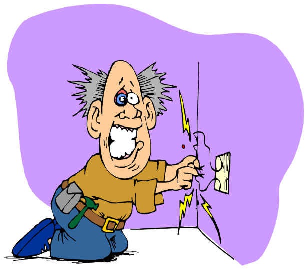
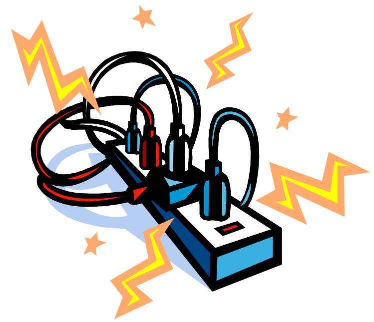
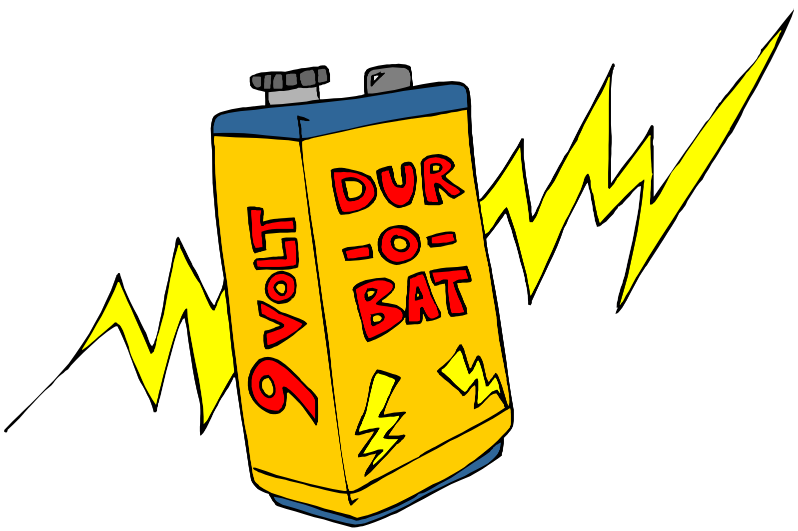
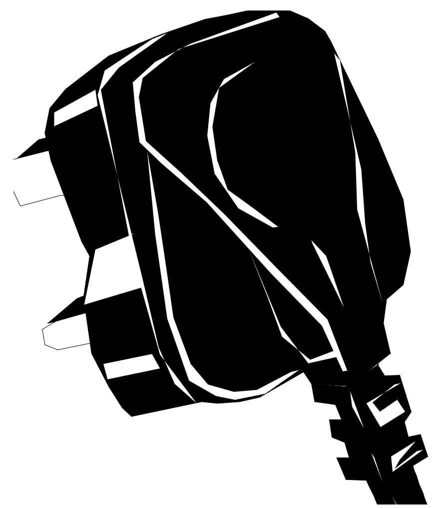
# Standard Grade Physics


# "USING ELECTRICITY"





**Name:** ______________________________ **Class:** ______ **Teacher:** ______________________

# Section 1 - From The Wall Socket

**ELECTRICITY is the common name for ELECTRICAL ENERGY.**

## 1. (a) Batteries and 'The Mains' - Our Supply of Electrical Energy

We use many **electrical appliances**. These need a supply of **electrical energy** (**electricity**) to operate.

We can supply this **electrical energy** through:

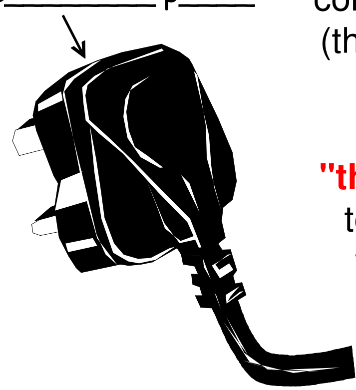
### (i) batteries


Many small electrical appliances (radios, compact disc players, etc) can run on the **electrical energy** supplied by **b** _ _ _ _ _ _ _ _ _ which are inserted into a special compartment in the back of the appliance.

### (ii) the mains supply

t______ - p____

e__________ p_____



e________

f____

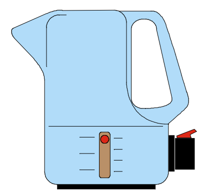
Most electrical appliances can be connected to the **m** _ _ _ _ **s** _ _ _ _ _ (the electricity sockets located in almost every room of our homes.)

This connection is made through a **"three-pin electric plug"** which is fitted to an **"electric flex"** (a flexible cable which is attached to the appliance.)

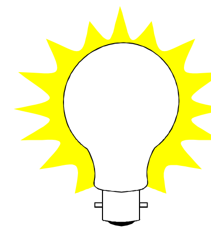
## (b) Household Electrical Appliances - Energy Changers

Household electrical appliances change (transform) **electrical energy** into **other forms of energy**. For example:

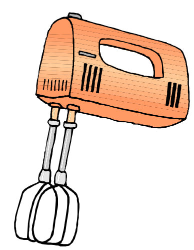
Write down the main **energy change(s)** for each of these electrical appliances:



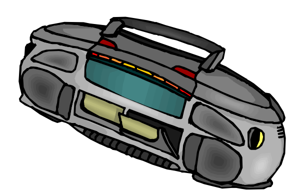
- **kettle**



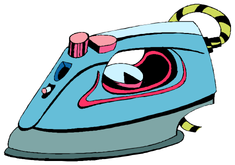
- **light bulb**



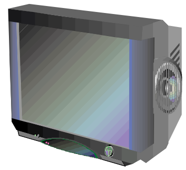
- **food mixer**



- **CD/cassette player**



● iron



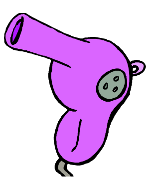
● colour television

● washing machine

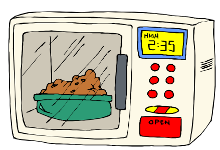
● electric cooker

● vacuum cleaner

● electric fan



● hair dryer



● microwave oven

# 2. POWER RATING OF HOUSEHOLD APPLIANCES

On every electrical appliance, you will find a small **information** or **rating plate** which tells you important details about the appliance.

One important detail is the **p** _ _ _ _ **r** _ _ _ _ _ of the appliance - a number which tells you how much **e** _ _ _ _ _ _ _ _ _ _ **e** _ _ _ _ _ the appliance changes (transforms) every second. (The **h** _ _ _ _ _ the power rating, the **h** _ _ _ _ _ the electrical energy changed/transformed every second - and the **h** _ _ _ _ _ the **c** _ _ _!)

Power ratings have units of **watts (W)** or **kilowatts (kW)**.

**1 000 W = 1 kW.**

**Model Number 210**
**230 volts**
**2000 W = 2 kW**

a typical rating plate

Beside each electrical appliance shown on the left, write down an appropriate **power rating**
- Use the values given in the box below:

| | | | | | |
|---|---|---|---|---|---|
| 15 W | 60 W | 200 W | 200 W | 300 W | 500 W |
| 850 W | 1 000 W | 2 000 W | 2 000 W | 3 000 W | |
| 12 000 W | | | | | |

Which type of electrical appliances have the highest **power rating**? ______________________________

______________________________

Which type of electrical appliances **cost the most** to run? ______________________________

______________________________

# 3. CHOOSING A SUITABLE FLEX FOR A HOUSEHOLD APPLIANCE

There are many different types of flex.

- Some flexes contain 2 plastic-covered metal wires - the **LIVE** wire (**brown** plastic cover) and the **NEUTRAL** wire (**blue** plastic cover). These wires carry **e**________ **c**_______ between the **m**____ **s**______ and the **a**_________ connected to it.

Why are the metal wires covered with **plastic**?

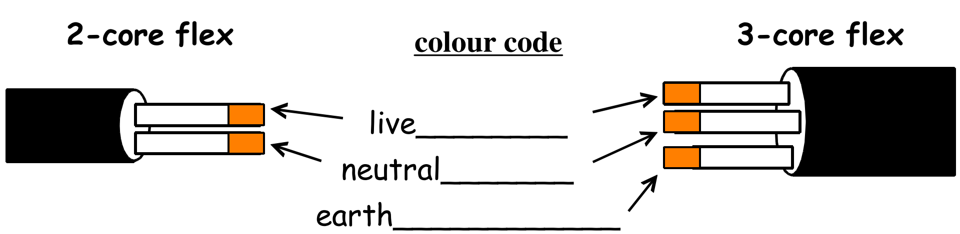
______________________________________________

______________________________________________

______________________________________________

- Other flexes contain a third wire - the **EARTH** wire (**green** and **yellow** striped plastic cover). This does not usually carry an **e**________ **c**_______, unless the appliance to which it is connected develops a **f**_____-. The EARTH wire is a safety device. (See later - page 8).

Complete the diagrams to show the correct **colour-coding** for the plastic-covered metal wires in a flex. (Use coloured pencils):




- The metal wire in different flexes has a different **t**_________. The thicker the metal wire, the **l**______ the size of the electric current it can carry safely without **h**_______ up the flex and starting a **f**___. Appliances with **l**____ power ratings (like electric cookers and heaters) use a **l**____ electric current, so require a flex that contains **t**_______ metal wires. Appliances with **s**____ power ratings (like television sets) use a **s**_______ electric current, so can have a flex that contains **t**_______ metal wires.

This data table can be used to select the correct type of flex for an electrical appliance, so long as you know the **power rating** of the appliance.

| Flex type | Power rating of electrical appliance | Thickness of metal wires in flex |
|---|---|---|
| A | up to 720 W | 0.50 mm |
| B | 721-1440 W | 0.75 mm |
| C | 1441-2400 W | 1.00 mm |
| D | 2401-3240 W | 1.25 mm |
| E | 3241-3840 W | 1.50 mm |

Which type of **flex** (A, B, C, D or E) would you fit to each of the following electrical appliances?

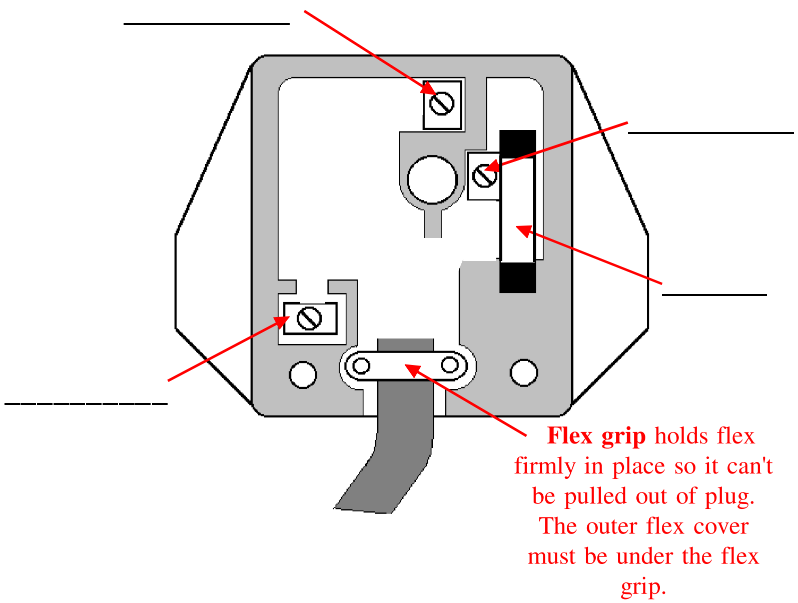
1) electric lamp (power rating 60 W) _______
2) electric kettle (power rating 1 000 W = 1 kW) _______
3) television set (power rating 100 W) _______
4) electric fire (power rating 2 000 W = 2 kW) _______
5) electric cooker (power rating 3 500 W = 3.5 kW) ______
6) fan heater (power rating 2 500 W = 2.5 kW) _______

# 4. WIRING A 3-PIN ELECTRIC PLUG, EXTENSION SOCKET AND LAMPHOLDER

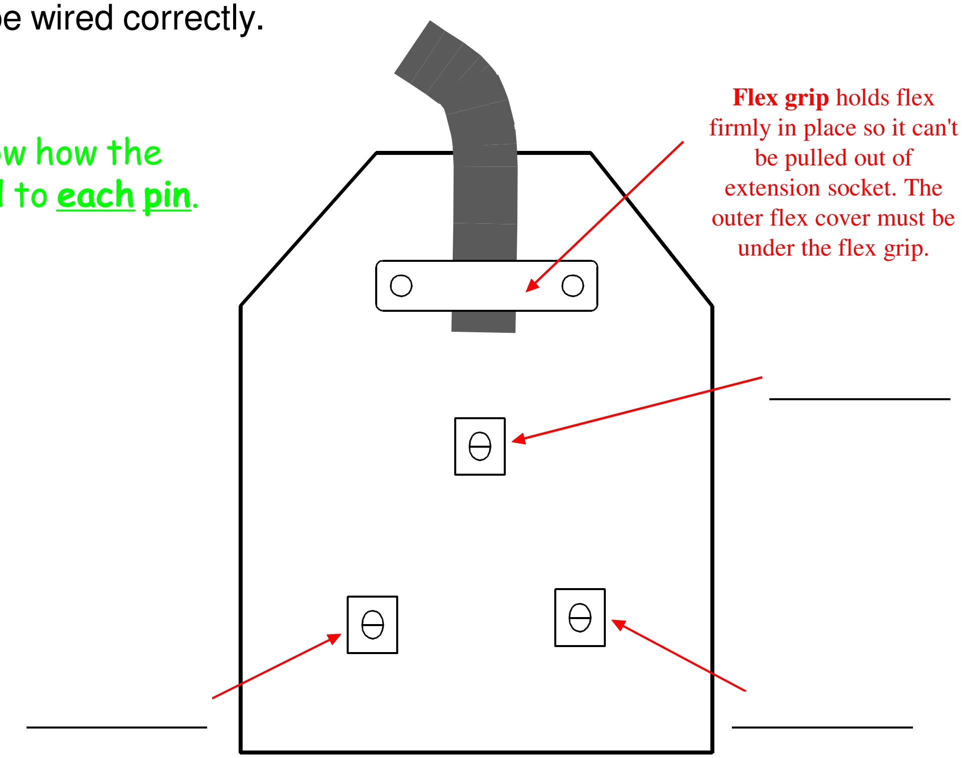
**Three-pin electric plugs**, **extension sockets** and **lampholders** are common in every home.

They must be wired correctly.

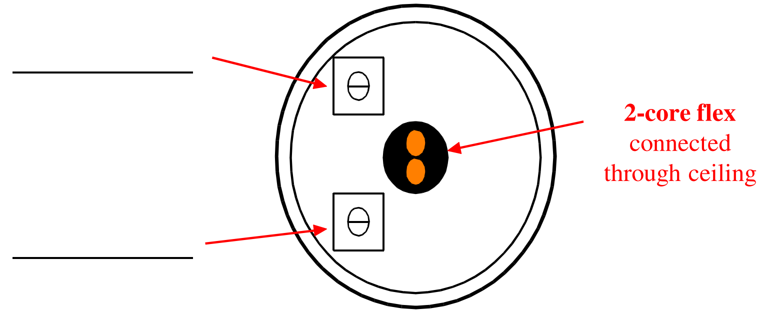
- Correctly label the **pins** in each diagram.
- Using coloured pencils, complete each diagram to show how the **plastic-coated metal wires** in a **flex** must be connected to **each pin**.




**three-pin electric plug**




**extension socket**




**lampholder** (looking down from ceiling)

# 5. SELECTING THE CORRECT FUSE FOR A THREE-PIN ELECTRIC PLUG

Every three-pin electric plug must be fitted with a **f** _ _ _ - a thin piece of **m** _ _ _ _ **w** _ _ _ enclosed in a cylinder.

Electric current flows from the mains supply to an appliance through the **m** _ _ _ _ **f** _ _ _ **w** _ _ _ .

The **f** _ _ _ must be connected to the **l** _ _ _ pin of the plug.

If the appliance develops a **fault**, the current flowing through its three-pin electric plug to its flex may suddenly become much larger. The large current could make the metal wires in the flex very **h** _ _ , melting the flex coating and causing a **f** _ _ _ .

This is prevented by the **f** _ _ _ . When the current passing through the fuse becomes **l** _ _ _ _ _ than the value marked on the fuse, the fuse wire **m** _ _ _ _ and breaks (and therefore stops any more current flowing through the flex.) - We say the fuse has **b** _ _ _ _ .

**THE F _ _ _ PREVENTS THE F _ _ _ BEING DAMAGED BY TOO L _ _ _ _ A CURRENT.**

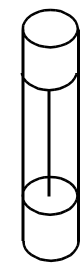
It is important to fit the correct value of fuse to the three-pin electric plug of an appliance. The fuse value chosen should be slightly **l** _ _ _ _ _ than the maximum value of current used by the appliance.

If a fuse with too **low** a value is chosen, it will **b** _ _ _ at the instant the appliance is switched on.

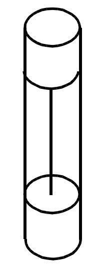
If a fuse with too **high** a value is chosen, it may not **b** _ _ _ if the current passing through the metal wires of the flex becomes too large - This could be a **f** _ _ _ hazard.

**It is now recommended that 2 standard values of fuse should be fitted in 3-pin electric plugs. The fuse value depends on the power rating of the appliance for which it will be used:**

- **Appliances up to power rating 700 W......Fit a 3 ampere (3 A) fuse.**
- **Appliances over power rating 700 W......Fit a 13 ampere (13 A) fuse.**



**3 amp fuse**



**13 amp fuse**

What value of **fuse** would you fit in the **three-pin electric plug** of:

1) a 60 W electric lamp __________

2) a 1 kW (1 000 W) electric kettle ___________

3) a 100 W television set ___________

4) a 2 kW (2 000 W) electric fire ____________

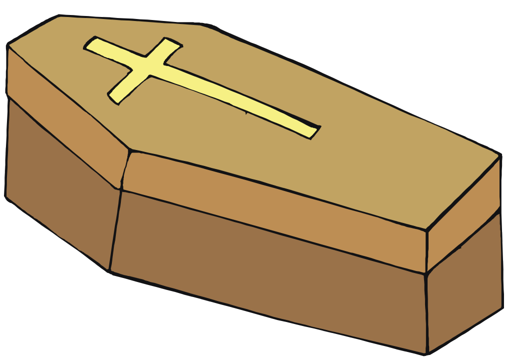
5) a 500 W electric blanket __________

6) a 2.2 kW (2 200 W) fan heater ___________

# 6. THE HUMAN BODY - A Conductor of Electricity

The human body is a conductor of electricity
- Electricity can pass through you !!!

If you come into direct contact with electricity from the **mains supply**, you will receive an **electric shock**.



Every day, people who come into direct contact with the **m** _ _ _ _ **s** _ _ _ _ _ receive an **e** _ _ _ _ _ _ _ **s** _ _ _ _ and **d** _ _ .

Moisture (water) **i** _ _ _ _ _ _ _ _ the ability of your body to conduct electricity.

If you touch electrical plugs, sockets or switches with **w** _ _ hands, your chances of receiving an electric shock are far **h** _ _ _ _ _ .

(a) Can the **human body** conduct **electricity**? ______

(b) What will you receive if you come into **direct contact** with the **mains supply**?

____________________________________

(c) What happens to many people who receive an **electric shock**? ____________________

(d) What affect does **moisture** (**water**) have on the ability of the **human body** to **conduct electricity**?

____________________________________

(e) Explain why touching a **light switch** with **wet hands** is **dangerous**: ______________________________

____________________________________________

____________________________________________

# 7. THE EARTH WIRE - A Safety Device

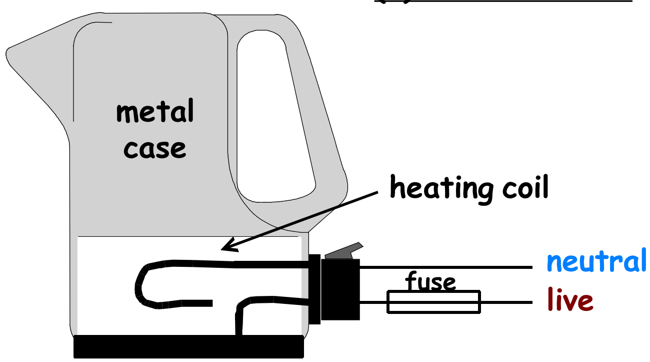
The **earth wire** is connected to the **m** _ _ _ _ **c** _ _ _ of an electrical appliance.

**The EARTH WIRE is a "S _ _ _ _ _ D _ _ _ _ _".**

## How the Earth Wire acts as a Safety Device

The diagrams below show a **faulty** electric kettle with a **metal case**. The heating coil has broken and the end connected to the **LIVE WIRE** is touching the **metal case**.

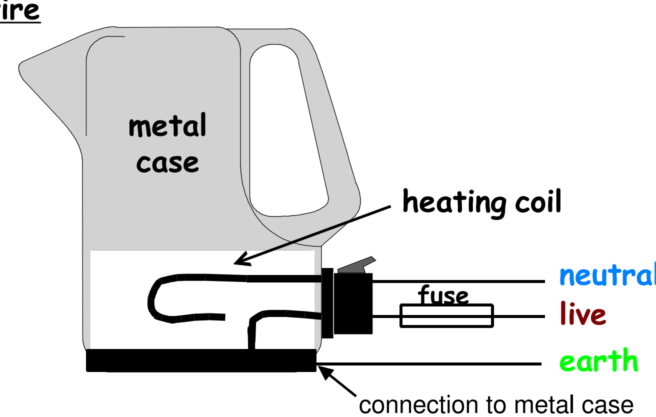
(a) NO earth wire




When the kettle is switched on, electric current flows from the **live wire**, through the **fuse**, onto the **metal case** - The **metal case** is **LIVE** (connected to the **live wire**.)

Anyone touching the **metal case** will receive an **e** _ _ _ _ _ _ _ _ **s** _ _ _ _ , i.e., electric current will flow from the kettle case through the person.

(b) WITH earth wire




If the metal case becomes **LIVE**, the **earth wire** will carry the electric current away from the metal case to the **earth** (**ground**).

It is **v** _ _ _ **e** _ _ _ for electric current to flow through the **earth wire**, so a much **l** _ _ _ _ _ current begins to flow through the **live wire** and **fuse** to the **metal case** and **earth wire** - This **l** _ _ _ _ _ current flowing through the **fuse** causes the **fuse** to **b** _ _ _ , thus stopping any more current from flowing.

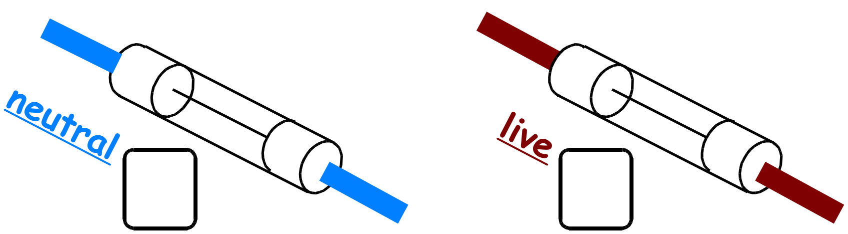
THIS ALL TAKES PLACE IN A FRACTION OF A SECOND, SO ANYONE TOUCHING THE METAL CASE WILL NOT RECEIVE AN **E** _ _ _ _ _ _ _ _ **S** _ _ _ _.

## 8. POSITION OF FUSE

It is vital that any fuse is connected in the **l _ _ _** wire - If it is connected in the **neutral** wire and the **live** wire breaks, no electric current will flow through the fuse, so the fuse can't **b** _ _ _ . The case of the electrical appliance will be **l** _ _ _ - If you touch it you will get an **e** _ _ _ _ _ _ _ _ **s** _ _ _ _.

(Make sure you can understand this - See on the kettle diagrams that when the heating coil breaks, the **NEUTRAL WIRE** is **disconnected totally** from the electric current flowing into the kettle through the **LIVE WIRE**.

Place a **tick** or **cross** in each box to show the **wire** in which a **fuse** must be connected:




Explain why a the **fuse** in a three-pin plug must always be connected in the **live wire**:

______________________________________________

______________________________________________

______________________________________________

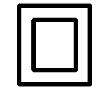
______________________________________________

______________________________________________

______________________________________________

______________________________________________

## 9. DOUBLE INSULATION



It is only important to connect an earth wire to an electrical appliance if the outer case of the appliance is made of a conducting material such as **m** _ _ _ _ .

If the outer case is made of an **insulating material** such as **plastic**, and the **live wire** comes into contact with the case, anyone touching the case **will not** receive an **e** _ _ _ _ _ _ _ _ **s** _ _ _ _ (since **p** _ _ _ _ _ _ _ does not **c** _ _ _ _ _ _ _ electricity.)

This is why certain electrical appliances such as television sets and video recorders (which have **p** _ _ _ _ _ _ _ **cases**) are not fitted with an **earth wire**. The flex which connects them to the mains supply only contains 2 plastic-covered metal wires - **live** and **neutral**.

Such electrical appliances are said to be **d** _ _ _ _ _ **i** _ _ _ _ _ _ _ _ _.

The **rating plate** on these appliances shows the **d** _ _ _ _ _ **i** _ _ _ _ _ _ _ _ _ _ **s** _ _ _ _ _ .

Draw the **double insulation symbol**:

Why do some electrical appliances **not** need to be fitted with an **earth wire**?

______________________________________________

______________________________________________

______________________________________________

If you see the **double insulation symbol** on the rating plate of an electrical appliance, describe the **flex** you should fit to the appliance:

______________________________________________

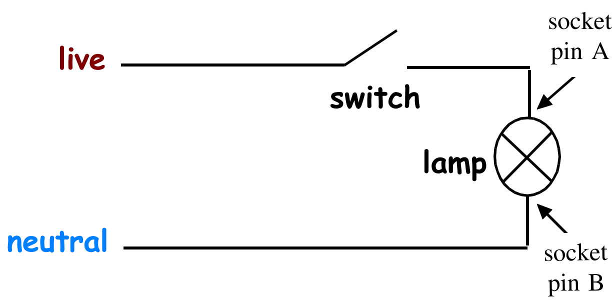
# 10. SWITCHES

**Switches** are used to connect or disconnect electrical appliances from the mains supply.

**A SWITCH MUST ALWAYS BE PLACED IN THE LIVE WIRE.**

### (a) SAFE lighting circuit

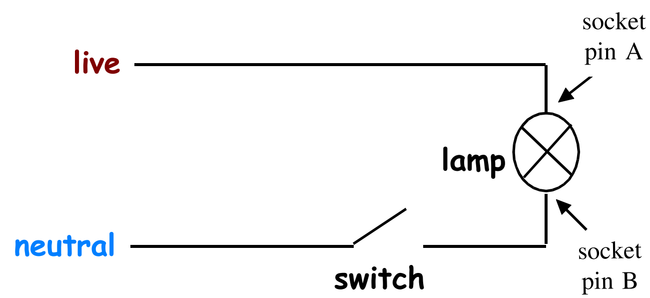
The lighting circuit shown below is **safe** because the switch is connected in the **l _ _ _ wire**:




When the switch is **open**, the lamp is **off** and **socket pin A** is **disconnected from** the **live wire** - Anyone touching **pin A will not** receive an **e _ _ _ _ _ _ _ s _ _ _ _**.

### (b) DANGEROUS lighting circuit

The lighting circuit shown below is **dangerous** because the switch is connected in the **n _ _ _ _ _ _ wire**:




When the switch is **open**, the lamp is **off**, but **socket pin A** is **still connected to** the **live wire** - Anyone touching **pin A will** receive an **e _ _ _ _ _ _ _ s _ _ _ _**.

(a) What are **switches** used for?

______________________________

______________________________

______________________________

(b) In which **wire** must a **switch** always be placed?

______________________________

(a) Is this circuit **safe** or **dangerous**?

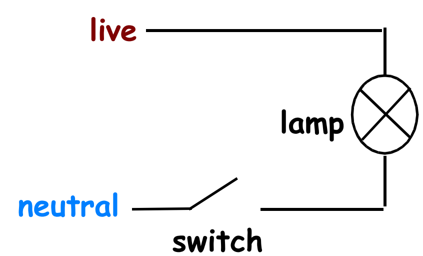
____________________

(b) Explain what would happen to someone if they touched any part of the lamp connected to the **live wire**: ______________________________

______________________________

______________________________

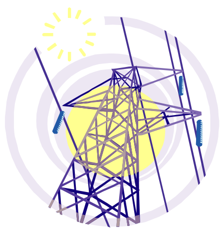
______________________________



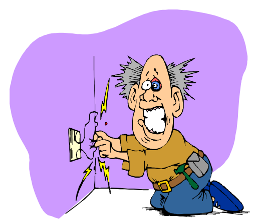
# 11. ELECTRICAL SAFETY HAZARDS

**MAINS ELECTRICITY IS DANGEROUS AND MUST BE TREATED WITH RESPECT**
**- ANY MISTAKE COULD COST YOU YOUR LIFE !!!**

Explain why the following situations involving **electricity** could lead to **accidents**:

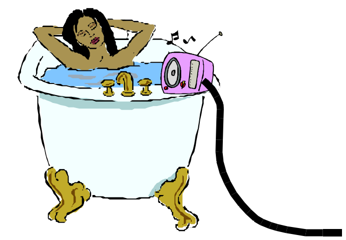


- Coming into contact with overhead power lines.

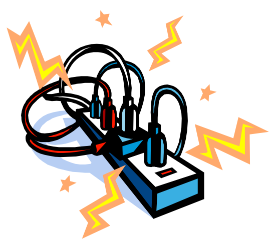


- Touching bare metal wires.

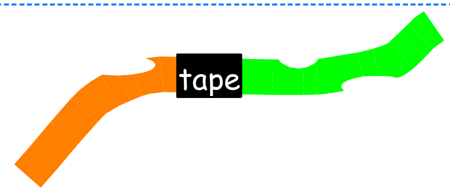
- Touching switches with wet hands.



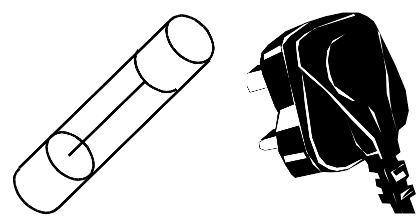
- Using, in the bathroom, appliances connected to the mains supply.



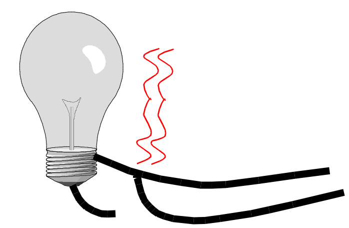
- Connecting too many appliances to a multiway adaptor.




- Using wrong, frayed or badly connected flexes.

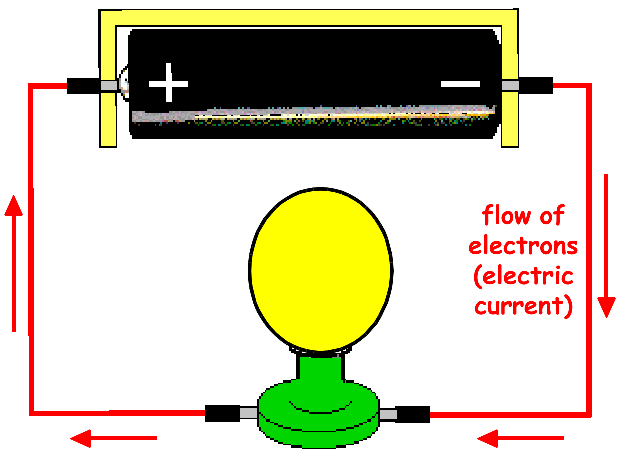


- Fitting the wrong value of fuse in a three-pin plug.



- Short circuits.

# Section 2 - Direct and Alternating Current




## 1. CURRENT and VOLTAGE

Tiny, negatively-charged particles called **e** _ _ _ _ _ _ _ _ _ flow around an electric circuit.

**E** _ _ _ _ _ _ _ _ _ can only flow through substances called **c** _ _ _ _ _ _ _ _ _ _ (e.g., **m** _ _ _ _ _ _ ) but not through substances called **i** _ _ _ _ _ _ _ _ _ _ (e.g., most **non - m** _ _ _ _ _ _, like **p** _ _ _ _ _ _ _ and **r** _ _ _ _ _ _ ).

The flow of electrons around an electric circuit is called an electric current.
Electric current is measured in units called amperes.
Unit symbol: A.

In this electric circuit, the battery gives the electrons **energy** (**e** _ _ _ _ _ _ _ _ _ _ **energy**) to flow around the circuit from its **n** _ _ _ _ _ _ _ _ (**-**) terminal to its **p** _ _ _ _ _ _ _ _ (**+**) terminal. The **v** _ _ _ _ _ _ _ of the battery indicated how much **e** _ _ _ _ _ _ _ _ _ _ **energy** it gives the electrons. The higher the **v** _ _ _ _ _ _ _, the higher the **e** _ _ _ _ _ _ _ _ _ _ **energy**.

The voltage of a battery (or other power supply) is a measure of the electrical energy it gives to the electrons in an electric circuit.
Voltage is measured in units called volts. Unit symbol: V.

The electrons lose their **e** _ _ _ _ _ _ _ _ _ _ **energy** as they flow around an electric circuit - In this circuit, the lamp converts most of their **e** _ _ _ _ _ _ _ _ _ _ **energy** into **l** _ _ _ _ and **h** _ _ _ energy:

**electrical** ⟶ **l** _ _ _ _ **+** **h** _ _ _

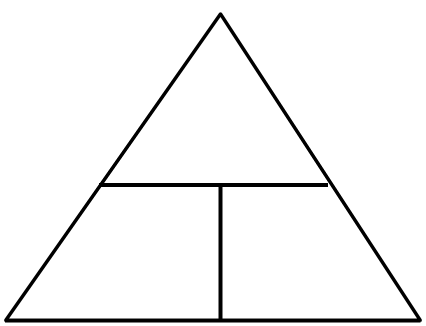
# 2. CURRENT, CHARGE and TIME

Every electron has a negative **c** _ _ _ _ _ _. **C** _ _ _ _ _ _ is measured in units called **c** _ _ _ _ _ _ _ _. Unit symbol: **C**.

The total quantity of **c** _ _ _ _ _ _ which flows through a conductor depends upon how many electrons pass along it in a given time. More electrons per second means more **c** _ _ _ _ _ _.

**Total QUANTITY of CHARGE (Q) = CURRENT (I) × TIME (t)**

**Unit: coulombs/ C** | **Unit: amperes/ A** | **Unit: seconds/ s**



1) What charge will have passed through a metal wire when:

- a current of 10 A flows for 20 seconds?
- a current of 15 A flows for 3 seconds?
- a current of 20 A flows for 1 minute?

2) Calculate the current flowing in an electric circuit when:

- 20 C of charge is passed for 10 seconds.
- 0.5 C of charge is passed for 5 seconds.
- 100 C of charge is passed for 1 minute.

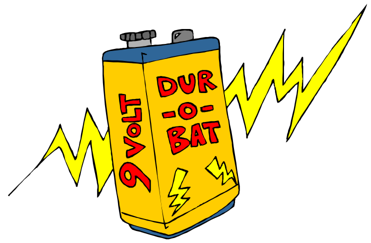
3) A lamp uses a current of 2 A. What time must the lamp be switched on for to allow:

- 50 C of charge to pass through it?
- 75 C of charge to pass through it?
- 100 C of charge to pass through it?

# 3. DIRECT CURRENT (d.c.) and ALTERNATING CURRENT (a.c.)

Electricity can be supplied in one of two forms - either **d** _ _ _ _ _ **current** (**d.c.**) or **a** _ _ _ _ _ _ _ _ _ _ _ **current** (**a.c.**)

## direct current (d.c.)


Direct current (d.c.) **is supplied by b** _ _ _ _ _ _ _ _ _.

A battery connected to the Y-input terminals of an oscilloscope produces this trace on the screen:

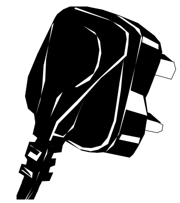
This shows that the current supplied from a battery has a constant value - Such a current is known as ____________ _________ ( ____ ).

Direct current (d.c.) passes through an electric circuit in only _______ direction.

- **How could you make the current flow in the opposite direction?** ________________________________________

________________________________________________

## alternating current (a.c.)



Alternating current (a.c.) **is supplied from the m** _ _ _ _ **s** _ _ _ _ _ _.

The mains supply connected to the Y-input terminals of an oscilloscope produces this trace on the screen:

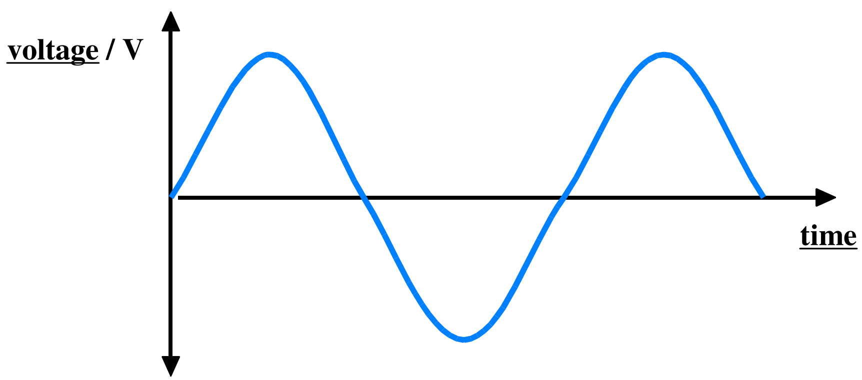
This shows that the current supplied from the mains supply has a value which changes (alternates) with time - Such a current is known as _______________ _________ ( ___ ).

An electron in a circuit connected to the mains supply keeps reversing its direction - it keeps travelling backwards and forwards over the same path ____ times every second.

We say that the mains supply has a frequency of ____ hertz (Hz).

## 4. VOLTAGE OF THE MAINS SUPPLY

The trace you observed on the oscilloscope screen for the **mains supply** is in fact a graph of **mains voltage against time** - It shows how the **mains voltage** changes with **time**.




The graph shows that the value of the **mains voltage** changes constantly with **time**.

The **maximum value** of the **mains voltage** is called the **p _ _ _ voltage**. In Britain, the **p _ _ _ voltage** of the **mains supply** has a value of about **325 volts**.

Mark this value on the graph.

Because the value of the **mains voltage** keeps changing with **time**, any electrical appliance connected to the **mains supply** will receive an **average** value of voltage. This **average voltage** will be **l _ _ _** than the **peak voltage**.

**In Britain, the average value of the mains supply voltage is _ _ _ V.**

## 5. SYMBOLS FOR CIRCUIT COMPONENTS

In the following sections, a number of different **circuit components** will be used.

- In the table below, draw the **circuit symbol** for each component:

| | | |
|---|---|---|
| • connecting wire | • cell/battery | • a.c. supply |
| • lamp (bulb) | • switch | • resistor |
| • variable resistor | • fuse | • capacitor |
| • LED | • ammeter | • voltmeter |

# Section 3 - Resistance

## 1. RESISTANCE

In an electric circuit, electrons flow through metal wires and circuit components.

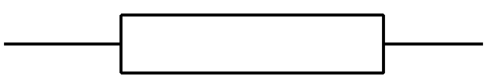
Every circuit component opposes the flow of electrons to some extent - This opposition to the flow of electrons is called **r** _ _ _ _ _ _ _ _ _.

- The **l** _ _ _ _ _ the resistance. the **s** _ _ _ _ _ _ the current.
- The **s** _ _ _ _ _ _ the resistance, the **l** _ _ _ _ _ the current.

When current flows through a circuit component, some **electrical energy** is converted into **heat energy** by the component. (This is made use of in the metal heating coils/elements of **electric fires**, **k** _ _ _ _ _ _ and **t** _ _ _ _ _ _ _.)

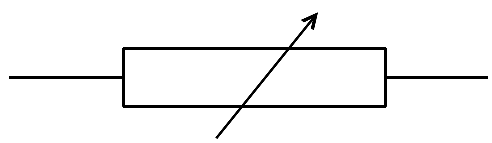
Some components are deliberately included in electric circuits to oppose the flow of electrons, i.e., they control the amount of current flowing in the circuit. These components are called **r** _ _ _ _ _ _ _ _.

### • FIXED RESISTORS



Each fixed resistor has only one value of resistance.

### • VARIABLE RESISTORS

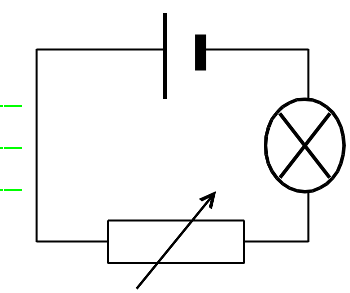


You can change the resistance of a variable resistor. (To change the resistance of a simple variable resistor, you turn a dial or move a slider on the resistor).

**Resistance is measured in o _ _ _ ( _ )**

1) Label every **circuit component** below.

2) What is the purpose of the **variable resistor** in each circuit?



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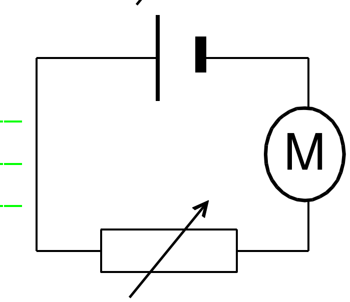


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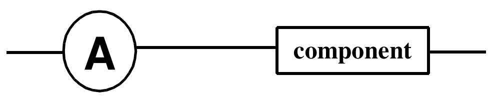
# Ammeters and Voltmeters

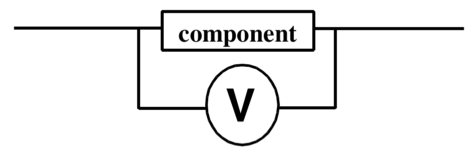
When we want to measure **current** and **voltage** values in an electric circuit, we use **ammeters** and **voltmeters**.

## Connecting ammeters and voltmeters

**Ammeters** measure the **c** _ _ _ _ _ _ _ flowing **t** _ _ _ _ _ _ _ a circuit component and must be connected **in line with** (**in series with**) the component:




**Voltmeters** measure the **v** _ _ _ _ _ _ **a** _ _ _ _ _ a circuit component and must be connected **across** (**in parallel with**) the component:



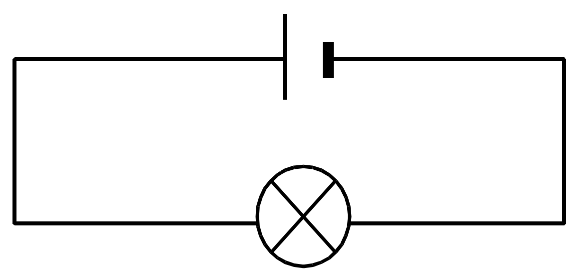

When we take readings from an **ammeter** connected to a circuit component, we 'talk about' the **current passing t** _ _ _ _ _ _ _ the component.

When we take readings from a **voltmeter** connected to a circuit component, we 'talk about' the **voltage a** _ _ _ _ _ the component.

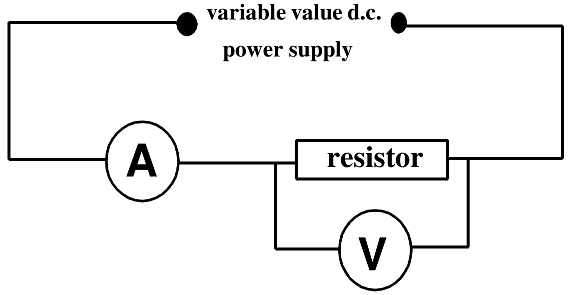
**3)** Which **circuit component** would you use to measure the **current** flowing through a lamp? ____________________

**4)** Which **circuit component** would you use to measure the **voltage across** a lamp? ____________________

**5)** Show this by drawing these **circuit components** in the correct place on this circuit diagram:



# Current Through a Component - Resistance and Ohm's Law




Using the circuit shown, every time you change the 'voltage setting' on the variable d.c. power supply, the values for the **voltage across the resistor** and **current passing through the resistor** will change.

If you change the 'voltage setting' 6 times, 6 different pairs of voltage and current values will be obtained:

Typical pairs of values are shown in this table:

| | | | | | | |
|---|---|---|---|---|---|---|
| **voltage across resistor (V)/ V** | **2.0** | **4.0** | **6.0** | **8.0** | **10** | **12** |
| **current through resistor (I)/ A** | **0.5** | **1.0** | **1.5** | **2.0** | **2.5** | **3.0** |
| $\frac{\text{voltage}}{\text{current}}$ | | | | | | |

No matter which pair of voltage and current values you take, when you divide voltage (V) by current (I), you will always get the same answer - *See this for yourself by completing the last row of the table.*

$$\frac{V}{I} = \text{constant value.}$$

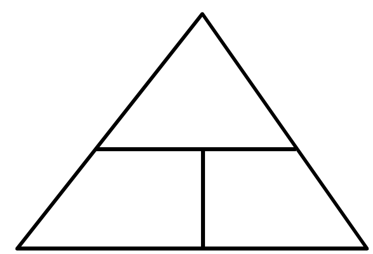
This **constant value** is called the **resistance** (**R**) of the resistor.

$$\text{resistance (R)} = \frac{\text{voltage (V)}}{\text{current (I)}}$$

**Unit: volts/ V** (voltage)

**Unit: amperes/ A** (current)

**Unit: ohms/ Ω** (resistance)



**This relationship, discovered in 1827 by a teacher in Germany called Georg Simon Ohm, is known as "Ohm's law".**

**6)** You should now attempt the following **"Ohm's law"** problems:

Calculate the **voltage** across:

- a 5 Ω resistor carrying a current of 3 A;
- a 10 Ω resistor carrying a current of 8 A;
- a 100 Ω resistor carrying a current of 0.2 A.

Calculate the **current** passing through:

- a 100 Ω resistor with 200 V across it;
- a 5 Ω resistor with 30 V across it;
- a 2.5 Ω resistor with 25 V across it.

Calculate the **resistance** of:

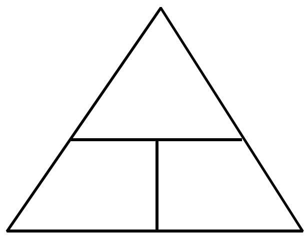
- a light bulb marked "6 V, 0.05 A";
- a resistor with 30 V across it and a current of 5 A passing through it;
- the heating coil of an electric fire which has 230 V across it and carries a current of 2.3 A.

# 2. ELECTRICAL ENERGY and POWER

In Section 1 of this topic, you learned that.....

**The power rating of an electrical appliance tells us how much electrical energy it changes (transforms) into other forms of energy every second.**

**ELECTRICAL POWER is the amount of ELECTRICAL ENERGY transformed every second.**



**Energy (E) = Power (P) x time (t)**

unit: joules (J) — unit: watts (W) — unit: seconds (s)

**7)** How much electrical energy does a 2 000 W electric kettle change into heat energy in 15 s?

**8)** How much electrical energy does a 100 W electric light bulb transform in 1 minute?

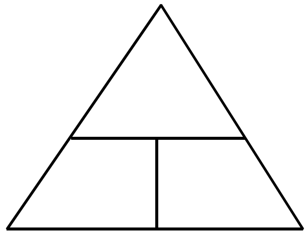
**9)** Calculate the power of an electric motor which transforms 5 000 J of electrical energy into kinetic energy every 2 s.

**10)** What is the power rating of an electric shaver which transforms 2 000 J of electrical energy in 50 s?

**11)** How many seconds does it take an 800 W electric blanket to transform 3 200 J of electrical energy?

**12)** How long does a 60 W television set take to transform 720 J of electrical energy?

The **electrical power** of an appliance can be calculated if we know the **voltage across the appliance** and the **current passing through the appliance**.



**Power (P) = Voltage (V) x Current (I)**

- Power: unit: watts (W)
- Voltage: unit: volts (V)
- Current: unit: amperes (A)

**13)** Calculate the **power rating** of:

- a 230 V soldering iron which uses a current of 0.1 A;
- a 12 V electric heater using a current of 2.5 A;
- a 230 V electric kettle which requires a current of 5 A.

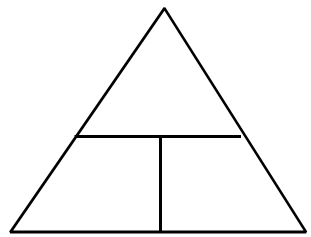
**14)** Calculate the **voltage** across:

- a 36 W light bulb using a current of 3 A;
- a 750 W electric drill carrying a current of 1.5 A;
- a 1 000 W electric oven using 5 A of current.

**15)** Determine the current passing through:

- a 230 V, 100 W food mixer;
- a 230 V, 4 600 W electric cooker;
- a 12 V, 2 W electric motor for a toy car.

The **electrical power** of an appliance can also be calculated if we know the **current passing through the appliance** and the **resistance of the appliance**.



**Power (P) = Current² ($I^2$) x Resistance (R)**

unit: watts (W) — unit: amperes (A) — unit: ohms (Ω)

You are going to show that you obtain the same value for **electrical power** whether you use the equation **P = VI** or **P = $I^2$R**.

Complete columns 2 - 5 of the table below using the equations **V = IR** and **P = VI**.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| electric appliance | current (A) | voltage (V) | resistance (Ω) | power (W) | $I^2R$ |
| torch bulb | 0.3 | 6 | | 1.8 | |
| car headlamp | 2 | 12 | | | |
| fish tank heater | 5 | 12 | | | |
| electric drill | | 230 | | 920 | |

Now calculate **$I^2$R** for each appliance and put your results in column 6 of the table.

**16)** How do the results in column 5 of the table (obtained using P = VI) compare with those in column 6 (obtained using P = $I^2$R)? ______________________________

______________________________

**17)** What can you say about the equations P = VI and P = $I^2$R?

______________________________

______________________________

You should now attempt the following **"$P = I^2R$"** problems:

**18)** Calculate the **power rating** of:

- a 5 Ω resistor carrying a current of 2 A.
- an electric cable of resistance 2 Ω carrying a current of 3 A.
- a 10 Ω resistor carrying 5 A of current.

**19)** Calculate the **current** passing through:

- a 2 Ω resistor which has a power rating of 0.5 W.
- an electric lamp which has a resistance of 32 Ω and a power rating of 2 W.
- the heating coil of an electric heater which has a resistance of 24 Ω and a power rating of 240 W.

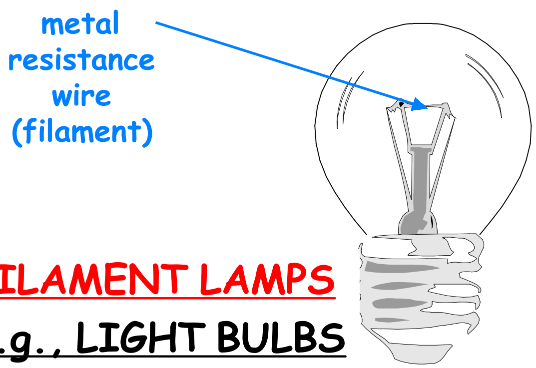
**20)** Calculate the **resistance** of:

- a 40 W resistor carrying 2 A of current.
- a 250 W electric motor which has a current of 0.5 A flowing through it.
- a 50 W circuit component which has 0.25 A of current passing through it.

# 3. HOUSEHOLD ELECTRIC LIGHTING

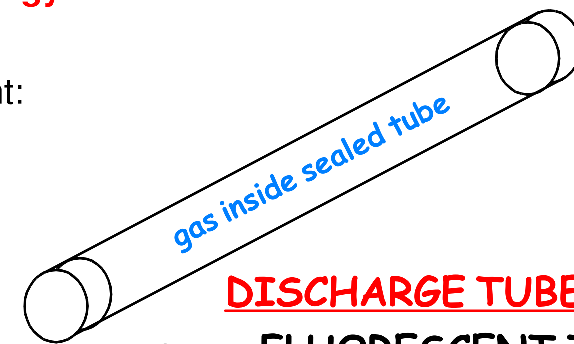
**Lighting** is one of the major uses for **electrical energy** in our homes.

There are **2 main types** of light:




**FILAMENT LAMPS**

**e.g., LIGHT BULBS**




**DISCHARGE TUBES**

**e.g., FLUORESCENT TUBES**

In any lamp, **electrical energy** is transformed (changed) into **light** and **heat energy**.

In a **filament lamp**, (e.g., **light bulb**), the energy transformation occurs in **metal resistance wire** known as a **filament**.
In a **discharge tube**, (e.g., **fluorescent tube**), the energy transformation occurs in a **gas** inside a sealed tube .

**Discharge tubes** are **more efficient** than **filament lamps** - **Discharge tubes** **transform more electrical energy into light** **(about 4 times more)** **and less into heat**.

- Complete the table to compare some of the properties of **filament lamps** and **discharge tubes**:

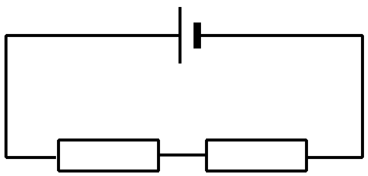
| | filament lamp | discharge tube |
|---|---|---|
| For example | | |
| Energy transformation | | |
| Where energy transformation takes place | | |
| efficiency | | |

# Notes

# Section 4 - Useful Circuits

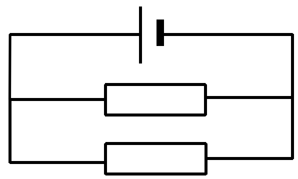
**Circuit components** can be connected to a **battery/power supply** in 2 different ways:

## (1) in a series circuit



The battery/power supply and circuit components are connected in a **continuous loop**.

## (2) in a parallel circuit



The circuit components are connected in **separate branches** across the battery/power supply.

### Current and Voltage Rules for Components in Series and Parallel Circuits

**Current in a Series Circuit**

The current is the **s _ _ _** at all points in the circuit.

**Voltages in a Series Circuit**

The voltages across the components add up to the **s _ _ _ _ _ voltage**.

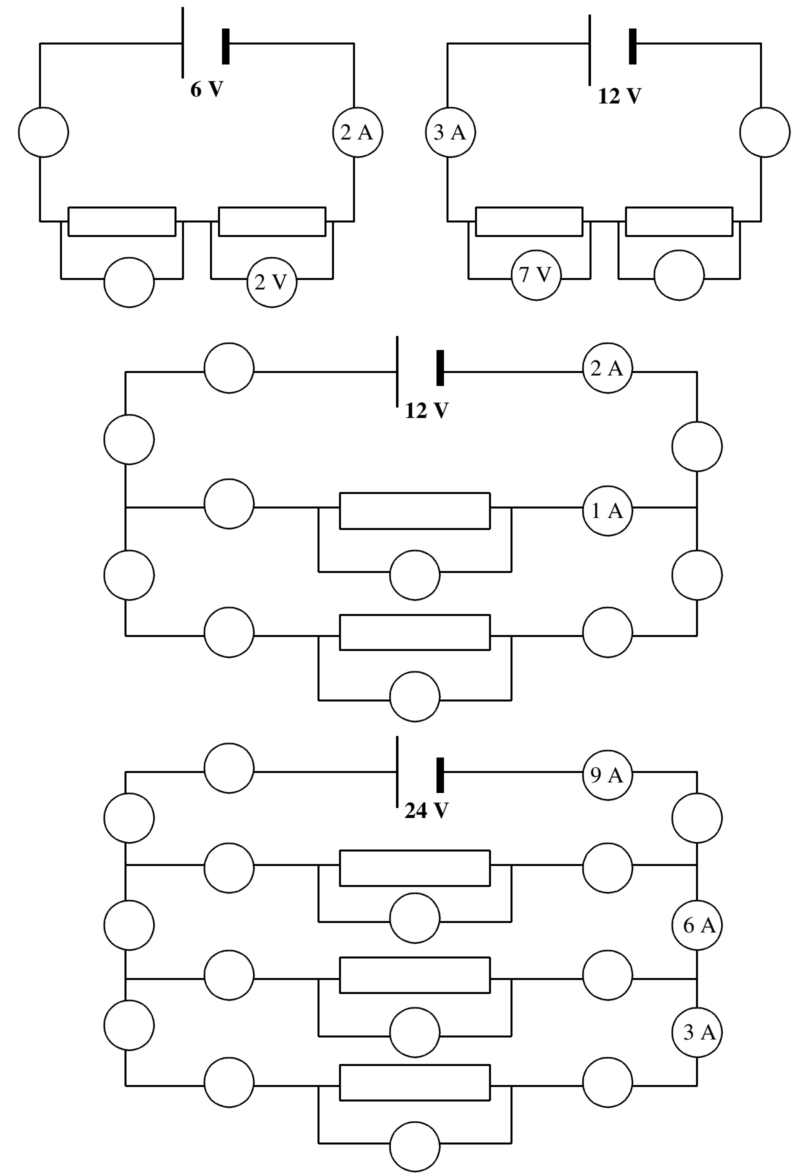
**Currents in a Parallel Circuit**

The currents flowing through the parallel branches add up to the **s _ _ _ _ _ current**.

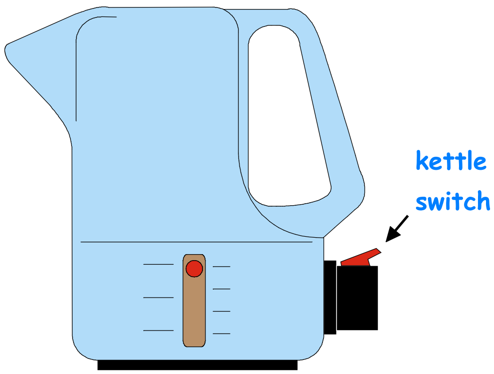
**Voltage in a Parallel Circuit**

The voltage across the parallel branches is the **s _ _ _** and equal to the **s _ _ _ _ _ voltage**.

**1) For each electric circuit shown below, write the correct current and voltage values on the meters:**



# HOUSEHOLD ELECTRICAL APPLIANCES - 2 or More Switches Used in Series




When you use an electric kettle, you:

1) Plug the kettle into a mains socket and turn the socket **switch** on.

2) Turn the kettle **switch** on.

You use **2 s** _ _ _ _ _ _ _ _ connected in **s** _ _ _ _ _ .

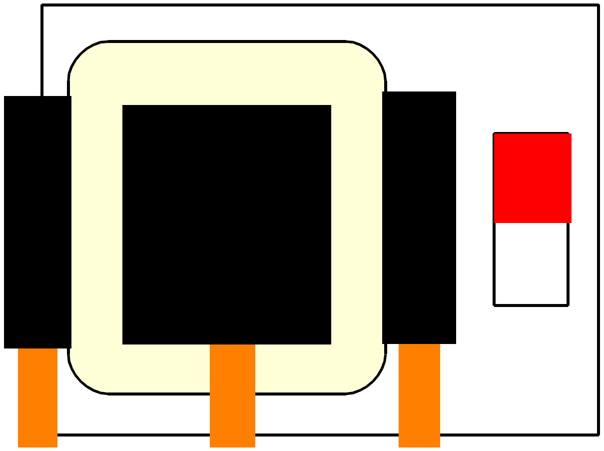
**2)** Complete this table to show which switch combinations will switch the kettle **on** or **off**:

| MAINS SOCKET SWITCH | KETTLE SWITCH | KETTLE ON or OFF |
|---|---|---|
| off | off | |
| on | off | |
| off | on | |
| on | on | |

**3)** List some other household appliances which, when connected to a mains socket, make use of 2 (or more) switches connected in series:____________________

____________________________________________

# TOO MANY HOUSEHOLD ELECTRICAL APPLIANCES CONNECTED TO THE SAME SOCKET/ADAPTOR - A Fire Hazard!



When we connect 2 or more electrical appliances to the mains supply via an electric socket, we are connecting the appliances in **p** _ _ _ _ _ _ _ - The appliances have the same mains voltage ( ____ V ) across them, but each draws a different **c** _ _ _ _ _ _ from the socket (depending on their **p** _ _ _ _ **r** _ _ _ _ _ ).

As we connect more appliances to a socket, the **c** _ _ _ _ _ _ taken from the socket **i** _ _ _ _ _ _ _ _. If too many appliances are connected to the socket, a dangerously large **c** _ _ _ _ _ _ could be drawn from it - The socket, socket wiring, plugs and flexes could **o** _ _ _ _ _ _ _ and start a **f** _ _ _!

**4)** Explain why connecting too many electrical appliances to one mains socket could be dangerous: ____________

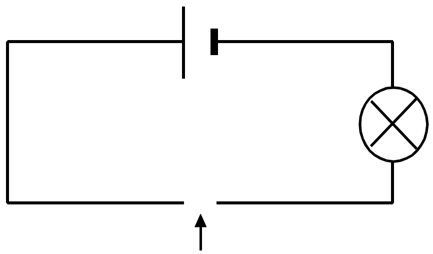
____________________________________________

____________________________________________

# CIRCUIT FAULTS
# - Open and Short Circuits

**Electric circuits** can develop 2 kinds of common **fault**:

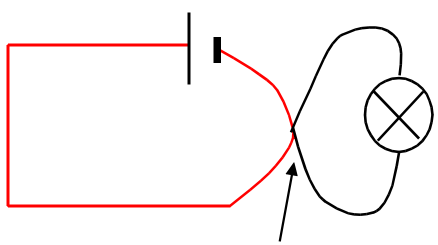
(1) an Open Circuit



Gap in circuit, e.g., broken wire or broken lamp filament.

No **e** _ _ _ _ _ _ _ **c** _ _ _ _ _ _ can flow around circuit, so lamp cannot **l** _ _ _ _.

(2) a Short Circuit

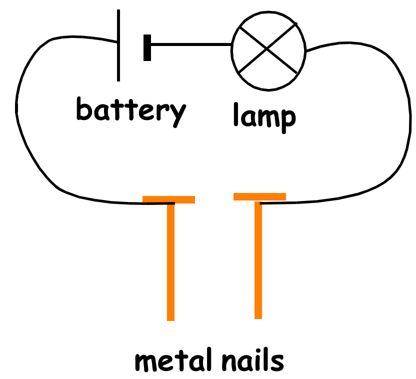


Wires have touched before electric current can reach the lamp.

The red loop has a lower **r** _ _ _ _ _ _ _ _ _ than the black loop, so **e** _ _ _ _ _ _ _ **c** _ _ _ _ _ _ flows around the red loop but none flows around the black loop - No **e** _ _ _ _ _ _ _ **c** _ _ _ _ _ _ reaches the lamp, so it cannot **l** _ _ _ _.

# TESTING FOR CIRCUIT FAULTS
# - the Continuity Tester

The diagram shows how to make a simple **continuity tester**:




Score out the **incorrect option** in each case:

- If you place the metal nails across an **open circuit**, the lamp **will** / **will not** **light**.
- If you place the metal nails across a **short circuit**, the lamp **will** / **will not** **light**.

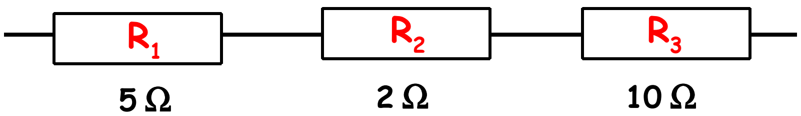
**NEVER USE A CONTINUITY TESTER ON ELECTRIC CIRCUITS CONNECTED TO THE MAINS SUPPLY - YOU COULD RECEIVE AN ELECTRIC SHOCK WHICH COULD KILL YOU !**

# RESISTORS IN SERIES

For resistors connected in **series**, the **total series resistance** ($R_s$) can be calculated using the formula:

$$R_s = R_1 + R_2 (+ R_3 + \ldots)$$

For example, for the resistors connected below:

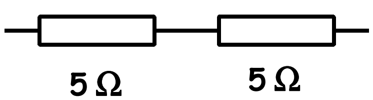


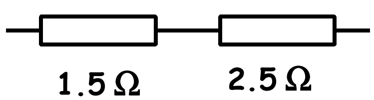

$$R_s = R_1 + R_2 + R_3$$

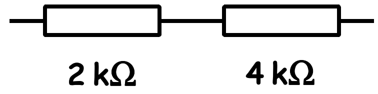
$$R_s = 5 + 2 + 10$$

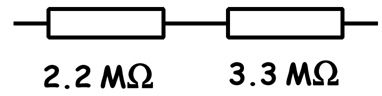
$$R_s = \underline{17\ \Omega}$$

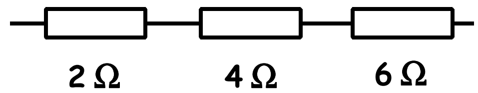
5) Calculate the **total series resistance** of each resistor combination:

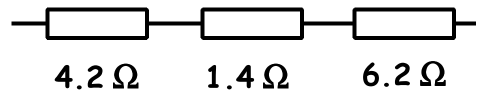


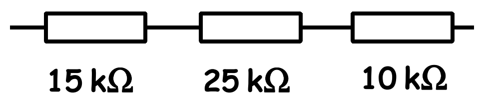



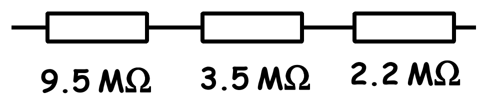



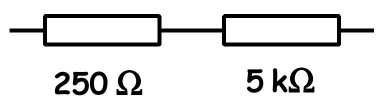



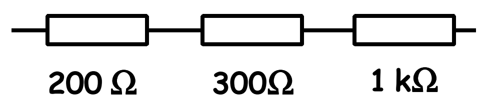



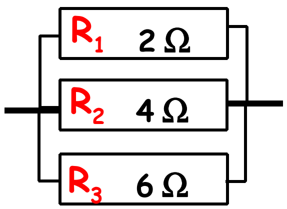



# RESISTORS IN PARALLEL

For resistors connected in **parallel**, the **total parallel resistance** ($R_p$) can be calculated using the formula:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \left( + \frac{1}{R_3} + \dots \right)$$

For example, for the resistors connected below:



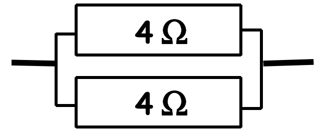

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

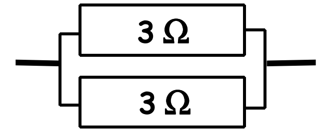
$$= \frac{1}{2} + \frac{1}{4} + \frac{1}{6}$$

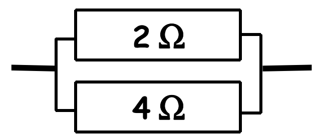
$$= \frac{11}{12}$$

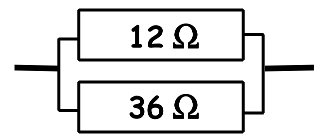
$$\therefore R_p = \frac{12}{11} = \underline{1.1\ \Omega}$$

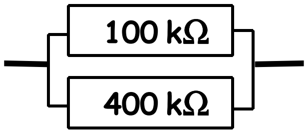
6) Calculate the **total parallel resistance** of each resistor combination:

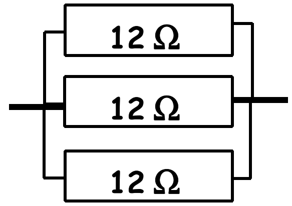


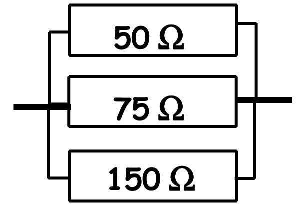



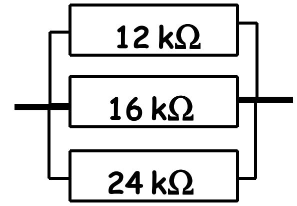



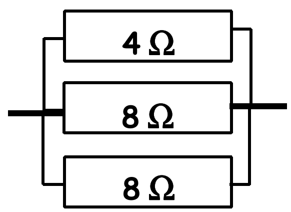

100 kΩ
400 kΩ

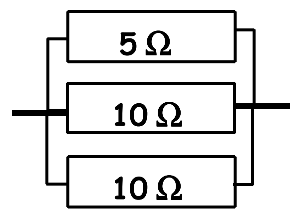

12 Ω
12 Ω
12 Ω

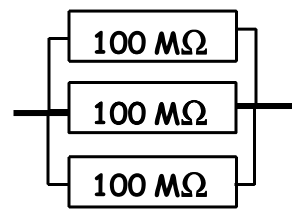

50 Ω
75 Ω
150 Ω


12 kΩ
16 kΩ
24 kΩ

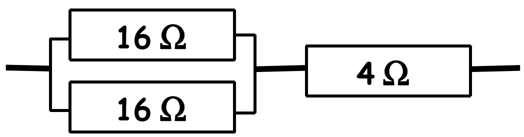

200 MΩ
800 MΩ

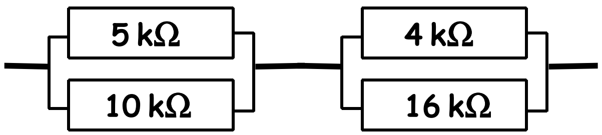

4 Ω
8 Ω
8 Ω

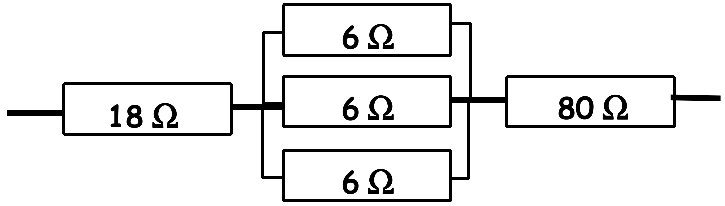

5 Ω
10 Ω
10 Ω

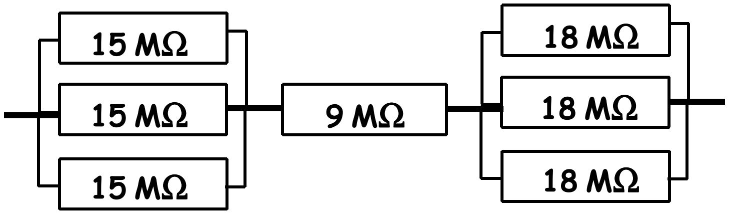

100 MΩ
100 MΩ
100 MΩ

**7)** Calculate the **total** **resistance** of each resistor combination:



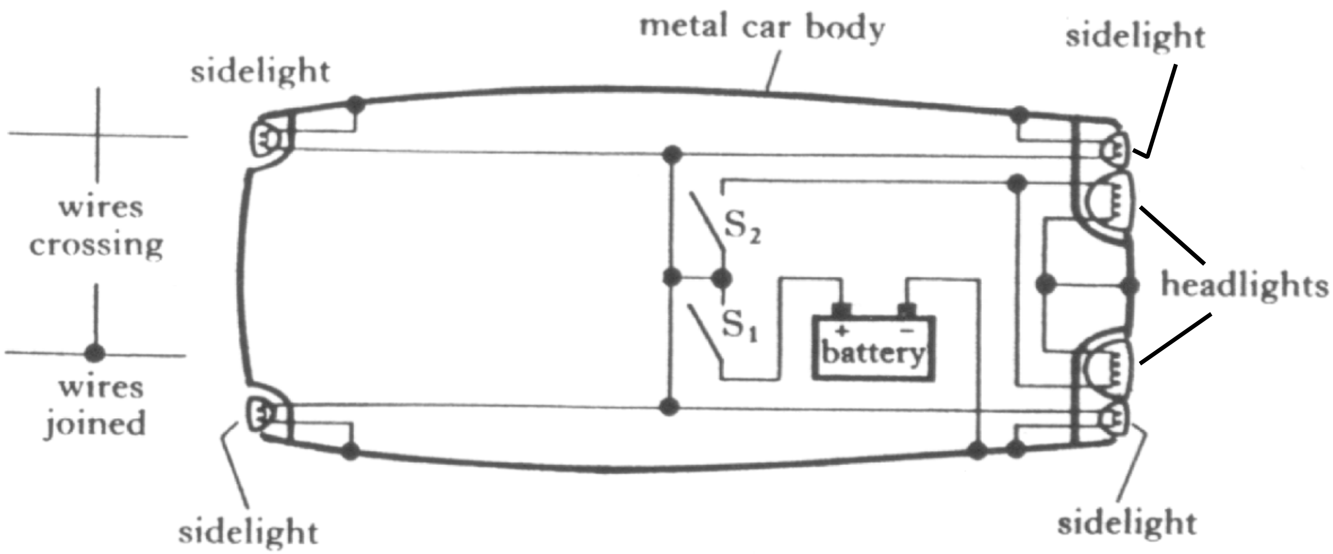



# CAR WIRING

In the **CREDIT PHYSICS EXAM**, you may be asked to draw or explain circuit diagrams which describe how the various car lighting requirements are achieved.

A typical **car wiring diagram** for the **sidelights** and **headlights** is shown below:



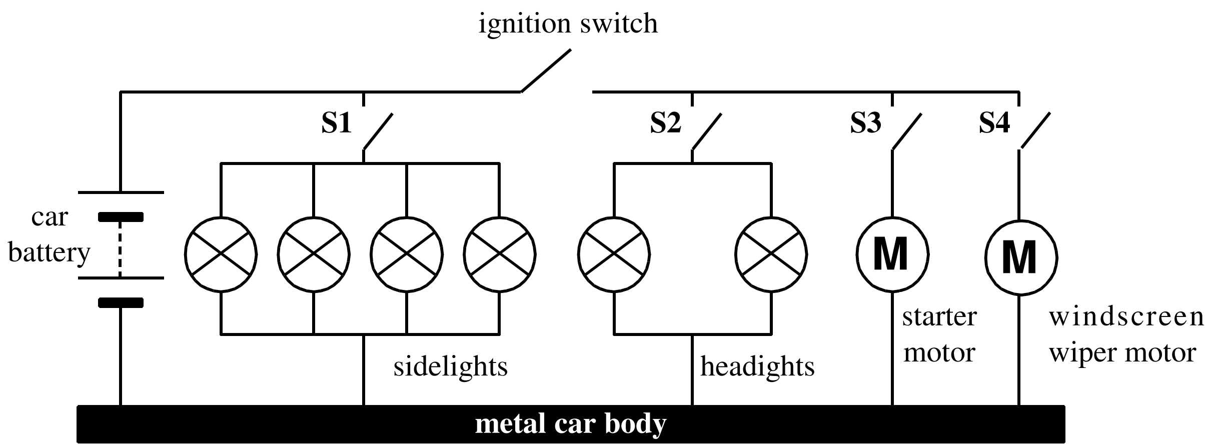

The car lights operate using electric current from the car **b** _ _ _ _ _ _.

The **n** _ _ _ _ _ _ _ terminal of the car battery is connected to the metal car body, as are connections from each light. Electric current can flow from the car battery, through the metal car body, to each light - This reduces the length of connecting **w** _ _ _ required.

The **sidelights** are switched on by closing switch ___. The **headlights** are switched on by closing switch ___.

The car lights are connected in **p** _ _ _ _ _ _ _ - If one lamp goes out, the other lamps remain **l** _ _.

**8)** The **wiring diagram** for a typical **car** is shown:




**(a)** What supplies **electrical energy** (**electricity**) to the various components? ________________________________

**(b)** Are the components connected in **series** or **parallel**? ___________

**(c)** Assuming all the **lamps** are switched **on**, explain what will happen to the remaining lamps if one lamp "blows": ________________________

________________________________________________________

________________________________________________________

**(d)** State one **advantage** of connecting all the components to the **car body**: ___________________________________

___________________________________________

**(e)** Which **switch** (or **switches**) must be **closed** to operate the:

**(i)** sidelights: ________________________________

**(ii)** headlights ________________________________

**(iii)** starter motor: _____________________________

**(iv)** windscreen wiper motor: _____________________

**(f)** Describe the **path** of the **electric current** flowing in the circuit when only **switch S1** is closed: ____________________________________

________________________________________________________

________________________________________________________

**9)** In a typical **4 door car**, a **lamp** lights inside the passenger compartment when **either** of the 4 doors is **opened**.

With the aid of a **circuit diagram**, explain how car designers make this possible:

# Notes

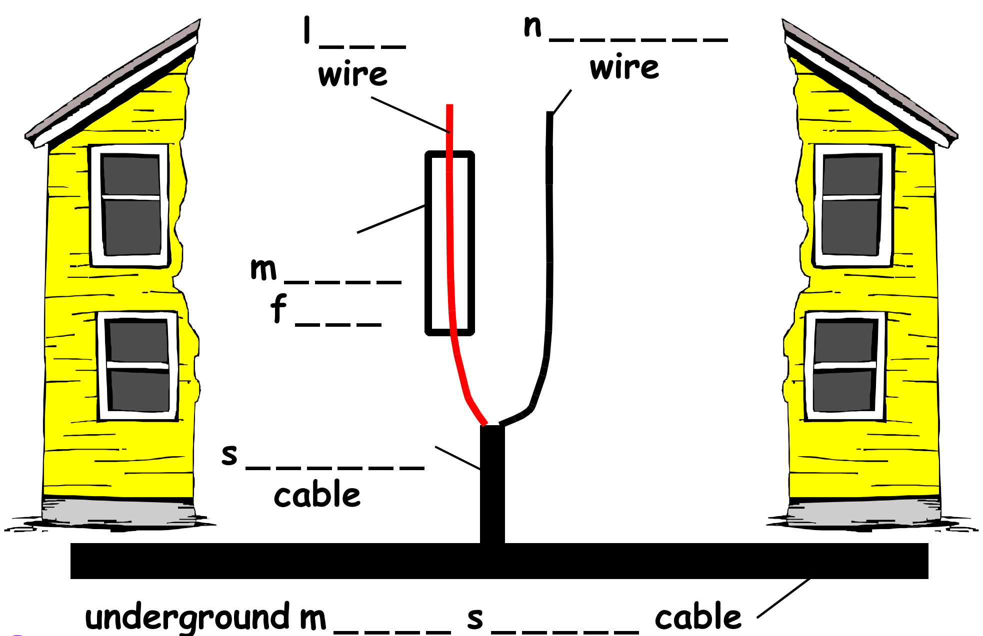
# Section 5 - Behind the Wall

## • The Mains Fuse

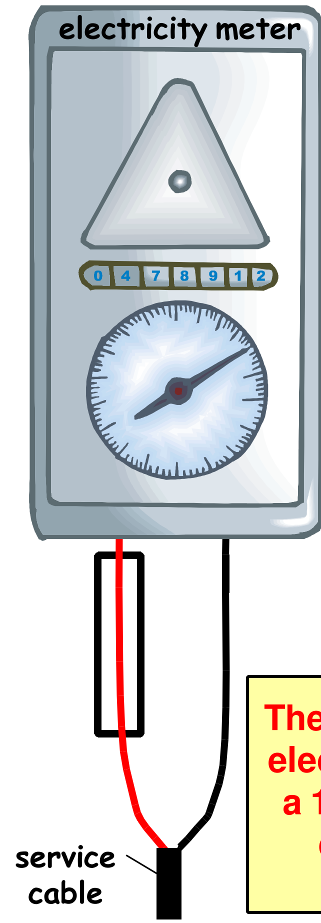
An **electricity supply company** provides **electrical energy** (**electricity**) to our homes from the **mains supply** - a network of cables which runs under every street. Homes are connected to the **mains supply** by a **service cable** which contains a **live** and a **neutral** wire.

A **mains fuse** is connected in the **live wire** of the **service cable**. The **mains fuse** protects the **mains wiring** (e.g., the **service cable** and **mains supply cable**.) If the appliances in the home draw **too large a current** from the **mains supply**, the **mains fuse** will **blow** and cut off the **current** supply, thus preventing the **mains wiring** from overheating and being damaged.

Label the diagram:




## • The Electricity Meter and the Kilowatt-hour




The **service cable** passes into an **electricity meter** which records how much **electrical energy** (**electricity**) the appliances in your home have used.

**Electrical energy** is measured in **joules** (**J**). However, **1 joule** is a very small quantity of **energy**, so the **electricity meter** uses a much larger **energy unit** - the **kilowatt-hour** (**kWh**).

The **electricity supply company** charges for the number of **kilowatt-hours** of **electrical energy** used.

**The kilowatt-hour (kWh) is the amount of electrical energy (electricity) supplied to a 1 kilowatt (1 kW) appliance when it is connected to the mains supply for 1 hour.**

1 kWh = 1 000 watts for 1 hour (3 600 seconds)
= 1 000 joules every second for 3 600 seconds
(since 1 watt = 1 joule per second)
= 1 000 joules x 3 600 = 3 600 000 joules.

**1)** Describe the **mains supply**.

**2) (a)** How are **homes** connected to the **mains supply**?

**(b)** Name the **wires** present in a **service cable**.

**3) (a)** What is connected in the **live wire** of the **service cable**?

**(b)** Describe the purpose of the **mains fuse** and explain how it works.

**4) (a)** What is the purpose of the **electricity meter** in a home?

**(b)** What **unit of energy** does an **electricity meter** use?

**(c)** Why does it not use the **joule** as the **unit of energy**?

**5) (a)** Define the **kilowatt-hour**.

**(b)** By calculation, show that:

***1 kilowatt-hour = 3 600 000 joules***

**6)** The **electricity meter readings** for four different homes, taken three months apart, are shown below.
In each case, calculate the **quantity of electricity used in kilowatt-hours** and the **cost of the electricity used** *(assuming 1 kilowatt-hour of electricity costs 12 pence).*

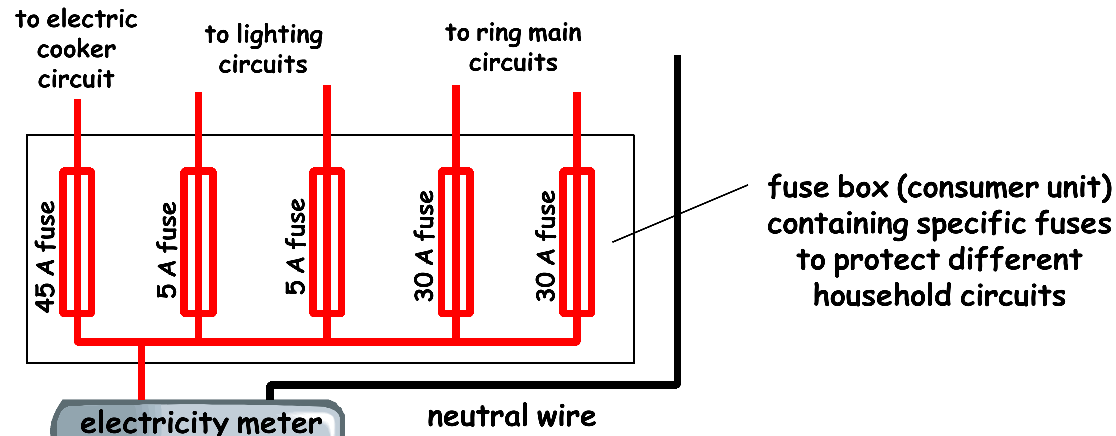
| | | |
|---|---|---|
| first meter reading | 3 5 2 7 5 | kilowatt-hours |
| second meter reading | 4 0 8 1 0 | kilowatt-hours |

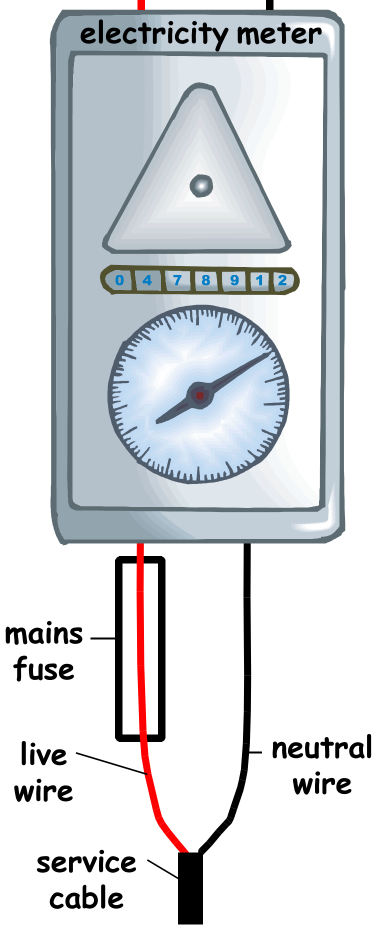
| | | |
|---|---|---|
| first meter reading | 3 7 8 6 3 | kilowatt-hours |
| second meter reading | 3 8 2 0 6 | kilowatt-hours |

| | | |
|---|---|---|
| first meter reading | 4 2 6 3 0 | kilowatt-hours |
| second meter reading | 4 8 5 2 5 | kilowatt-hours |

| | | |
|---|---|---|
| first meter reading | 5 8 9 7 0 | kilowatt-hours |
| second meter reading | 5 9 8 5 5 | kilowatt-hours |

# • The Fuse Box (Consumer Unit) - Fuses and Circuit Breakers




The **live wire** entering your home from the **service cable** passes from the **electricity meter** into a **fuse box** (which is now commonly called a **consumer unit**.)

House wiring consists of several separate circuits, each of which has a specific function - for lighting, one for the electric cooker, etc.) Some circuits require larger currents than others, so have thicker metal cables to prevent overheating.

The cable in each circuit contains a specific **fuse** to protect it from **too large a current** - Each **fuse** is located in the **fuse box** (**consumer unit**). For example, a **lighting circuit** requires a **5 amp fuse**. If the **current** in a **lighting circuit** becomes **larger than 5 amps**, the **fuse** in the **fuse box** (**consumer unit**) will **blow** and **cut off the current supply**. It is vital to fit the correct value of fuse. Fuses should never be replaced with items such as nails or paper clips! - These will not stop large electric currents flowing - They are a **fire hazard**.

In modern **fuse boxes** (**consumer units**), **fuses** have been replaced with special components called **circuit breakers**.

**A CIRCUIT BREAKER IS AN AUTOMATIC SWITCH THAT CAN BE USED INSTEAD OF A FUSE.**

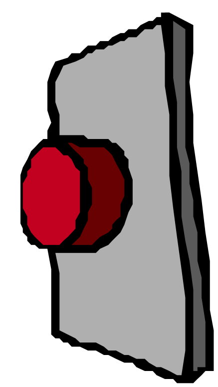
When placed in a circuit, a **circuit breaker** will **trip** (**switch off**) when the **current** becomes **too large**, thus **cutting off the current supply**.

**Circuit breakers** are often used in preference to a **fuse** because:

1) They operate faster than fuses;

2) Unlike fuses, they do not have to be replaced every time a fault occurs - They can be reset once a fault has been repaired simply by flicking a switch or pushing a button.

switch-reset circuit breaker


push button-reset circuit breaker

**7) (a)** After the **live wire** leaves your home's **electricity meter**, where does the wire go?

**(b)** What is another name for a **fuse box**?

**8) (a)** What does **house wiring** consist of?

**(b)**Why do some **house wiring circuits** have **thicker metal cable** than other circuits?

**9) (a)** What **device** is placed in each **house wiring circuit** to protect the circuit from **damage** by **too large a current**?

**(b)** Where are these **devices** located?

**(c)** Explain how these devices **protect house wiring circuits**.

**(d)** Why should a **fuse** never be replaced with such items as **nails** or **paper clips**?

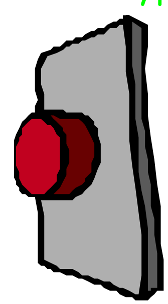
**10) (a)** In modern **fuse boxes** (**consumer units**), what **devices** have replaced **fuses**?

**(b)** What is a **circuit breaker?**

**(c)** Explain how a **circuit breaker** operates.

**(d)** Give *two reasons* why **circuit breakers** are often used in preference to **fuses**.

**(e)** Label each type of **circuit breaker** shown below:



## • Lighting Circuits

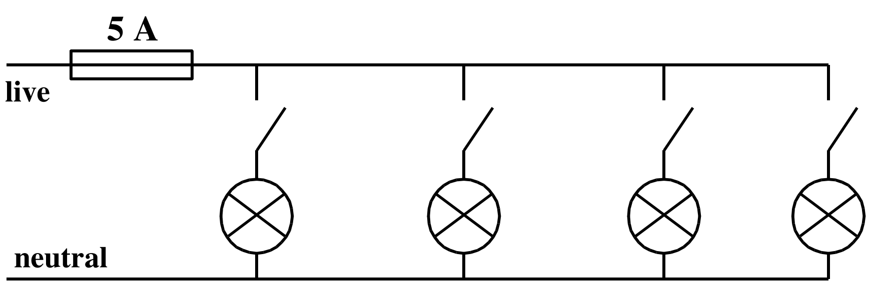
In a **lighting circuit**, the lamps are connected in **parallel** across the **live** and **neutral** wires so that each lamp has the full **230 volt supply voltage** across it.

Because the lamps are in **parallel**, each lamp can be switched on or off separately. If any lamp burns out or has a faulty connection, the other lamps can remain lit.

Most lamps are controlled by a **single switch** which must always be connected in the **live** wire.

Lamps do not require a large current to operate, so:

- a **lighting circuit** is protected by a **5 A fuse**;
- a **lighting circuit** is constructed of **thinner metal cable** than other household circuits.




11) Draw a **circuit diagram** for a house **lighting circuit**.

12) (a) Describe how the **lamps** are connected in a house **lighting circuit**.

(b) State the **voltage** across each **lamp** in a house **lighting circuit** when each **lamp** is switched on.

(c) Because each **lamp** in a house **lighting circuit** is connected in **parallel**:

(i) How are we able to switch them on and off?

(ii) What happens to the **other lamps** if **one lamp** develops a fault and cannot light?

(d) What value of **fuse/circuit breaker** protects a house **lighting circuit**?

(e) (i) State whether household **lighting circuits** require **thick** or **thin** metal cable compared to other house **wiring circuits**.

(ii) Explain your answer.

# • Ring Main Circuits

We provide most of our household appliances (kettles, televisions, etc) with **electricity** by plugging them into **electrical sockets** fitted into the walls.

The **electrical sockets** are connected in **parallel** in a special circuit called a **ring main** circuit.

When electric **current** from the **mains supply** enters a **ring main** circuit, the **current** can travel to one of the sockets by **2 routes** - **clockwise** and **anticlockwise**. **The current splits up - usually half travelling clockwise, the other half anticlockwise**.

The fuse protecting a **ring main** circuit normally has a value of **30 A**. This allows the circuit to carry enough current for several appliances to be switched on at the same time.

Since the metal cables in a **ring main** circuit carry only about **half the total current entering the circuit**, they only need to be able to carry a maximum current of **15 A** - So **thinner** (and therefore **less expensive**) cables can be used.

As well as a **live** and **neutral** wire, a **ring main** circuit contains a third wire - the **earth wire** - which is usually connected to a metal water pipe that comes up through the ground. The **earth wire** is a **safety precaution**. Electric **current** only flows through it if an appliance connected to the **ring main** circuit develops a **fault**.

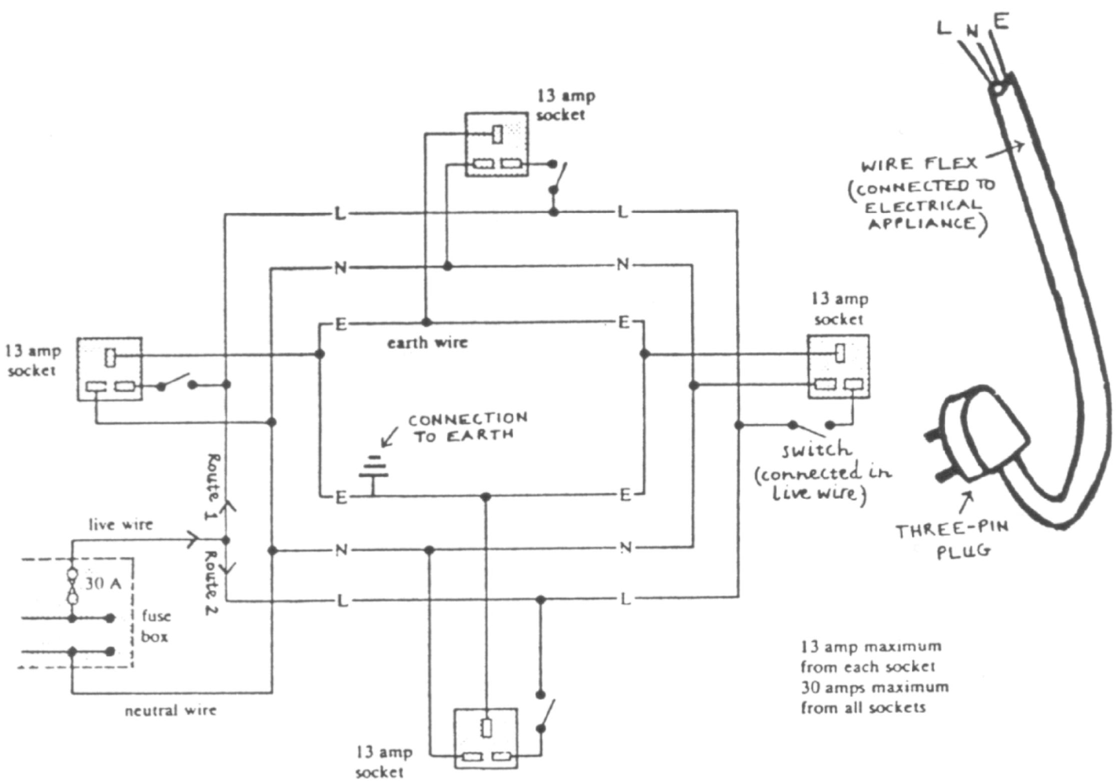
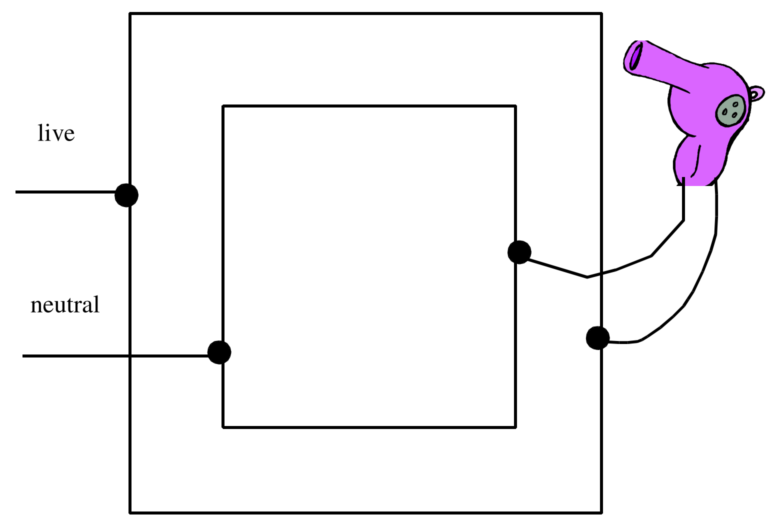



Diagram adapted. Original diagram taken from page 75 of "O-GRADE PHYSICS", by Alistair Reid, publisher: Edward Arnold, ISBN 0 7131 0435 X.

**13)** The diagram below represents a hair dryer connected to the live and neutral wires of a ring main circuit. (The earth wire has not been shown). The hair dryer requires an electric current of 5.0 A.

On the diagram, show the size and direction of the electric current as it passes through the ring main circuit.



**14) (a)** Draw the **circuit diagram** for a **ring main circuit**.

Your diagram should show:

- (for easiness) only the **live** and **neutral** wires - No **earth wire;**
- an **electric kettle** connected to the **live** and **neutral** wires.

**(b)** On your **circuit diagram**, show how an **electric current** of 8.0 A travels from the **mains supply** to the **kettle** and back to the **mains supply**.

**15)** State some of the **advantages** a **ring main circuit** has over an **ordinary parallel circuit**:

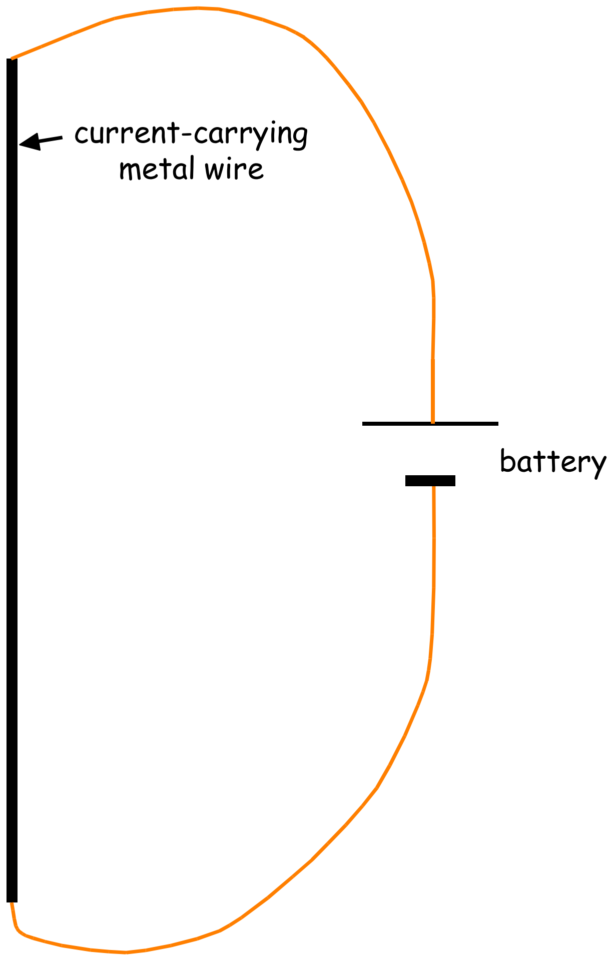
**16)** State **2 differences** between a **lighting circuit and a ring main circuit** :

# Section 6 - Movement From Electricity

## MAGNETIC FIELDS AROUND CURRENT-CARRYING METAL WIRES

When we pass an **electric current** through a **metal wire**, a **m** _ _ _ _ _ _ _ _ **f** _ _ _ _ is created around the wire.

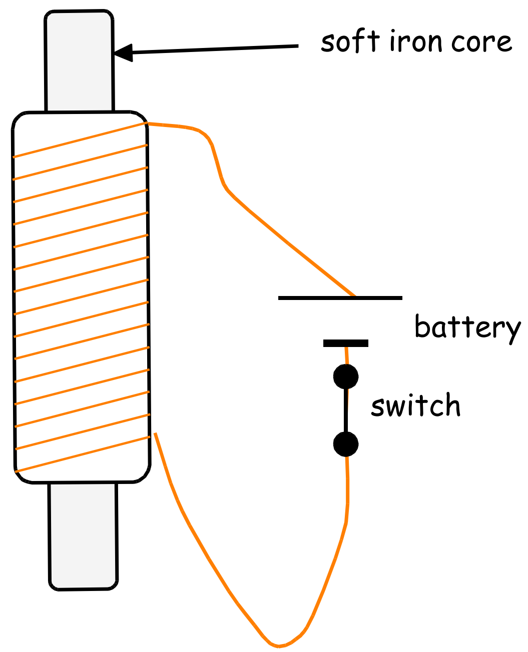
Draw the shape of the **magnetic field** surrounding this **current-carrying metal wire**:




If we wind the **metal wire** around a soft **iron core**, the **m** _ _ _ _ _ _ _ _ **f** _ _ _ _ is **s** _ _ _ _ _ _ _ _ .

This device is called a **s** _ _ _ _ _ _ _ or **e** _ _ _ _ _ _ _ _ _ _ _ _ _ .

Draw the shape of the **magnetic field** surrounding this **electromagnet**:




- How do we turn the **magnetic field** **ON**?

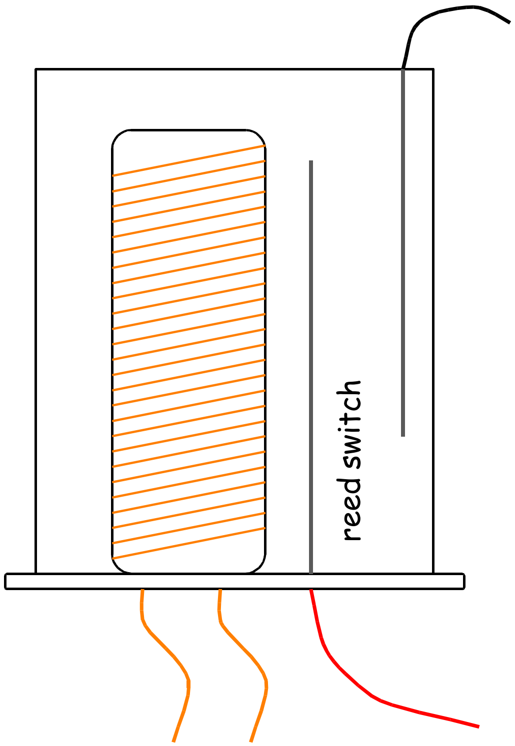
- How do we turn the **magnetic field** **OFF**?

# PRACTICAL EXAMPLES OF THE MAGNETIC EFFECT OF A CURRENT

## • Relay Switch

A **relay** is a device which uses a **low voltage** to switch on a **high voltage** circuit.

Complete the **relay** diagram below by adding **wires** and **circuit symbols**. You should show a **low voltage circuit below** switching on a **high voltage circuit to the right**:




## • Electric Bell

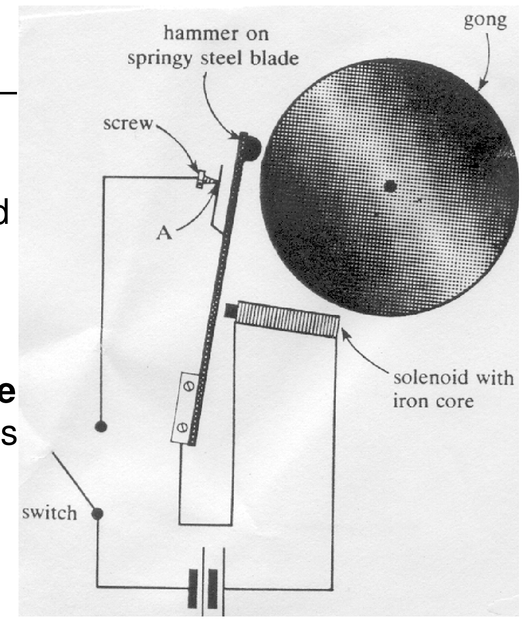



Diagram taken from page 67 of "O-GRADE PHYSICS", by Alistair Reid, publisher: Edward Arnold, ISBN 0 7131 0435 X.

**1)** When the **switch** is **c** _ _ _ _ _, an **e** _ _ _ _ _ _ _ _ **c** _ _ _ _ _ _ _ flows around the circuit.

**2)** A **m** _ _ _ _ _ _ _ _ **f** _ _ _ _ is created around the **s** _ _ _ _ _ _ _ _. The **solenoid** becomes an **e** _ _ _ _ _ _ _ _ _ _ _ _ _.

**3)** The **springy steel blade** is **a** _ _ _ _ _ _ _ _ _ towards the **solenoid**, so the **h** _ _ _ _ _ hits the **g** _ _ _.

**4)** There is now a **g** _ _ between the **screw** and **point A**, so the circuit is **b** _ _ _ _ _ and no **e** _ _ _ _ _ _ _ _ **c** _ _ _ _ _ _ _ flows.

**5)** The **m** _ _ _ _ _ _ _ _ **f** _ _ _ _ around the **s** _ _ _ _ _ _ _ _ is thereby switched **o** _ _, so the **h** _ _ _ _ _ _ is no longer **a** _ _ _ _ _ _ _ _ _ - It springs back to where it started.

**6)** The circuit is now **c** _ _ _ _ _ _ _ _ again, so the process happens again.

**7)** The process repeats continuously until the **switch** is **o** _ _ _ _ _ or the **battery** is **d** _ _ _ _ _ _ _ _ _ _ _ _.

# CURRENT-CARRYING METAL WIRE IN A MAGNETIC FIELD

When a **current-carrying metal wire** is placed in a **magnetic field**, e.g., **between opposite poles of a magnet**, the **wire** experiences a **force** which can make it **move**.

For example:

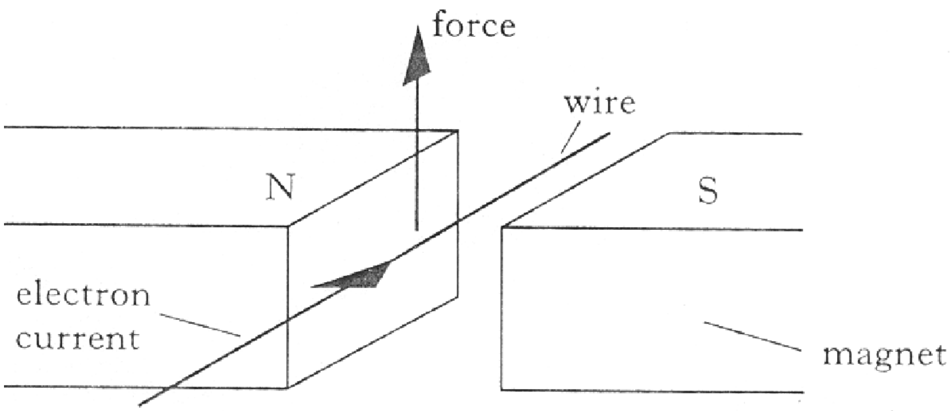


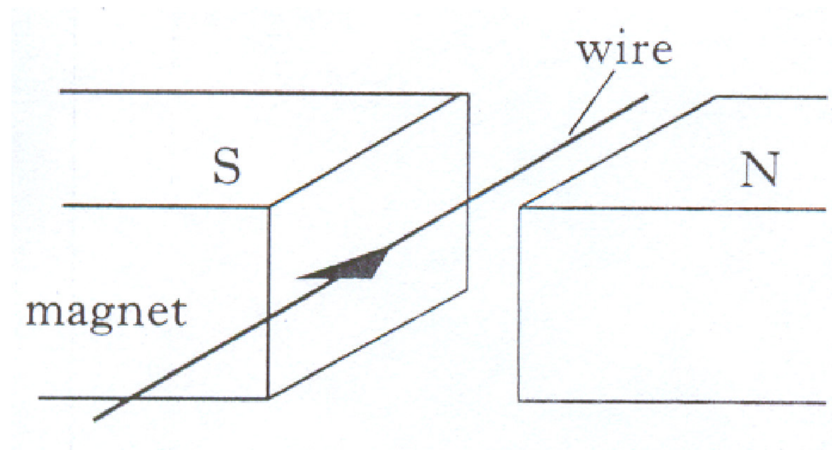

Diagram copyright SQA.

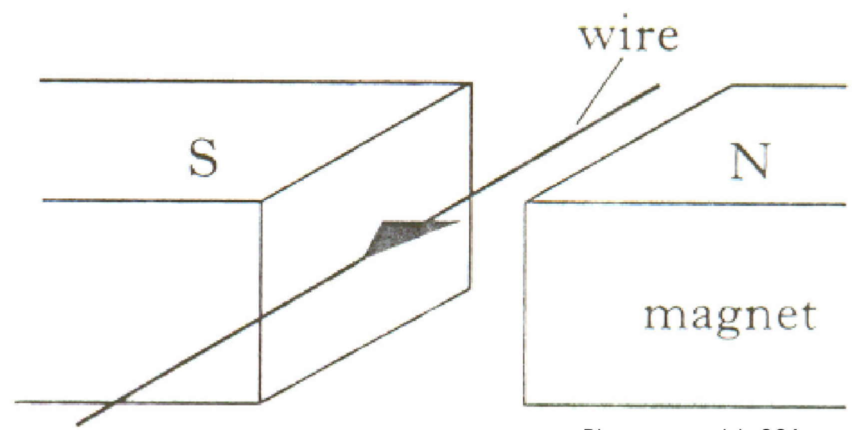
The **direction** of the **force** acting on the **current-carrying metal wire** depends upon:

**1)** The **direction** of the **e** _ _ _ _ _ _ _ _ **c** _ _ _ _ _ _ _.

**2)** The **direction** of the **m** _ _ _ _ _ _ _ _ **f** _ _ _ _.

On each diagram below, draw an **arrow** to show the ***direction*** of the **force** acting on the **current-carrying metal wire**:




Diagrams copyright SQA.

# ELECTRIC MOTORS

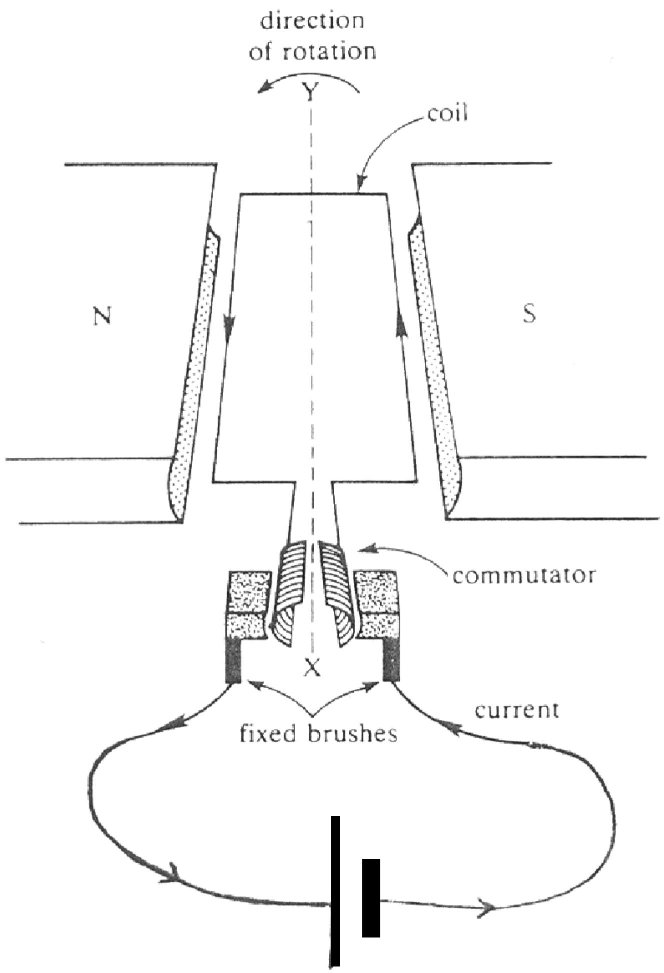



Diagram adapted. Original diagram taken from page 68 of "O-GRADE PHYSICS", by Alistair Reid, publisher: Edward Arnold, ISBN 0 7131 0435 X.

In this diagram of a simple **electric motor**, the **battery**, **brushes**, **commutator** and **metal coil** form a complete **electric circuit**.

**Electric current** flows around the circuit as follows:

From **b** _ _ _ _ _ _ _, through right-hand **b** _ _ _ _, through right-hand half of **c** _ _ _ _ _ _ _ _ _ _, along right-hand half of **metal c** _ _ _, back along left-hand half of **metal c** _ _ _, through left-hand half of **c** _ _ _ _ _ _ _ _ _ _, through left-hand **b** _ _ _ _ back into **b** _ _ _ _ _ _ _.

**E** _ _ _ _ _ _ _ _ **c** _ _ _ _ _ _ _ flows in **o** _ _ _ _ _ _ _ _ directions on either side of the **metal c** _ _ _.

Because the **current-carrying metal coil** is in a **m** _ _ _ _ _ _ _ _ **f** _ _ _ _, one side is forced **u** _ while the other side is forced **d** _ _ _. These forces make the **metal c** _ _ _ rotate about the axis XY (anti-clockwise in this case) until it reaches a **vertical** ( **u** _ and **d** _ _ _ ) **position.**

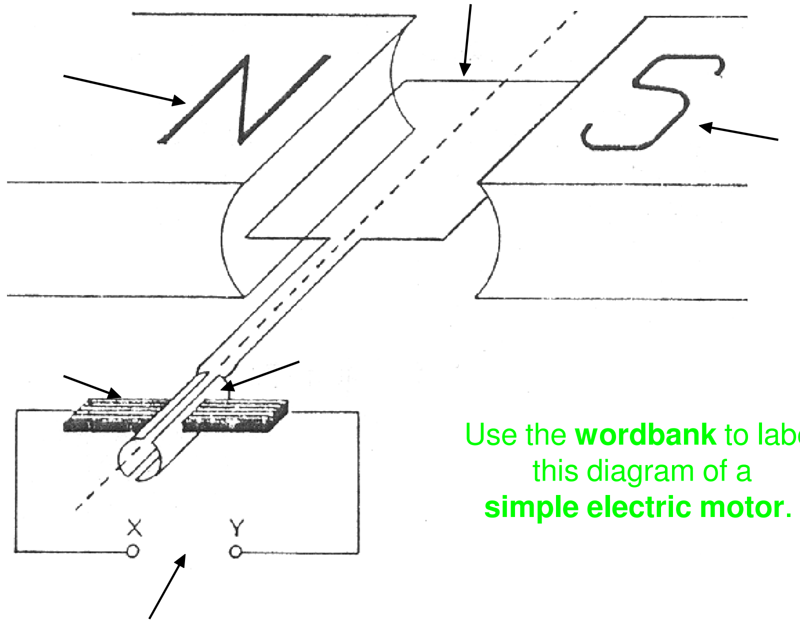
When the **metal c** _ _ _ is vertical, the **g** _ _ _ between the 2 halves of the **c** _ _ _ _ _ _ _ _ _ _ are lined up with the **b** _ _ _ _ _ _ _, so no **e** _ _ _ _ _ _ _ _ **c** _ _ _ _ _ _ _ flows through the **metal c** _ _ _.

However, the existing motion of the **metal c** _ _ _ is sufficient to **"tip it over the top"** - The left-hand-side becomes the right-hand-side and vice versa.

**E** _ _ _ _ _ _ _ _ **c** _ _ _ _ _ _ _ can now flow through the **metal c** _ _ _ again, as previously - So it continues to rotate.

- Explain the purpose of the **brushes**:

- Explain the purpose of the **commutator**:






Use the **wordbank** to label this diagram of a **simple electric motor**.

- brush
- commutator
- d.c. power supply (or battery)
- North magnetic pole
- South magnetic pole
- rotating metal coil

What **2** things could you change to make the motor turn in the **opposite direction**?

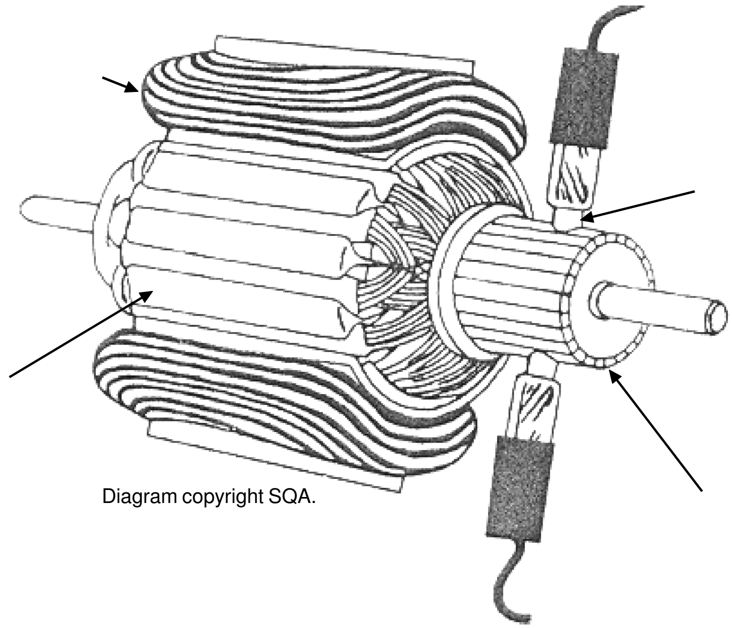
1) ______________________________________________

______________________________________________

2) ______________________________________________

______________________________________________

A **commercial electric motor**, like those used in **washing machines**, is shown below:





In **commercial motors**:

**1)** The **brushes** are made of **carbon** (**graphite**).

**2)** The **commutator** is **multi-sectional** - Made up of many sections.

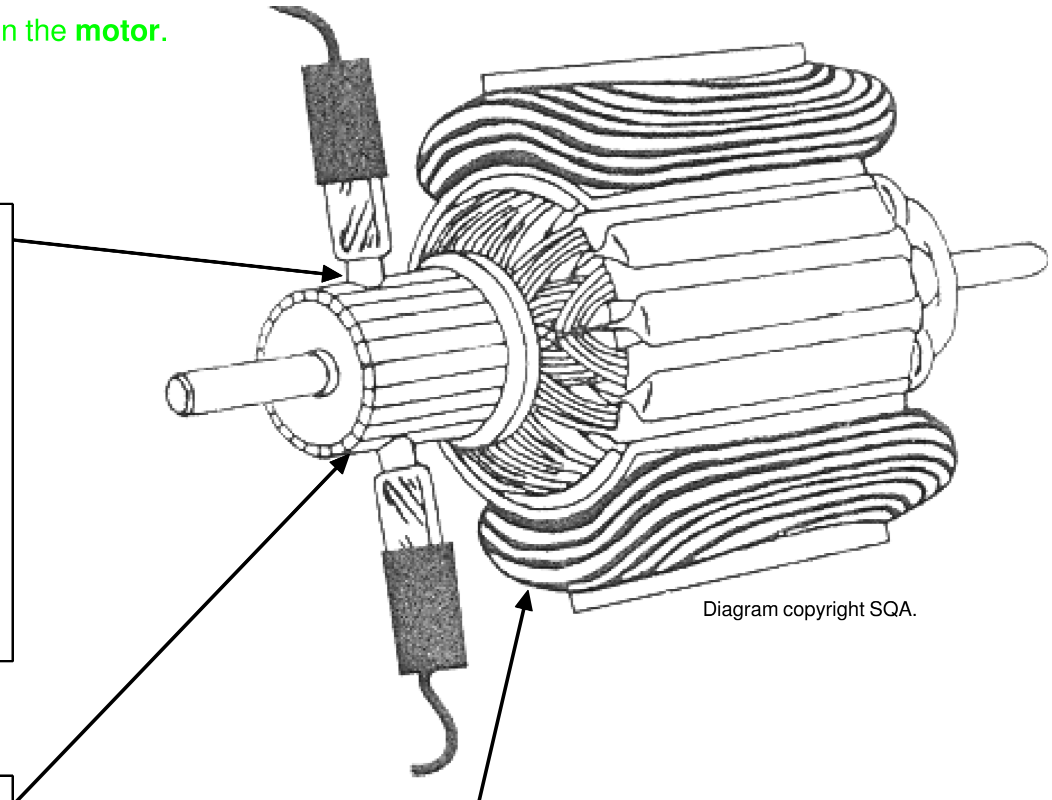
**3) Field coils** (**electromagnets**) are used instead of **bar magnets**.

Use this **wordbank** to label the diagram of the **commercial electric motor**.

- carbon (graphite) brush
- field coil (electromagnet)
- multi-section commutator
- rotating coil

This is a diagram of a **commercial electric motor**.

Name the **3** parts indicated and state the reasons for their use in the **motor**.




**Name of part:** ____________________

**Reason for use:** ____________________

____________________

____________________

**Name of part:** ____________________

**Reason for use:** ____________________

____________________

____________________

**Name of part:** ____________________

**Reason for use:** ____________________

____________________

____________________

# Section 1 - From The Wall Socket

## At the end of this section, you should be able to:

### General Level

☐ State what type of energy is supplied from batteries and the mains supply.

☐ Describe the energy changes in some household appliances.

☐ State the power rating of some household appliances.

☐ State the colour of the live, neutral and earth wires in a flex.

☐ Choose the correct flex for an appliance, if you are given the appliance's power rating.

☐ State which wires in a flex should be connected to the terminals of a three-pin plug, extension socket and lampholder.

☐ Explain why there is a fuse in a three-pin plug.

☐ Choose the correct fuse for the three-pin plug connected to an appliance.

☐ State that the human body conducts electricity and describe how water affects its conductivity.

☐ State the purpose of an earth wire.

☐ State what type of appliance does not need an earth wire.

☐ Draw the double insulation symbol.

☐ Describe some dangerous situations involving electricity and explain the dangers involved.

### Credit Level

☐ Explain how an earth wire works.

☐ Explain why fuses and switches must always be connected in the live wire.

# Section 2
# - Direct and Alternating Current

## At the end of this section, you should be able to:

### General Level

☐ Describe what an electric current is.

☐ Explain why electric charges can move through a conductor.

☐ State the units of current and voltage.

☐ State what type of electric current is supplied from batteries and from the mains supply.

☐ Explain the terms d.c. and a.c.

☐ State the frequency of the mains supply.

☐ State the voltage of the mains supply.

☐ Draw circuit symbols for a cell (battery), fuse, lamp, resistor, variable resistor, capacitor and diode.

### Credit Level

☐ Describe how the supply voltage affects the amount of energy which is given to the charges flowing in an electric circuit.

☐ State the unit of charge.

☐ Carry out calculations involving charge, current and time.

☐ State how the peak voltage of an a.c. supply compares with the voltage value usually quoted for it.

# Section 3 - Resistance

## At the end of this section, you should be able to:

### General Level

- [ ] Describe what happens to a metal wire when a current flows through it.
- [ ] Name 3 electrical appliances used in the home which turn electrical energy into heat energy.
- [ ] State the unit of resistance.
- [ ] State how changes in resistance affect the size of current flowing in an electric circuit.
- [ ] Give 2 uses for variable resistors.
- [ ] Use ammeters and voltmeters and draw circuit diagrams to show their correct position in electric circuits.
- [ ] Carry out calculations involving resistance, voltage and current.
- [ ] State the units of energy and power.
- [ ] Carry out calculations involving power, energy and time.
- [ ] Carry out calculations involving power, voltage and current.
- [ ] Describe the effect of energy changes in filament lamps, fluorescent lamps and electrical heaters.

### Credit Level

- [ ] State what happens to the quantity V/I when the current changes in a resistor at constant temperature.
- [ ] Carry out calculations involving power, current and resistance.
- [ ] Explain why electrical power can be calculated using either $P = VI$ or $P = I^2R$.

# Section 4 - Useful Circuits

## At the end of this section, you should be able to:

### GENERAL LEVEL

- ☐ Give the rules for: **currents** in **series circuits**;
  **currents** in **parallel circuits**;
  **voltages** in **series circuits**;
  **voltages** in **parallel circuits**.
- ☐ Give an example of **switches** in **series** in the **home**.
- ☐ Explain why connecting **too many appliances** to **one socket** could be **dangerous**.
- ☐ Describe how to make and use a **continuity tester**.
- ☐ Test for **open** and **short circuits**.

### CREDIT LEVEL

- ☐ Calculate the **total resistance** of a number of **resistors** connected in **series** and **parallel**.
- ☐ Draw and explain **circuit diagrams** for **car wiring**.

# Section 5 - Behind the Wall

## At the end of this section, you should be able to:

### General Level

- ☐ State that household wiring connects appliances in **parallel**.
- ☐ Explain the purpose of the **mains fuse**.
- ☐ State what a **circuit breaker** is used for.
- ☐ State what is measured in **kilowatt-hours**.

### Credit Level

- ☐ Explain the relationship between **kilowatt-hours** and **joules**.
- ☐ State why a **circuit breaker** might be better than a **fuse**.
- ☐ Use a **circuit diagram** to describe a **ring main** circuit.
- ☐ Describe some **advantages** of a **ring main** circuit.
- ☐ State 2 differences between a **lighting circuit** and a **ring main** circuit.

# Section 6
# - Movement From Electricity

## At the end of this section, you should be able to:

### General Level

- [ ] Describe the **magnetic effect** of an **electric current**.
- [ ] Give 2 examples of devices which use the **magnetic effect**.
- [ ] Describe what happens when a **current-carrying wire** is placed in a **magnetic field**.
- [ ] Identify the parts of a **motor**.

### Credit Level

- [ ] State what affects the direction of the force on a **current-carrying wire**.
- [ ] Explain how a simple electric motor works.
- [ ] Explain the use of the main parts of a **commercial electric motor**.