla	T

MATHEMATICAL SYMBOLS

Symbol	Example	Meaning in full
.	3.14	thee point one four
+	a +b	a plus b
-	c-d	c minus d
=	T=24	T equals twenty four
x	3x10	three multiplied by ten / three times ten
:	16:8	sixteen divided by eight
%	10%	ten per cent
°	20°	twenty degrees
>	> 10	greater than ten
<	< 20	less than twenty
≤	≤ 12	less than or equals to twelve
≥	≥ 30	greater than or equals to thirty
√	√16	the square root of sixteen
n^3	10^3	ten to the power of three
{}		curly brackets
[]		square brackets
()		round brackets
∞	A ∞ B	A is proportional to B

CONVENTIONAL METRIC UNITS

Name	Multiplication	Symbol
nano	10^{-9}	n
micro	10^{-6}	µ
milli	10^{-3}	m
kilo	10^{3}	k
mega	10^{6}	M
giga	10^{9}	G
tera	10^{12}	T

ELECTRICAL AND ELECTRONIC COMPONENTS

Common components and their functions

Component	Function
amplifier	amplifies an electric current- that is, increases the amplitude (wave height) of the current
battery	several cells connected together
capacitor	consists of two conductors which are separated by a dielectric (insulating) material- allows a certain amount of electrical charge to be stored
cell	an electrical storage device, containing chemicals, which supplies a direct current
circuit -breaker	a safety device which automatically switches off a circuit
diode	a device with two terminals which allows current to flow in one direction only
fuse	a thin conductor which burns and breaks at a certain amperage, to protect a circuit
inductor	a coil which is used to produce electromagnetic induction
inverter	converts direct current to alternating current
potentiometer	a variable resistor with three connections
rectifier	converts alternating current to direct current
relay	a switch which is operated electrically (not mechanically)
resistor	produces a precise amount of resistance
rheostat	a variable resistor with two terminals
switch	allows electric current to flow when closed (switched on), and stops current flowing when opened (switched off)
transformer	a step-up transformer increases voltage and reduces amperage, and a step-down transformer reduces voltage and increases amperage
transistor	a device with three terminals which can be used as an amplifier or switch

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