CHAPTER

6 Using electricity

REMEMBER

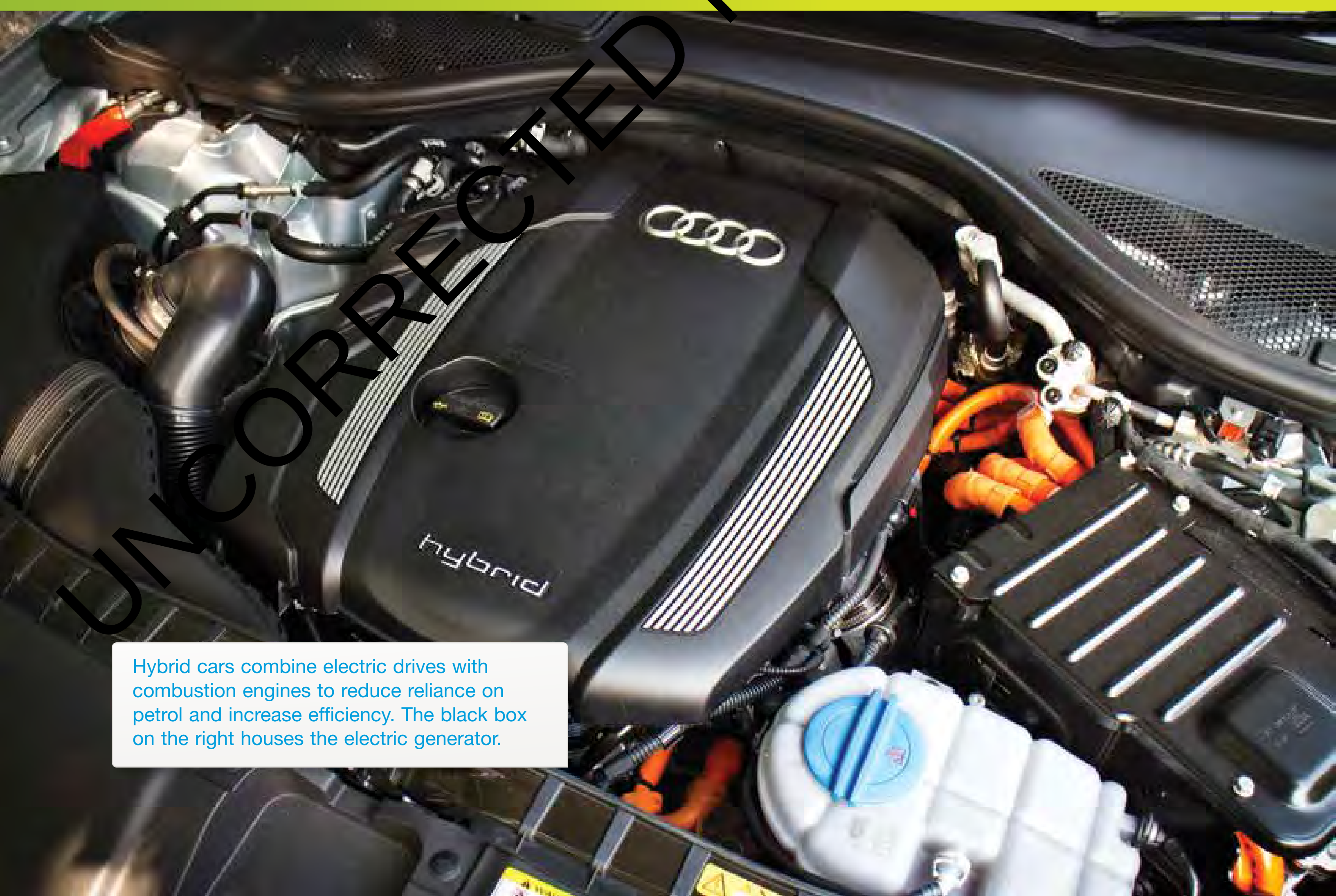
Before beginning this chapter, you should be able to:

- identify a range of common components of simple electric circuits
- recognise the circuit symbols for common components of simple electric circuits
- describe the operation of simple series and parallel circuits
- connect components into simple circuits following a circuit diagram.

KEY IDEAS

After completing this chapter, you should be able to:

- model simple electrical devices as simple direct current (DC) circuits
- model household (AC) systems as simple direct current (DC) circuits
- describe the operation of household electrical circuits and such components as circuit breakers, fuses and residual current devices (RCDs)
- convert quantities of energy to kilowatt-hours (kW-h)
- identify the causes, effects and treatment of electric shocks to humans in the context of household use of electricity
- present data obtained from electric circuit investigations in tables and graphs
- assess risk in the use of electrical equipment.



Hybrid cars combine electric drives with combustion engines to reduce reliance on petrol and increase efficiency. The black box on the right houses the electric generator.

Electricity in the real world

In this chapter you will see how the basic rules for series and parallel circuits can be applied to household use of electricity. The safe use of electricity will also be discussed, as well as the effects of electric shocks on the human body.

Parallel circuits are usually preferred over series circuits, because each device in a parallel circuit can be turned on and off independently. Devices in parallel circuits also have the same voltage drop. In series circuits, on the other hand, the devices have the same current flowing through them and the voltage is shared across the circuit. If one device is switched off, all the devices go off.

Household use of electricity

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Unit 1 | AOS 2 | Topic 3 | Concept 1

Household electricity
Concept summary and practice questions

Houses connected to the main electrical grid are supplied with an AC voltage of 230 V rms at a frequency of 50 Hz. The term '230 V rms' means that the AC voltage produces the same heating effect when applied across a conductor as would a DC voltage of 230 V applied across the same conductor. The actual value of the voltage oscillates between +325 V and –325 V. 'Root mean square' (rms) refers to the mathematical process by which the equivalent DC voltage is calculated. 'A frequency of 50 Hz' means that the full cycle is completed 50 times each second. The voltage supplied is sinusoidal in nature.

Frequency is a measure of how many times per second an event happens.

Period is the amount of time one cycle or event takes, measured in seconds.

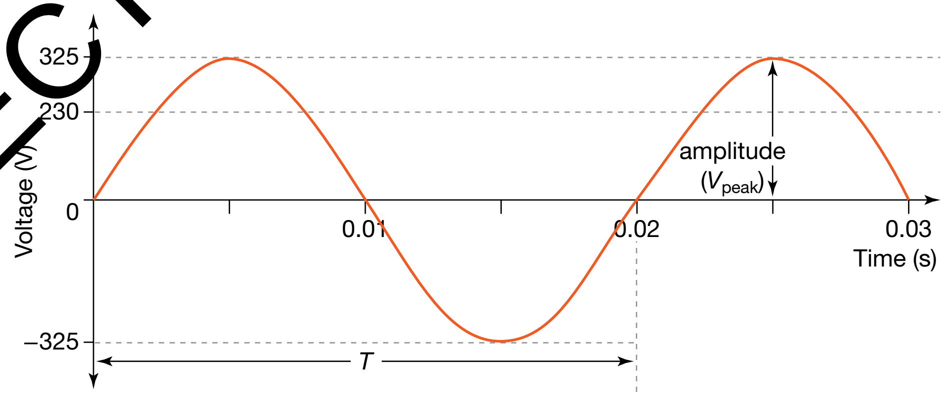
Frequency (f) is a measure of how many times per second an event happens. The unit for frequency is the hertz (Hz). One hertz means one cycle or event per second. **Period** (T) is the amount of time one cycle or event takes, measured in seconds. Period is the reciprocal of frequency.

$$T = \frac{1}{f}$$

or

$$f = \frac{1}{T}$$

A frequency of 50 Hz means that the period is 0.02 s, as shown below.



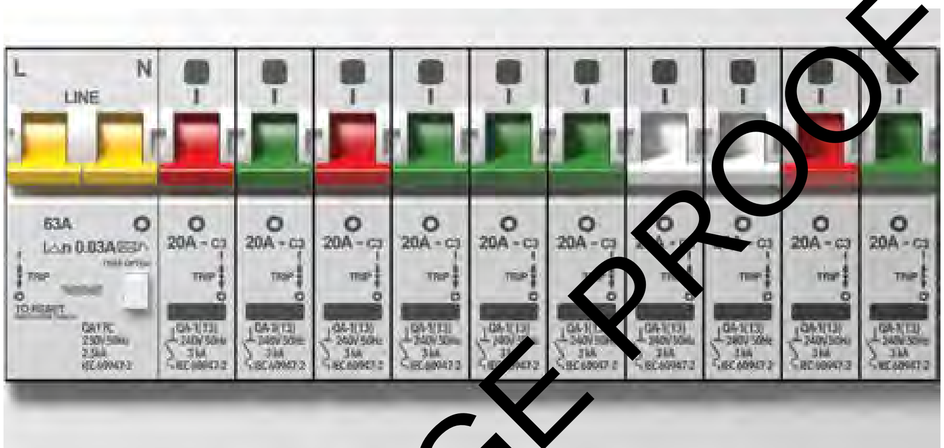
The variation of voltage with time for a supply of 230 V rms, 50 Hz

Electricity is fed into the home through underground cables or overhead lines. It enters the house through a switchboard. This contains a mains switch which can cut off the supply of electricity to the house. There is also a meter that measures the amount of electrical energy transformed in the house. From the meter, the electricity enters a fuse box or circuit breaker box where it is divided among a number of parallel circuits. The role of fuses and circuit breakers is dealt with later in this chapter.

The **active wire** in a circuit is connected to the 240 V rms supply at the switchboard.

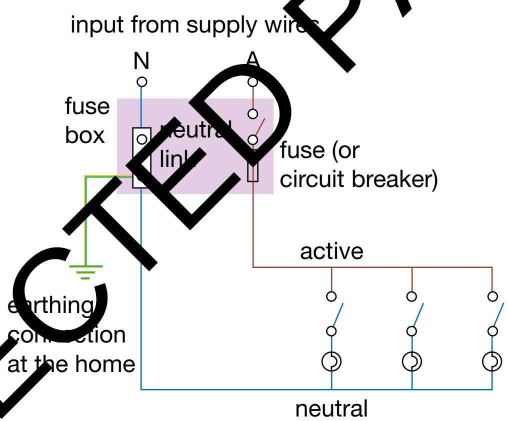
The structure of household circuits differs from the structure of DC circuits studied in chapters 4 and 5. Household circuits make use of the earth to complete the circuit. The **active wire** in a circuit is connected to the 230 V rms supply at the switchboard. Its voltage oscillates periodically between +340 V and −340 V relative to a reference voltage called 'earth'. The earth is defined as having a voltage of 0 V. The **neutral wire** is connected to the neutral link at the switchboard, which is connected to the earth through the supply wires and via a metal rod driven into the ground at the switchboard. The neutral wire is always at 0 V. The voltage drop between the active and the neutral wire oscillates between +340 V and −340 V.

The **neutral wire** in a circuit is connected to the neutral link at the switchboard, which is connected to the earth.



A typical household circuit breaker. All the switches are in the off position. When the switches are turned up, the current flows. If the circuit is broken, the switches will flick down to the off position.

When an appliance is connected between the active wire and the neutral wire, current flows backwards and forwards between the active and neutral wires through the device, supplying it with energy.



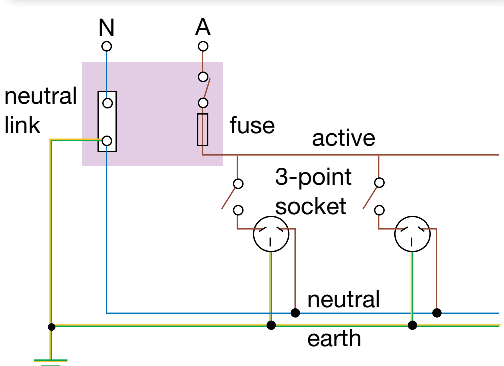
A typical household lighting circuit

Conventional current flows from a high voltage to a low voltage. When the active wire is positive, the current flows from the active to the neutral wire and so to the earth. When the active wire is negative, the neutral wire at 0 V will have the higher voltage, and the current will flow from the neutral to the active wire.

In lighting circuits, only the active and neutral wires are used if there are no metal fittings. The current oscillates through the filaments of the globes, transforming energy. If metal fittings are used, they must be earthed. A typical lighting circuit is shown in the figure at left.

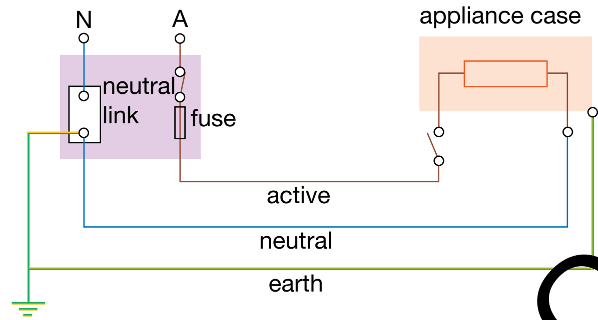
In power circuits, a third wire is used. This is called the **earth wire**. It connects the case of the appliance being used to the earth as a safety device. Its function is discussed in the section on safety later in this chapter. Otherwise, a power circuit operates in exactly the same way as a lighting circuit, with the current oscillating between the active and neutral wires through the appliance. The figure at left shows how 3-point power sockets are connected in a typical power circuit.

The **earth wire** is used in power circuits as a safety device; it connects the case of the appliance being used to the earth.



A typical power circuit

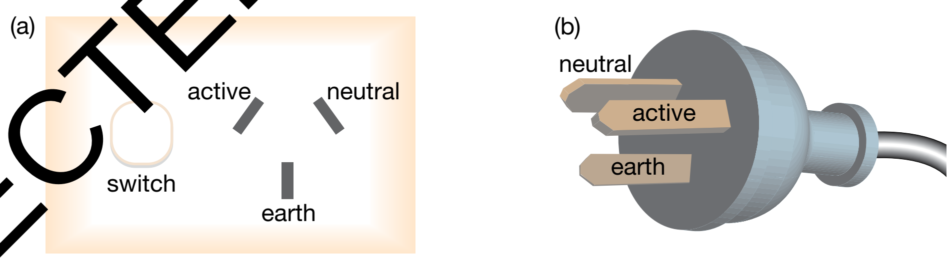
The figure below shows the connection of the earth wire to the case of an appliance.



The connection of the earth wire to the case of an appliance

Note that in both the lighting and power circuits the switch is in the wire connecting the device to the active wire. A switch in the neutral wire would also turn off the device, but the functional parts of the device would be 'live'. That is, the functional parts (e.g. the heating element of a toaster) would still be directly attached to the active wire.

If you were to touch anything in contact with the active wire while you were in contact with the ground, there would be a voltage drop across you and a potentially lethal current could flow through you. For this reason, if ever it is necessary to tamper with the functional parts of an electrical device, it must be unplugged first. The 3-point socket may have been wrongly wired, and it is not worth taking the risk.



(a) A 3-point socket. The top left point is the active, the top right point is the neutral, and the bottom point is the earth connection. The switch is connected in the active wire. Also shown (b) is the wiring arrangement of a typical 3-point appliance plug. Note that the active pin is inserted into the active socket.

Different-coloured insulating plastic is used to distinguish the three wires from each other. In the modern system, the active wire is brown, the neutral wire is blue and the earth wire is striped green and yellow. In the old system, red was used for the active, black for the neutral, and green for the earth wires.

Power ratings

The total power used in an electrical circuit, be it series or parallel, is the sum of the power used by each device in the circuit. Electrical appliances or devices are given a power rating, which is usually printed on them.

Sample problem 6.1

A toaster is rated at 1400 W, 230 V.
(a) What current does the toaster draw when operating normally?
(b) What is the resistance of the toaster element when hot?

Solution: (a)

$$P = VI, \text{ so } I = \frac{P}{V}$$

$$\Rightarrow I = \frac{1400 \text{ W}}{230 \text{ V}}$$

$$\Rightarrow I = 6.09 \text{ A}$$

(b)

$$V = IR$$

$$\Rightarrow R = \frac{V}{I}$$

$$\Rightarrow R = \frac{230 \text{ V}}{6.1 \text{ A}}$$

$$\Rightarrow R = 37.8\ \Omega$$

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Weblink
Operating costs of electrical appliances

Revision question 6.1

A compact fluorescent light globe is rated at 15 W, 230 V.
(a) Calculate the current through the globe when it is operating normally.
(b) Calculate the resistance of the globe when it is operating normally.

Paying for electricity

The meter on a household switchboard is used to measure how much electrical energy has been consumed on the premises. The amount of electrical energy used in a household can be determined by multiplying the rate of power transformation by the time. Since power is equal to the voltage drop multiplied by current, and the voltage drop across a household is 230 V, the meter on the switchboard records the total current that has passed through the premises over a certain period of time. This amount is converted into the amount of energy 'consumed' or transformed.

The unit used for measuring energy in this case is the **kilowatt-hour** (kW-h). This is the amount of energy transformed by a 1000 W appliance when used for one hour.

A **kilowatt-hour** (kW-h) is the amount of energy transformed by a 1000 W appliance when used for one hour.

Sample problem 6.2

How many joules does one kilowatt-hour represent?

Solution: Energy = power × time.

1 h = 3600 s, 1 kW = 1000 W.

Therefore 1 kW-h = 1000 W × 3600 s, or 3.6×10^6 J, or 3.6 MJ.

The cost to consumers of 1 kW-h of electrical energy can be found on electricity accounts. Find out what 1 kW-h of electrical energy costs in your household. To calculate the cost of running a particular appliance, two methods can be used. In the first, calculate the energy in kilowatt-hours by multiplying the power rating of the appliance, in kilowatts, by the number of hours that it was used for.

The second method is used if the power rating is unknown. Calculate the energy consumed in joules, using the formula $E = VIt$, where E is the energy consumed, V is the voltage drop across the device, I is the current flowing through the device and t is the time in seconds. The amount of energy is then converted into kilowatt-hours by dividing by 3.6×10^6.

To calculate the cost, use the formula:

$$\text{cost} = \text{energy} \times \text{rate}.$$

Sample problem 6.3

A television draws 0.37 A of current when connected to a 230 V supply.

(a) What is the power rating of the television?

(b) How much energy does the television consume if it is operated for 5 hours a day for 4 weeks?

(c) What is the cost of running the TV for this period of time if the consumer is charged at a rate of 16.381 cents per kilowatt-hour?

Solution:

(a)
$$P = VI$$
$$P = 230\text{ V} \times 0.37\text{ A}$$
$$= 85\text{ W}$$

(b)
$$\text{energy} = \text{power} \times \text{time}$$
$$\text{time} = 28\text{ days} \times 5\text{ hours per day} = 140\text{ h}$$
$$\text{power} = 85\text{ W}$$
$$\text{So energy} = 85\text{ W} \times 140\text{ h}$$
$$= 12\,000\text{ W-h}$$
$$= 12\text{ kW-h}$$

(c)
$$\text{cost} = \text{energy} \times \text{rate}$$
$$= 12\text{ kW-h} \times 16.381\text{ cents}$$
$$= 197\text{ cents or }\$1.97$$

Revision question 6.2

A home sound system consumes 2.4 W of electric power when it is on standby and connected to a 230 V supply.

(a) Calculate the current that flows through the system when it is on standby.

(b) Calculate the energy consumed by the system if it is left on standby for one week.

(c) Calculate the cost of leaving the system on standby for one week if electricity is priced at 12 c per kW-h.

A shocking experience

An **electric shock** is a violent disturbance of the nervous system caused by an electrical discharge or current through the body.

There are various factors that contribute to the severity of an electric shock. The first of these is the size of the voltage involved. Also, the human body is far more sensitive to alternating current than direct current. Voltages as low as 32 V AC and 115 V DC can be fatal.

It is not the voltage alone that causes damage to the human body. When you slide across a car seat, you can generate a voltage of several thousand volts. When you get out of the car and touch the ground, you are discharged and experience a shock, but with no serious consequences. The voltage drop across a person is one factor in determining the seriousness of an electric shock, but clearly other factors are involved.

The following information refers to shocks involving alternating currents with a frequency of 50 Hz.

An **electric shock** is a violent disturbance of the nervous system caused by an electrical discharge or current through the body.

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Unit 1 | AOS 2 | Topic 3 | Concept 3

Electric shock
Concept summary and practice questions

Resistance of the human body

One contributing factor to the severity of an electric shock is the resistance of the human body. The interior of the body is a good conductor of electricity. The tissues and fluids beneath the skin conduct electricity due to the presence of ions in the fluids.

The skin provides the main resistance to the flow of electricity in the body. The resistance of the skin ranges in value from 10^6 Ω for dry skin, to 1500 Ω for a person with wet hands, and about 500 Ω for a person sitting in a bath. This is a good reason for keeping electrical appliances away from water in the bathroom; tap water is also a reasonably good conductor.

Resistance to current flow is offered by the skin up to about 600 V, at which point the skin is punctured and offers little resistance to current flow. Breaks or cuts in the skin also reduce the resistance of the skin.

One of the main reasons for the high resistance of skin is the poor contact that is made between the skin and the electrical source. Water improves the contact. In hospitals, a conducting gel is used when a good electrical contact is required, for example when using an electrocardiogram.

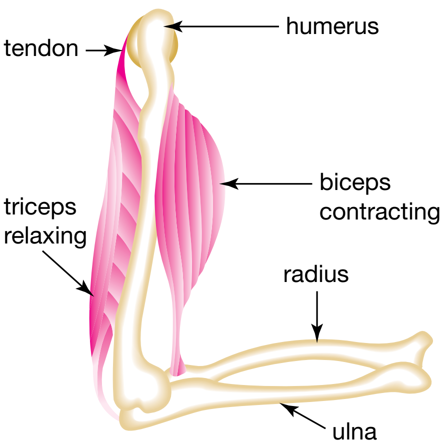

Diagram showing the biceps and triceps in the human arm

The effect of current

The most important factor to be considered in respect to the severity of an electric shock is the amount of current flowing through the body. This is important because impulses within the nervous system are themselves electrical in nature.

Even very small currents passing along nerves make muscles contract. Skeletal muscles (muscles attached to the bones) work in pairs. To raise your forearm, for example, the biceps muscle contracts and the triceps muscle relaxes. To lower your forearm, the biceps muscle relaxes and the triceps muscle contracts. This arrangement of muscles is shown in the figure at left.

One effect of passing a small current through the body is to make muscles contract. Another effect stimulates the nerves that send pain signals to the brain, causing the painful sensations associated with shocks.

AS A MATTER OF FACT

You may have heard of someone who received an electric shock being 'thrown across the room.' This is not due to any explosion, but to the violent contraction of the person's muscles.

A current of 9 mA AC across the chest causes shock. A current of twice that amount causes difficulty in breathing. A current of 20 mA causes muscles to become paralysed: they contract and stay contracted. A person unfortunate enough to touch a live conductor with the palm of their hand will grip onto the conductor and not be able to let go. Lazy electricians, if unsure whether a wire is live, may bring the back of the hand towards the wire. Any shock they receive will contract the muscles so that the hand is pulled away from the wire. This procedure is definitely not recommended.

A current as low as 25 mA through the trunk of the body can cause **fibrillation**. This is the disorganised rapid contraction of separate parts of the heart so that it pumps no blood, and death soon follows. Sometimes fibrillation subsides when the external voltage is removed.

Fibrillation is the disorganised, rapid contraction of separate parts of the heart so that it pumps no blood; death may follow.

PHYSICS IN FOCUS

Heart starter

Defibrillation is a medical intervention technique carried out on victims of heart attack. If the cardiac monitor shows that fibrillation is occurring, a current of 20 A at 3000 V is passed through the heart for about 5 ms. This produces a major contraction of all the muscles in the heart, which usually jolts them back into the proper rhythm. The shock is applied above and below the heart via two large electrodes called paddles. Conducting gel is used to make good contact with the body. It is important that the operator and other staff are well insulated from the patient.

The effect of current path

The third factor affecting the severity of an electric shock is the path of the current through the body. Respiratory arrest generally requires the current to pass through the back of the head. Ten milliamps of current through the forearm muscles make them contract sufficiently to hold the victim to any live conductor he or she is gripping. The most dangerous pathway for current is through the trunk of the body.

Time of exposure

The final factor contributing to the severity of a shock is the time of exposure to the current. The longer the current flows through the body, the greater the damage to tissue will be. Table 6.1 shows what effects current size and time duration have on the heart.

TABLE 6.1 Electric shock current-versus-time parameters

Current (mA)	Time (ms)	Effect
50	10–200	Usually no dangerous effect
50	>4000	Fibrillation possible
100	10–100	Usually no dangerous effect
100	>600	Fibrillation possible
500	>40	Fibrillation possible

In the event of a shock

Electrocution is death brought about by an electrical shock.

The first priority, when helping a victim of electric shock, is to make sure that the victim is not still connected to the electrical source. If the person is still connected, and you grab them, you could be electrocuted too. (**Electrocution** is death brought about by an electrical shock.) Your muscles may contract and you will not be able to let go of the victim, becoming a victim yourself. Turn off the electric circuit, or knock the victim away from the live conductor with an insulating material, for example a wooden chair.

Artificial respiration should be given to the victim if breathing has ceased. Respiratory failure is a common cause of death among shock victims. This is true of people who have been struck by lightning also.

Call an ambulance immediately.

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Unit 1	Household electrical safety
AOS 2	Concept summary and practice questions
Topic 3	
Concept 4	

Safety in household circuits

Every year many lives are lost and much property is damaged or destroyed because of electrical 'accidents' or through electrical faults in both industrial and domestic situations. Accidents occur because basic safety precautions are not followed in dealing with electricity. The effects of electricity on the human body have already been discussed. This section looks at some common electrical faults and the safety devices employed to reduce the danger to people.

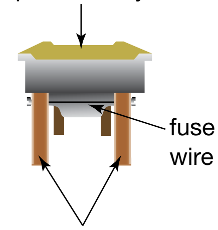
Fuses and circuit breakers

One common pitfall is overloading a circuit. In parallel circuits, the total current flowing in the circuit is the sum of the individual currents flowing through the devices in the circuit. Too many appliances operating on a single power circuit will produce a large current in the conducting wires. The wires will get hot and melt their insulation, potentially causing a fire in the walls or ceilings of the building.

A **short circuit** can occur when frayed electrical cords or faulty appliances allow the current to flow from one conductor to another with little or no resistance. This allows the current to increase rapidly, with the same results as an overload.

Cheap extension cords are another source of overheating. They are not designed to carry more than 7.0 A safely, and exceeding this amount may result in the insulation melting and allowing arcing to occur.

In domestic applications each circuit is protected by either a **fuse** or a **circuit breaker**. A fuse is a short length of conducting wire or strip of metal that melts when the current through it reaches a certain value. The most common type of fuse is the plug-in type illustrated at right. This has a ceramic body with metal prongs projecting from each end. A short piece of special fuse wire connects the metal prongs. When the current through the fuse exceeds a predetermined value, the wire melts, or 'blows', breaking the circuit.



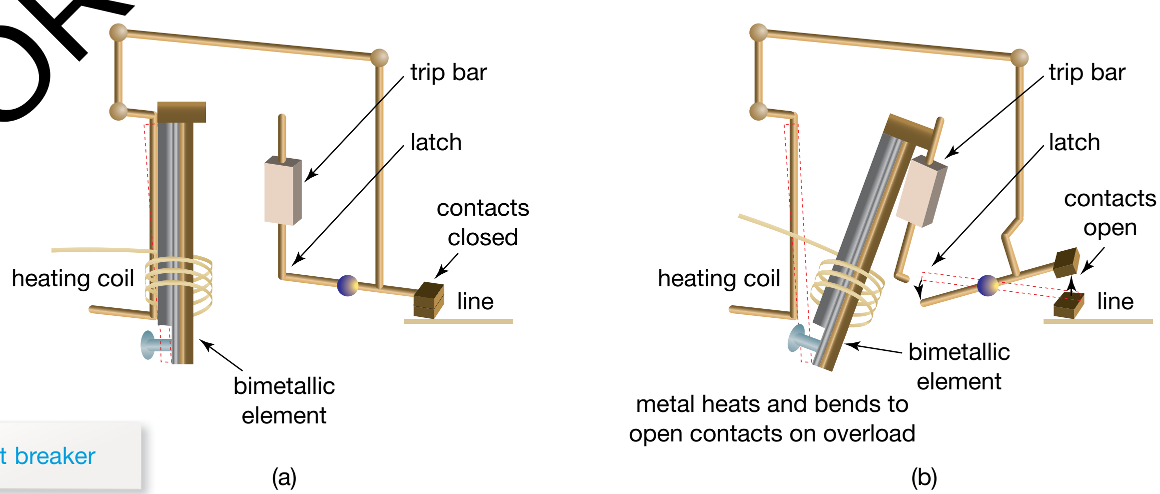
A plug-in fuse

A circuit breaker carries out the same function as a fuse. It breaks the circuit when the current through the circuit exceeds a particular value. The advantage circuit breakers have over fuses is that they can be reset easily. There are two types of circuit breaker available: thermal and electromagnetic.

A **short circuit** can occur when frayed electrical cords or faulty appliances allow the current to flow from one conductor to another with little or no resistance. The current increases rapidly, causing the wires to get hot and potentially cause a fire.

A **fuse** is a short length of conducting wire or strip of metal that melts when the current through it reaches a certain value, breaking the circuit.

A **circuit breaker** carries out the same function as a fuse by breaking the circuit when the current through it exceeds a certain value.



A thermal circuit breaker

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When a current flows through the thermal type of circuit breaker, the heating coil heats the bimetallic strip. The two metals in the bimetallic strip expand at different rates when heated, causing the strip to bend. When the current exceeds the predetermined amount, the bimetallic strip bends so much that it opens the catch and the circuit is broken. Because of the time it takes to heat up the strip, these circuit breakers will not trip if the current surge is of a short duration. This type of circuit breaker is not satisfactory if a short circuit occurs and offers little assistance in preventing electrocutions.

The electromagnetic type uses the magnetic effects of electric current; it uses an electromagnet to lift the catch and break the circuit. The bigger the current is in the coil, the stronger the electromagnetic force will be on the lever system. Again, these circuit breakers are designed to break the circuit at predetermined values of the current. To prevent this type of circuit breaker tripping when a short-duration current surge occurs, the switching mechanism is usually restrained in some way. The magnetic circuit breaker will trip almost instantly when a heavy overload occurs. It provides good protection against short circuits.

Both fuses and circuit breakers are placed in the active wire at the meter box. Light circuits are generally designed to take a maximum safe current of 5.0 A, whereas power circuits have a maximum safe current of 15 A.

Sample problem 6.4

A kitchen circuit has the following appliances operating in it: a 1000 W toaster, a 312 W refrigerator, a 1200 W kettle, a 600 W microwave oven and a 60.0 W juicer. The circuit is protected by a 15 A fuse, and it is connected to a 230 V, 50 Hz supply.

(a) What is the current flowing through the fuse when all the appliances are operating at the same time?

(b) Will the fuse 'blow' if a 2400 W heater is used at the same time as the other appliances?

Solution: (a) The total current in the circuit is the sum of the individual currents of the appliances. This can be calculated using the power ratings of the appliances and the formula $P = VI$ or $I = \frac{P}{V}$.

For the toaster, $I = \frac{1000\text{ W}}{230\text{ V}} = 4.35\text{ A}.$

For the refrigerator, $I = \frac{312\text{ W}}{230\text{ V}} = 1.36\text{ A}.$

For the kettle, $I = \frac{1200\text{ W}}{230\text{ V}} = 5.22\text{ A}.$

For the microwave oven, $I = \frac{600\text{ W}}{230\text{ V}} = 2.61\text{ A}.$

For the juicer, $I = \frac{60\text{ W}}{230\text{ V}} = 0.261\text{ A}.$

So the total current in the circuit is $4.35 + 1.36 + 5.22 + 2.61 + 0.261 = 13.8$ A. The fuse will not melt.

(b) A 2400 W heater will draw an additional 10.4 A, so the total current in the circuit will be 24.2 A. This is much greater than 15 A, so the fuse will blow.

Revision question 6.3

A bathroom fan, light and heater system consists of one 75 W light globe, four 150 W heat lamps and one 100 W fan. It is connected to a 230 V supply.

(a) Calculate the total current through the system when the fan and light globe are in use.

(b) Calculate the total current through the system when the fan and two heat lamps are in use.

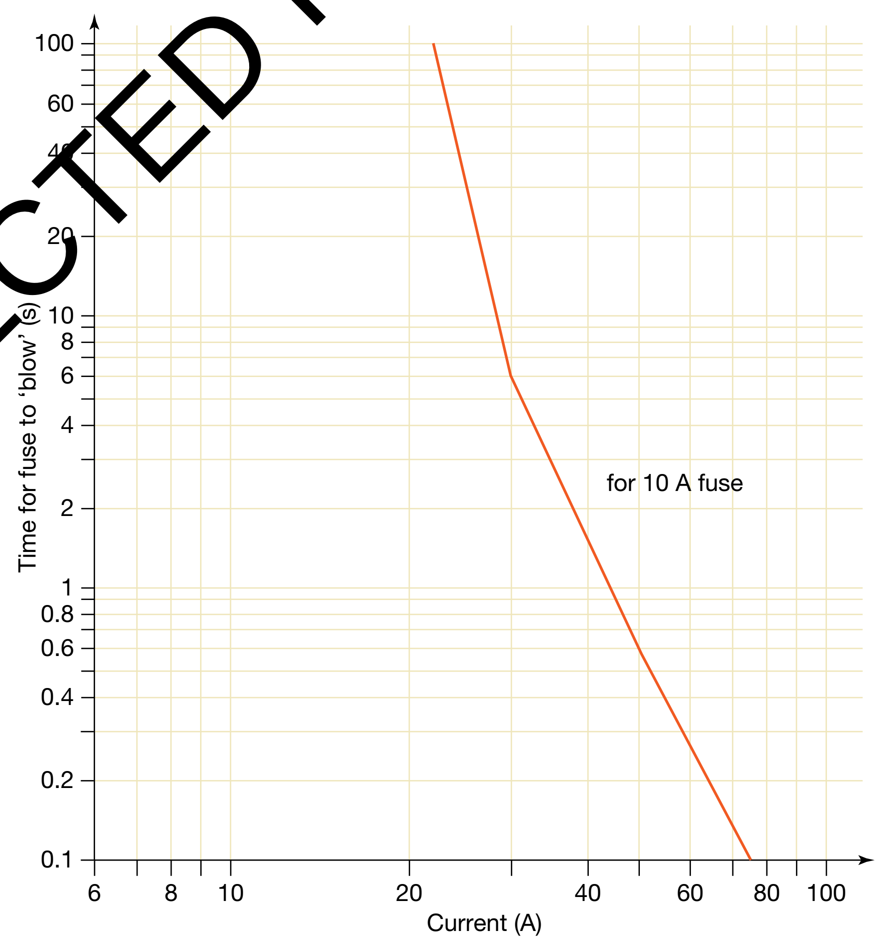
(c) Calculate the total current through the system when all the devices are in use.

Earthing

The earth wire is another safety measure used for power circuits. It connects the metal chassis of an appliance to the earth, which is at 0 V. This connection is made via a metal rod driven into the ground at the switchboard.

An electrical fault could occur if the active wire were to come into contact with the metal case of an appliance. The case would then carry an AC voltage, and anyone touching the case would receive a shock. The earth wire provides a lower-resistance conducting path to the earth than the appliance and the person. The low resistance involved produces a large current in the circuit, and the fuse blows or the circuit breaker trips.

The earth wire does not provide the most reliable protection. As can be seen in the graph below, the amount of time it takes to blow a fuse depends on the size of the current. A quicker method of breaking the circuit is needed if lives are to be saved.



Time before a typical 10 A fuse 'blows', as a function of (rms) current

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Electrical safety

If the current is flowing through a person to the earth, the following principles should be followed: the current should be as small as possible, and the time of exposure to the current should be as short as possible. Fuses are not designed to meet these requirements. Their main function is to prevent fires in buildings due to the overheating of wires when they carry too great a current.

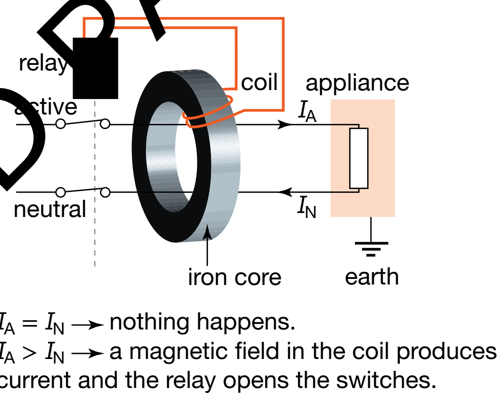
Residual current device

A **residual current device** operates by making use of the magnetic effects of a current to break a circuit in the event of an electrical fault.

The **residual current device** is illustrated below. It operates by making use of the magnetic effects of a current, and it is similar to a transformer. The current in the active wire flows in the opposite direction to the current in the neutral wire. Both currents pass through the iron loop. When the current in the active wire is equal in magnitude to the current in the neutral wire, each wire produces a magnetic field. These fields are equal in magnitude, but opposite in direction, and have no overall effect.

However, if there is an electrical fault and a residual current flows to the earth via the earth wire or a person, the current in the active will be greater than in the neutral. The residual current is the difference between the active and neutral currents. The magnetic effects of the two currents will no longer cancel. A current is then produced in the relay circuit and both the active and neutral wires of the circuit are broken by a switch.

A residual current device operates in about 40 ms, limiting the current to 30 mA. At such values the shock will be perceptible, but not likely to have any harmful effects. The residual current device is useful only when the current flows to earth, not if the current flows through the person between the active and neutral wires.

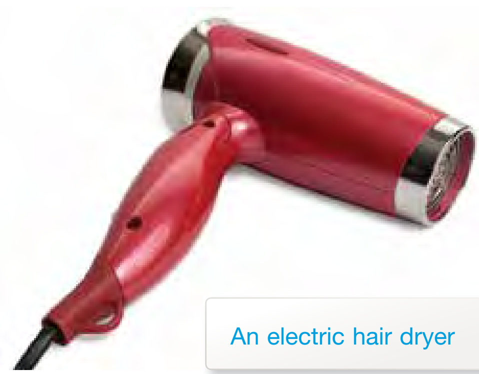


A residual current device

Double insulation

Hand-held electrical tools and appliances, such as electric drills and hair dryers, are protected by double insulation. These appliances have only a 2-pin plug, using only the active and neutral wires. They should not be earthed. The symbol ⧈ on the casing of an appliance means that it is double insulated.

As the name implies, double insulation means that the accessible metal parts cannot become live unless two independent layers of insulation fail. The inner layer is called the functional insulation. This layer has both electrical insulation and heat-resisting properties. The outer layer is called protective insulation and often forms part of the casing.



An electric hair dryer

Chapter review

Summary

- Household electricity is provided as alternating current with a frequency of 50 Hz.
- Household circuits include an active wire that oscillates between +325 and –325 volts relative to the earth, which is defined as having a voltage of zero. Household circuits also include a neutral wire, which is connected to the earth. Electric current flows backwards and forwards between the active wire and the neutral wire.
- In many circuits an earth wire is used to connect the case of an appliance directly to the earth as a safety device.
- The rules relating to series and parallel circuits can be applied to both AC and DC circuits.
- The kilowatt-hour is a unit widely used to measure the amount of electrical energy consumed.
- An electric shock is a violent disturbance of the nervous system caused by an electrical discharge or current through the body.
- The severity of an electric shock depends on a number of factors, including current, pathway through the body and time of exposure.
- Fuses and circuit breakers are safety devices that use different methods to break an electric circuit when a dangerous level of current flows through it.
- The residual current device opens switches in the active and neutral wires when the currents in these wires become unequal due to an electrical fault. It is designed to protect against electrocution and operates more quickly than a typical fuse.

Questions

Household use of electricity

1. What is meant when it is said that a house is supplied with electricity at 230 V rms, 50 Hz?

2. Why is an overload in a household circuit potentially dangerous?

3. What coloured insulation is used for the active, neutral and earth wires in modern houses?

4. Sketch a power point and plug. Label the active, neutral and earth in each case.

5. Why do many appliances need to be connected to both the neutral and earth wires?

6. When is the earth wire used in household lighting circuits?

7. What is the cost of running a 300 W refrigerator for a year (365 days) if the refrigerator operates on average for 12 hours a day, and electricity costs 31.28 cents per kilowatt-hour?

8. An oil heater is rated at 1000 W and runs off 230 V supply.
(a) What current does the heater draw?
(b) What is the effective resistance of the heater?
(c) If electricity costs 17 cents per kilowatt-hour, what does it cost to run the heater for 5.0 h?

9. The following table gives the power consumption of various products when they are on standby.

Product	Power (W)
Laptop computer	14.5
Modem	3.4
Cordless phone equipment	3.7
DVD player	2.4
Television	6.2

(a) Calculate the energy used by each product if it is left on standby for one year.
(b) Calculate the mass of greenhouse gases produced by these products if they are left on standby for one year, assuming that 1 kW-h of energy produces greenhouse gases that are equivalent to 1.444 kg kilograms of CO_2.

Safety in household circuits

10. What is the difference between a shock and electrocution?

11. Describe factors that reduce the resistance of human skin.

12. Why is the amount of current flowing through the body important in determining the severity of an electric shock?

13. What is fibrillation?

14. What would happen if you touched a shock victim who was still conducting an electrical current?

15. How is the severity of a shock related to the time of exposure?

16. What is ‘double insulation’?

17. A worker touched an overhead power line and was electrocuted. A newspaper reported the incident in the following way:

> ‘He touched the cable and 50 000 V of electricity surged through his body.’

Criticise this statement.