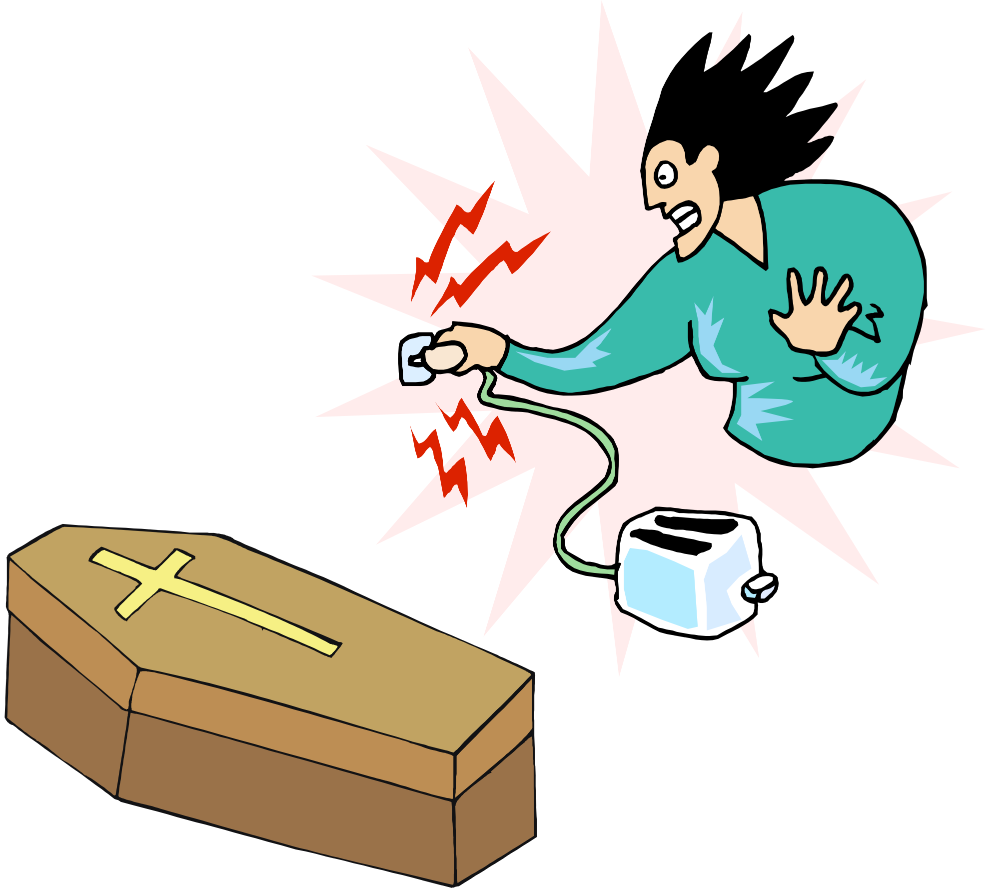
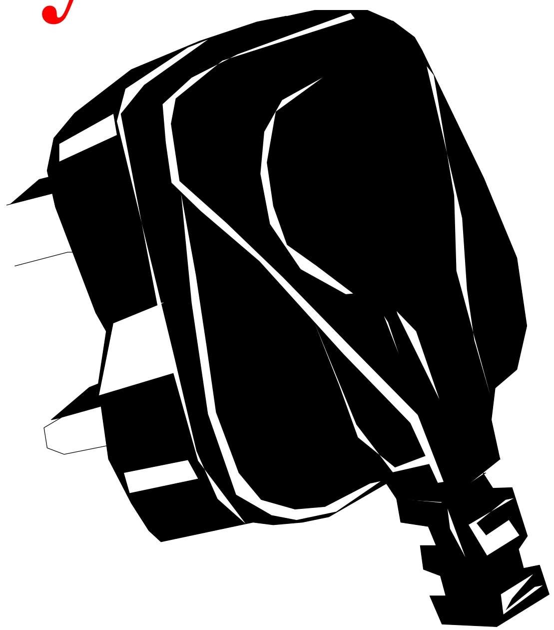
Standard Grade Physics

Supplying Electricity





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

Supplying Electricity Learning Outcomes

Blue = general **red = credit**

	Section 1 - Source to Consumer				
1	identify circumstances in which a voltage will be induced in a conductor				
2	identify on a given diagram the main parts of an a.c. generator				
3	state that transformers are used to change the magnitude of an a.c. voltage				
4	describe the structure of a transformer				
5	carry out calculations involving the relationship between primary voltage, secondary voltage, number of turns on primary coil and number of turns on secondary coil				
6	state that high voltages are used in the transmission of electricity to reduce power loss				
7	describe qualitatively the transmission of electrical energy by the National Grid system				
8	explain from a diagram how an a.c. generator works				
9	state the main differences between a full-size generator and a simple working model				
10	10 state the factors which affect the size of the induced voltage, ie field strength, number of turns on the coil, relative speed of magnet and coil				
11	11 explain why a transformer is not 100% efficient				
12	12 carry out calculations on transformers involving input and output voltages, turns ratio, primary and secondary currents and efficiency				
13	13 carry out calculations involving power loss in transmission lines.				

	Section 2 - Behind the Wall				
1	state that household wiring connects appliances in parallel				
2	state that mains fuses protect the mains wiring				
3	state that a circuit breaker is an automatic switch which can be used instead of a fuse				
4	state that kWh is a unit of energy				
5	describe, using a circuit diagram, a ring circuit				
6	state advantages of using the ring circuit as a preferred method of wiring in parallel				
7	give two differences between the lighting circuit and the power ring circuit				
8	state one reason why a circuit breaker may be used in preference to a fuse				
9	explain the relationship between kilowatt-hours and joules.				

Supplying Electricity Learning Outcomes

Blue = general **red = credit**

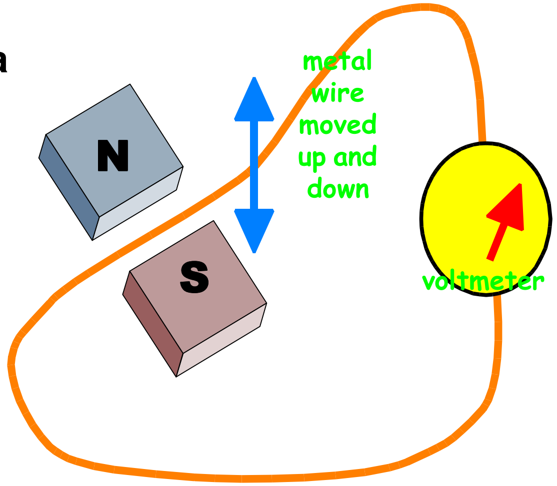
	Section 3 - From the Wall Socket				
1	describe the mains supply/battery as a supply of electrical energy and to describe the main energy transformations occurring in household appliances				
2	state approximate power ratings of different household appliances				
3	select an appropriate flex given the power rating of an appliance				
4	state that fuses in plugs are intended to protect flexes				
5	select an appropriate fuse given the power rating of an appliance				
6	identify the live, neutral and earth wire from the colour of their insulation				
7	state to which pin each wire must be connected for plug, lampholder and extension socket				
8	state that the human body is a conductor of electricity and that moisture increases its ability to conduct				
9	state that the earth wire is a safety device				
10	state that electrical appliances which have the double insulation symbol do not require an earth wire				
11	draw the double insulation symbol				
12	explain why situations involving electricity could result in accidents (to include proximity of water, wrong fuses, wrong, frayed or badly connected flexes, short circuits and misuse of multiway adaptors)				
13	explain how the earth wire acts as a safety device.				
14	explain why fuses and switches must be in the live lead.				

Section 1: SOURCE to CONSUMER

• Inducing a Voltage in a Conductor

We can induce (make) a voltage in a metal wire conductor by:

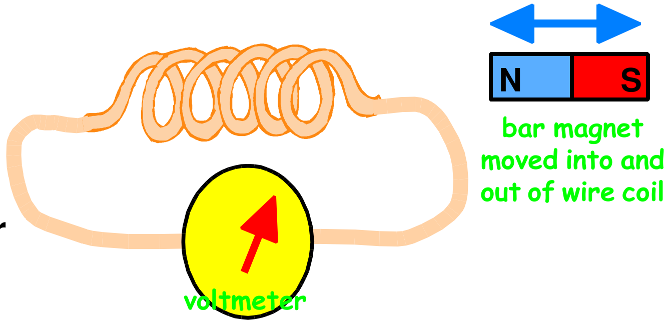
(a) Moving a metal wire ___ or _____ between the _________ poles of a bar magnet.



When the metal wire moves up, the voltmeter kicks in one direction.

When the metal wire moves down, the voltmeter kicks in the ___________ direction.

(b) Winding the metal wire into a _______ then moving a bar magnet ____ or ____ ___ the coil.



When the bar magnet moves into the wire coil, the voltmeter kicks in one direction.

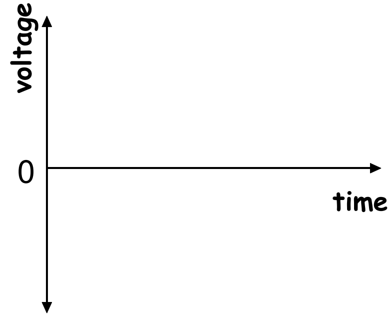
When the bar magnet moves out of the wire coil, the voltmeter kicks in the ___________ direction.

To make the induced voltage larger, we can:

- **use a s _ _ _ _ _ _ _ _ magnet;**
- **move the wire or magnet f _ _ _ _ _;**
- **wind m _ _ _ turns of wire on the coil.**

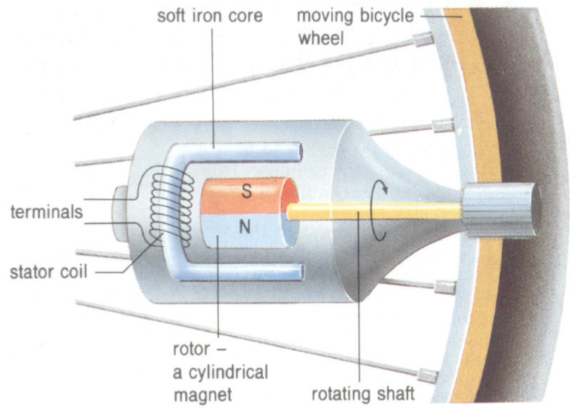
The voltage produced by <u>continuous</u> up and down or in and out movement is <u>alternating</u> - It produces alternating current (a.c.)

Draw the shape of an a.c. voltage.



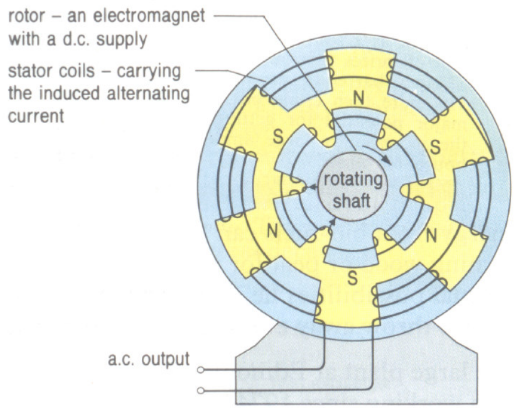
In a simple a.c. generator, like the dynamo on a bicycle, a bar m _ _ _ _ _ is turned next to a metal wire c _ _ _ (called a s _ _ _ _ _ c _ _ _) which is wound round a soft iron c _ _ _.

This i _ _ _ _ _ _ (makes) a v _ _ _ _ _ _ in the s _ _ _ _ _ c _ _ _.



In full size generators, like those in a power station:

- the bar magnet is replaced by several e _ _ _ _ _ _ _ _ _ _ _ _ _.
- There is more than one s _ _ _ _ _ c _ _ _, so the a.c. produced is s _ _ _ _ _ _ _.

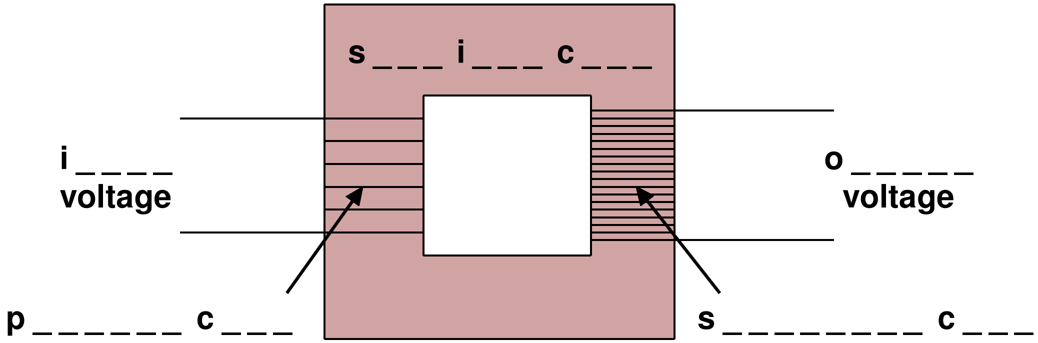


Both diagrams taken from page 170 of "PHYSICS THROUGH APPLICATIONS", edited by Jim Jardine, publisher: Oxford University Press, ISBN 0 19 914280 7.

• Transformers

Transformers are used to change the size of an
_._. v _ _ _ _ _ _ _ .
They do not work with d _ _ _ _ _ _ c _ _ _ _ _ _ _ (_._.).
These devices contain transformers:

Label the parts of this transformer:

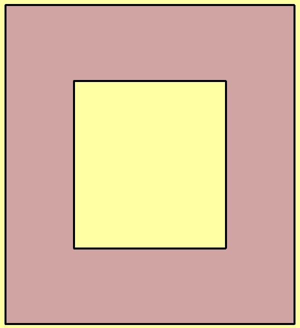


• Step-Up Transformers

These have <u>more</u> turns of wire in their s _ _ _ _ _ _ _ _ _ c _ _ _ than they have in their p _ _ _ _ _ _ _ c _ _ _ .

They i _ _ _ _ _ _ _ _ the size of the a.c. v _ _ _ _ _ _ _ applied across the p _ _ _ _ _ _ _ c _ _ _ . (The output voltage is l _ _ _ _ _ than the input voltage).

Draw the primary and secondary coils on this transformer to show which has more turns:

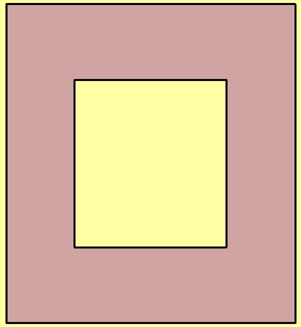


• Step-Down Transformers

These have <u>less</u> turns of wire in their s _ _ _ _ _ _ _ _ _ c _ _ _ than they have in their p _ _ _ _ _ _ _ c _ _ _ .

They d _ _ _ _ _ _ _ _ the size of the a.c. v _ _ _ _ _ _ _ applied across the p _ _ _ _ _ _ _ c _ _ _ . (The output voltage is s _ _ _ _ _ _ _ than the input voltage).

Draw the primary and secondary coils on this transformer to show which has more turns:



This formula applies to transformers. It relates the primary and secondary voltages to the number of turns of wire in the primary and secondary coils:

number of turns of wire in p _ _ _ _ _ _ _ c _ _ _

voltage across p _ _ _ _ _ _ _ c _ _ _

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

number of turns of wire in s _ _ _ _ _ _ _ _ _ c _ _ _

voltage across s _ _ _ _ _ _ _ _ _ c _ _ _

$\frac{N_p}{N_s}$ is known as the <u>turns ratio</u> of the transformer.

21) Use the transformer formula to calculate the missing quantity in each case.
Say whether the transformer is a <u>step-up</u> or <u>step-down</u> transformer:

N_p = 100 turns, N_s = 200 turns V_p = 2 V a.c., V_s = ?	N_p = 1 000 turns, N_s = 250 turns V_p = 20 V a.c., V_s = ?	N_p = 100 turns, N_s = 500 turns V_p = ?, V_s = 10 V a.c.	N_p = 10 000 turns, N_s = 500 turns V_p = ?, V_s = 6 V a.c.
N_p = ?, N_s = 2 000 turns V_p = 2.5 V a.c., V_s = 50 V a.c.	N_p = ?, N_s = 3 000 turns V_p = 2.4 V a.c., V_s = 0.6 V a.c.	N_p = 1 500 turns?, N_s = ? V_p = 1.2 V a.c., V_s = 24 V a.c.	N_p = 10 000 turns?, N_s = ? V_p = 23 V a.c., V_s = 2.3 V a.c.

This formula also applies to transformers. It relates the voltage and current for the primary coil to the voltage and current for the secondary coil.

Input power = Output power

voltage across p _ _ _ _ _ _ c _ _ _ (v)

voltage across s _ _ _ _ _ _ _ _ c _ _ _ (v)

$$V_p I_p = V_s I_s$$

current in p _ _ _ _ _ _ c _ _ _ (A)

current in s _ _ _ _ _ _ _ _ c _ _ _ (A)

22) Use the above formula to calculate the missing quantity in each case.
Say whether the transformer is a step-up or step-down transformer:

V_p = 5 V a.c., V_s = 15 V a.c.
I_p = ?, I_s = 4 A a.c.

V_p = 24 V a.c., V_s = 2 V a.c.
I_p = ?, I_s = 30 A a.c.

V_p = 1.2 V a.c., V_s = ?
I_p = 9 A a.c., I_s = 1.5 A a.c.

V_p = 125 V a.c., V_s = ?
I_p = 1.6 A a.c., I_s = 5 A a.c.

V_p = 3 V a.c., V_s = 15 V a.c.
I_p = 10 A a.c., I_s = ?

V_p = 12 V a.c., V_s = 3 V a.c.
I_p = 1.5 A a.c., I_s = ?

V_p = ?, V_s = 230 V a.c.
I_p = 7.5 A a.c., I_s = 1.5 A a.c.

V_p = ?, V_s = 24 V a.c.
I_p = 4.5 A a.c., I_s = 1.5 A a.c.

No transformer is 100% efficient - Some of the electrical energy supplied to the primary coil is always lost to the surroundings. This is due to:

- H _ _ _ loss in the coils - When current passes through the primary and secondary coils, some electrical energy is changed to h _ _ _ energy which escapes into the air.
- H _ _ _ _ _ _ _ _ _ loss - The transformer core is constantly being magnetised and demagnetised. This converts some of the electrical energy to heat.
- E _ _ _ c _ _ _ _ _ _ _ are created in the transformer core.

This formula is used to calculate the efficiency of a transformer (or any other machine/device):

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}} \times 100\ \%$$

23) Use the above formula to calculate the efficiency of these transformers:

Power output = 30 W
Power input = 40 W

Power output = 200 W
Power input = 250 W

Power output = 720 W
Power input = 1 000 W

Power output = 1 300 W
Power input = 2 000 W

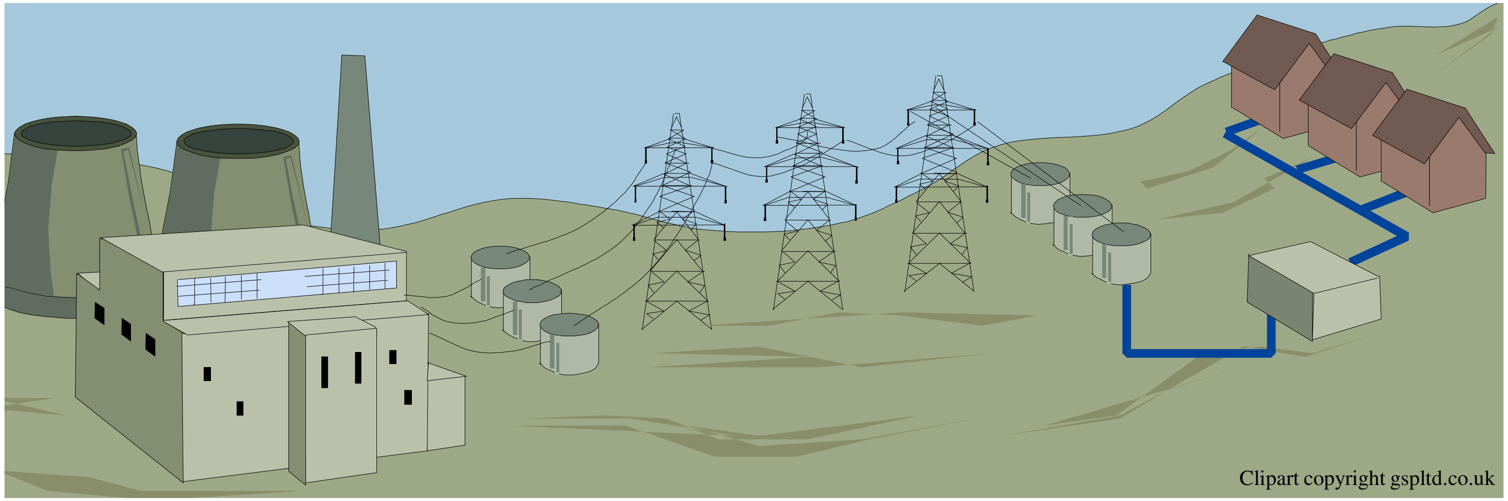
V_p = 100 V a.c., I_p = 2 A a.c., V_s = 60 V a.c., I_s = 3 A a.c.

V_p = 25 V a.c., I_p = 5 A a.c., V_s = 150 V a.c., I_s = 0.5 A a.c.

The National Grid - Sending Electricity Around The Country

Use the words in the box to label the diagram which shows how electricity is sent from a power station to your home:

homes
overhead power lines
power station
pylons
step-down transformers
step-up transformers
substation
underground power lines



1) Electricity from a power station is sent to a _ _ _ _ _ - _ _ transformer which makes the v _ _ _ _ _ _ _ larger (typically _________ V) but makes the c _ _ _ _ _ _ _ smaller.

2) The electricity is sent around the country through o _ _ _ _ _ _ _ _ p _ _ _ _ l _ _ _ _ which are held up by p _ _ _ _ _ - The connection of pylons across the country is called the N _ _ _ _ _ _ _ _ G _ _ _.

3) The electricity arrives at a _ _ _ _ _ - _ _ _ _ transformer which makes the v _ _ _ _ _ _ _ smaller (___ V for our homes, but _________V for factories). This makes the c _ _ _ _ _ _ _ larger.

4) The electricity is passed to our homes via a s _ _ _ _ _ _ _ _ _ _ through u _ _ _ _ _ _ _ _ _ _ _ p _ _ _ _ l _ _ _ _.

Power is lost when electricity passes through overhead power lines.

$$P = I^2 R$$

P: power lost in overhead power lines (w)

I: size of current passing through overhead power lines (A)

R: resistance of overhead power lines (Ω)

By using a **step-up transformer** to make the voltage higher but the current smaller before it is passed through the overhead power lines, less power is lost in the overhead lines.

24) Use the "power formula" to calculate the power lost in each of these overhead power lines:

Current = 100 A Resistance of power line = 20 Ω	Current = 10 A Resistance of power line = 20 Ω
Current = 50 A Resistance of power line = 5 Ω	Current = 10 A Resistance of power line = 5 Ω
Current = 250 A Resistance of power line = 10 Ω	Current = 25 A Resistance of power line = 10 Ω
Current = 20 A Resistance of power line = 30 Ω	Current = 5 A Resistance of power line = 30 Ω

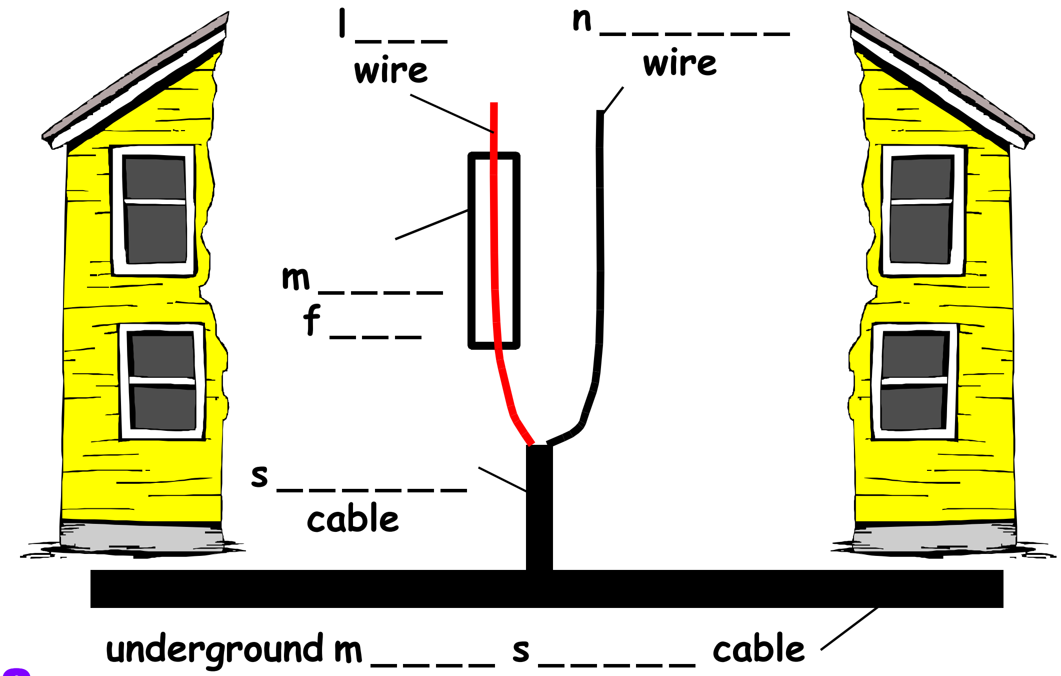
SECTION2 BEHIND THE WALL

• The Mains Fuse

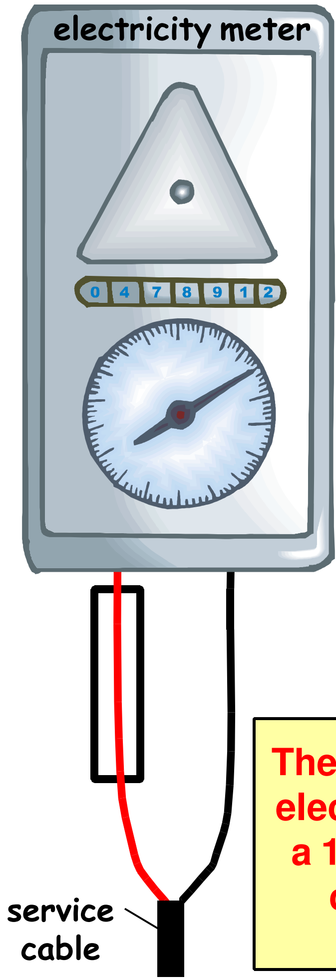
An **electricity supply company** provides **electrical energy** (**electricity**) to our homes from the **mains supply** - a network of cables which runs under every street. Homes are connected to the **mains supply** by a **service cable** which contains a **live** and a **neutral** wire.

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 8 pence).*

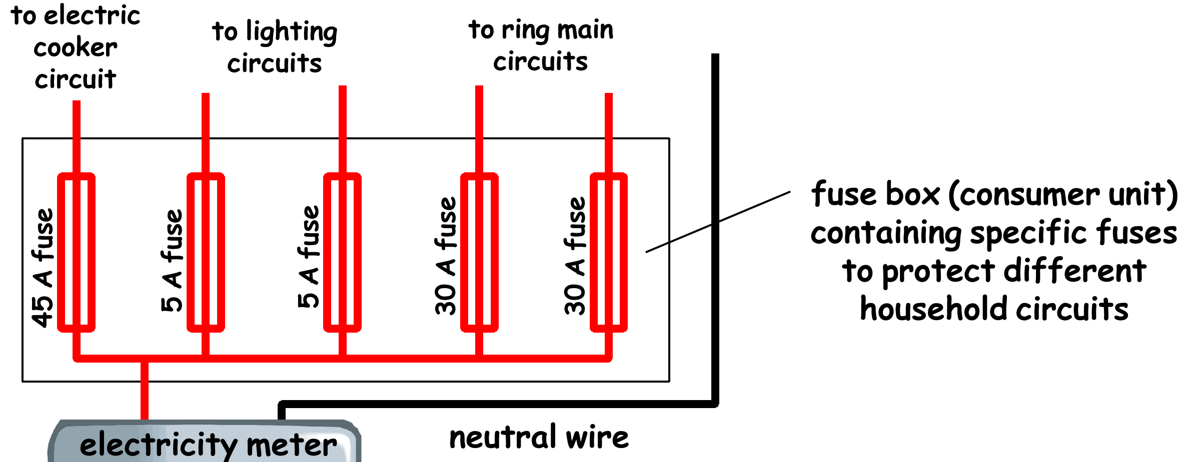
first meter reading	3	5	2	7	5	kilowatt-hours
second meter reading	4	0	8	1	0	kilowatt-hours

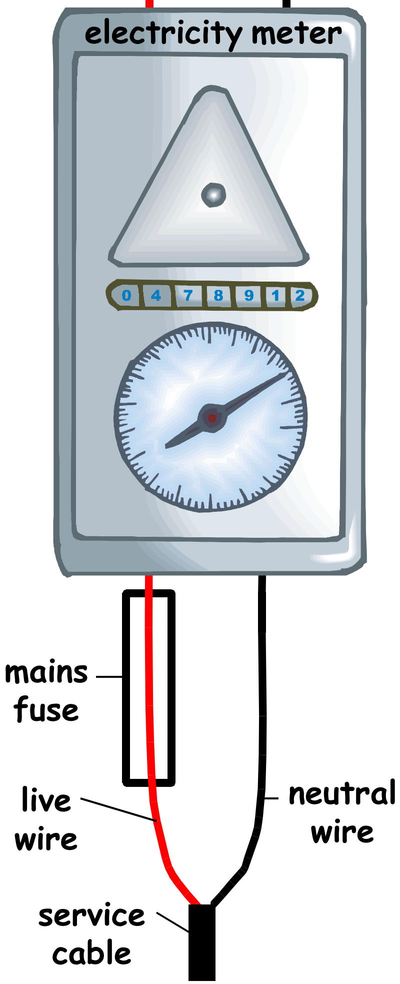
first meter reading	3	7	8	6	3	kilowatt-hours
second meter reading	3	8	2	0	6	kilowatt-hours

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.

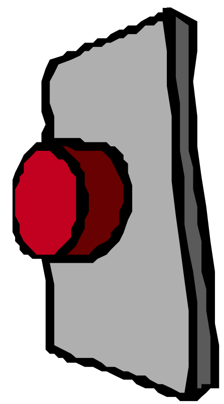
When placed in a circuit, a **circuit breaker** will **trip** (**switch off**) when the **current** becomes **too large**, thus **cutting off the current supply**.

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**?

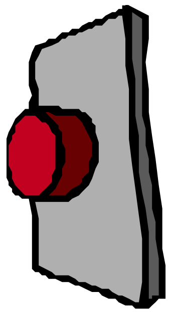
10) (a) In modern **fuse boxes** (**consumer units**), what **devices** have replaced **fuses**?

(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

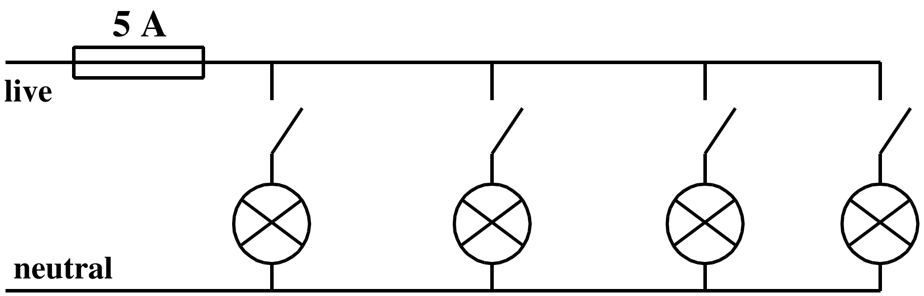
In a **lighting circuit**, the lamps are connected in **parallel** across the **live** and **neutral** wires so that each lamp has the full **230 volt supply voltage** across it.

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**.

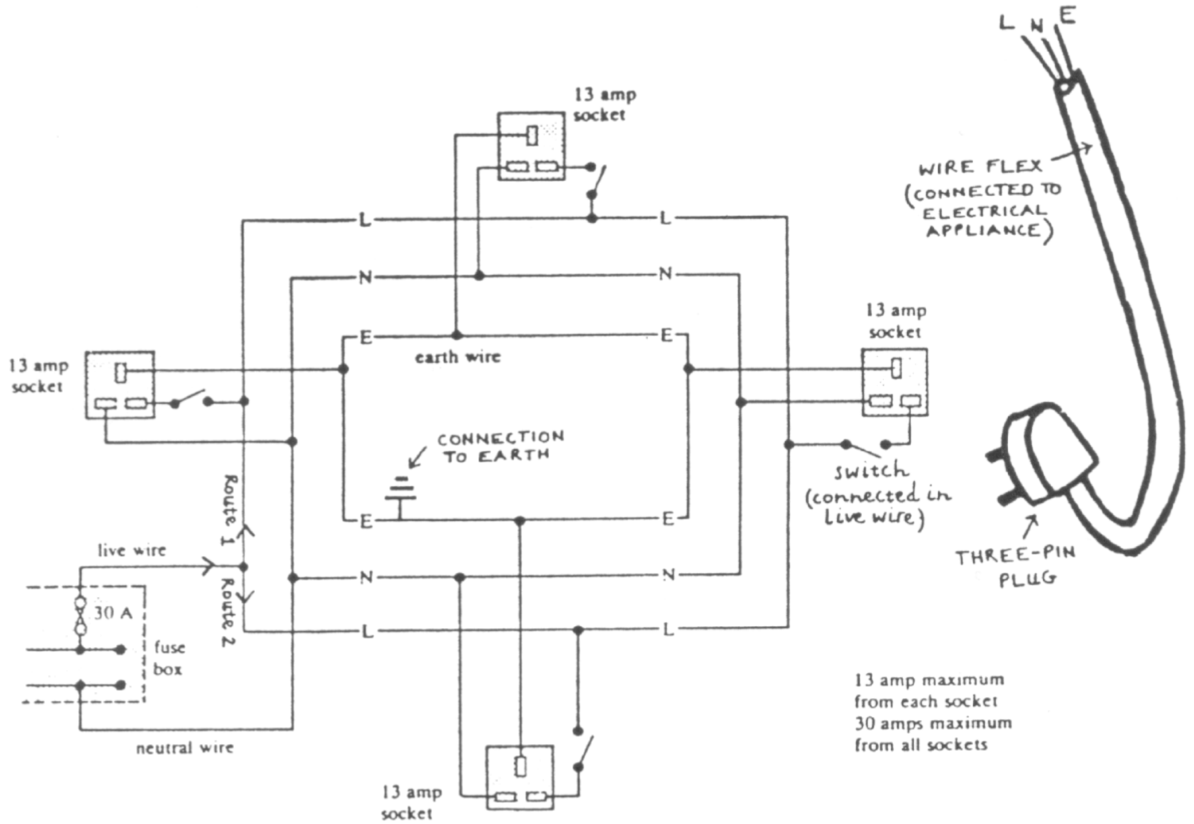
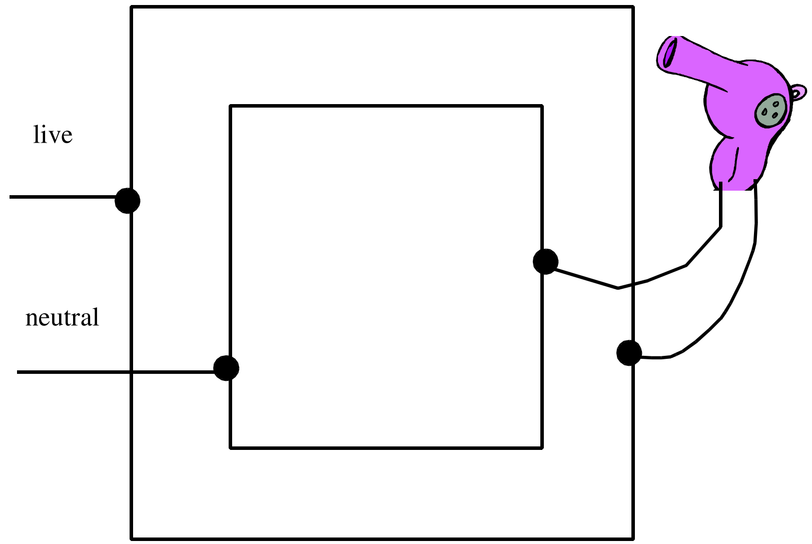


Diagram adapted. Original diagram taken from page 75 of "O-GRADE PHYSICS", by Alistair Reid, publisher: Edward Arnold, ISBN 0 7131 0435 X.

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** :

3. ELECTRICITY - FROM THE WALL SOCKET

ELECTRICITY is the common name for ELECTRICAL ENERGY.

(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:

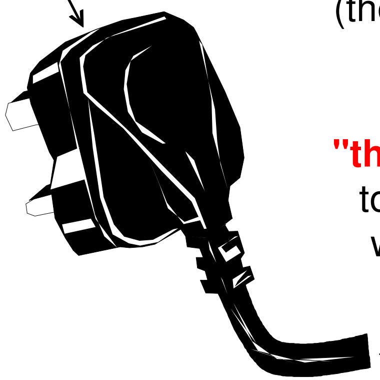
(i) batteries

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____

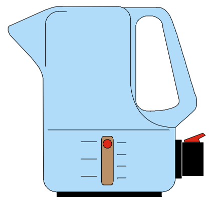
Most electrical appliances can be connected to the **m** _ _ _ _ **s** _ _ _ _ _ _ (the electricity sockets located in almost every room of our homes.)

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.)

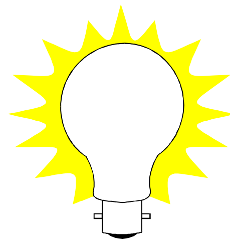
(b) Household Electrical Appliances - Energy Changers

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

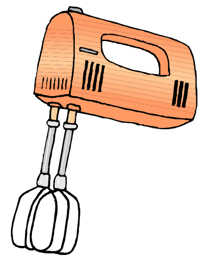
Write down the main <u>energy change(s)</u> for each of these electrical appliances:



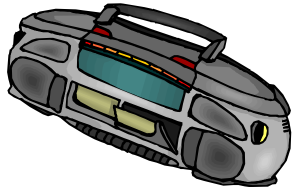
- kettle



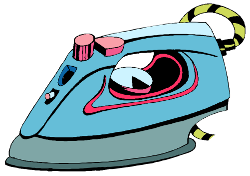
- light bulb



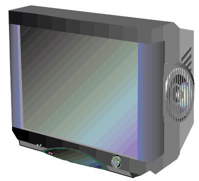
- food mixer



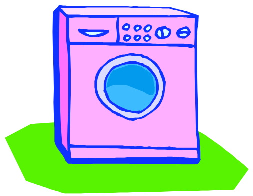
- CD/cassette player



● iron



● colour television

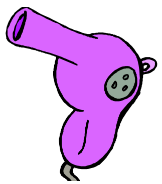


● washing machine

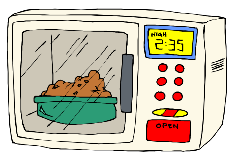
● electric cooker

● 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**?

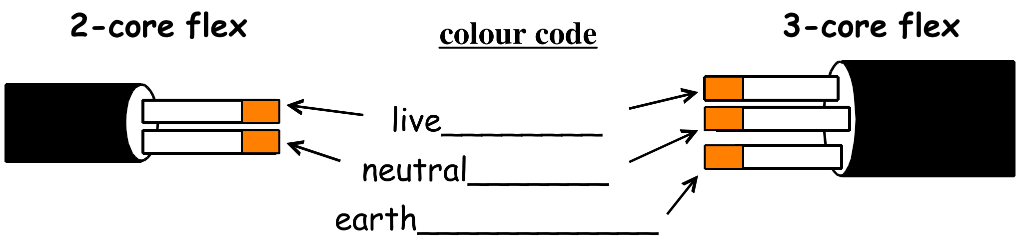
____

____

____

● 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

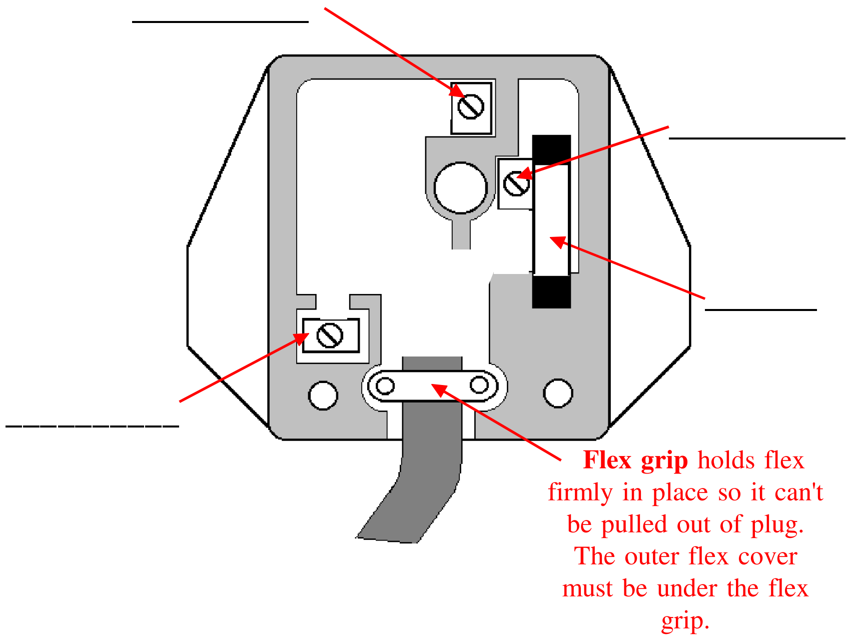
Which type of **flex** (A, B, C, D or E) would you fit to each of the following electrical appliances?

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) ________

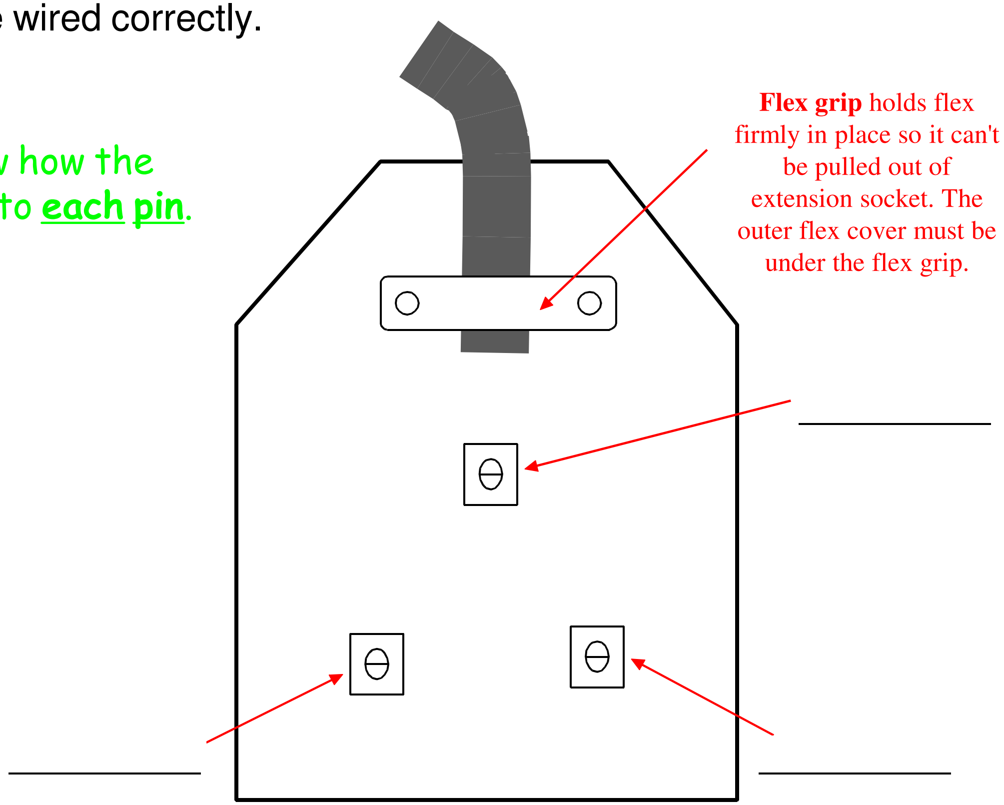
4. WIRING A 3-PIN ELECTRIC PLUG, EXTENSION SOCKET AND LAMPHOLDER

Three-pin electric plugs, **extension sockets** and **lampholders** are common in every home. They must be wired correctly.

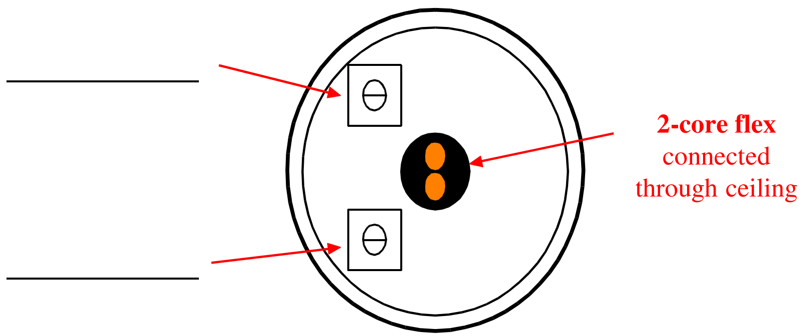
- Correctly label the **pins** in each diagram.
- Using coloured pencils, complete each diagram to show how the **plastic-coated metal wires** in a **flex** must be connected to **each pin**.



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.

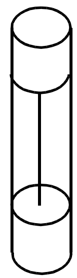
It is important to fit the correct value of fuse to the three-pin electric plug of an appliance. The fuse value chosen should be slightly **l** _ _ _ _ _ than the maximum value of current used by the appliance.

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

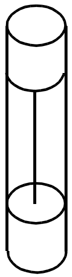
If a fuse with too **high** a value is chosen, it may not **b** _ _ _ if the current passing through the metal wires of the flex becomes too large - This could be a **f** _ _ _ hazard.

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 __________

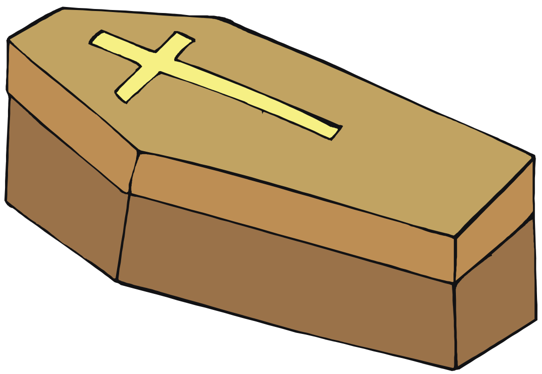
5) a 500 W electric blanket __________

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

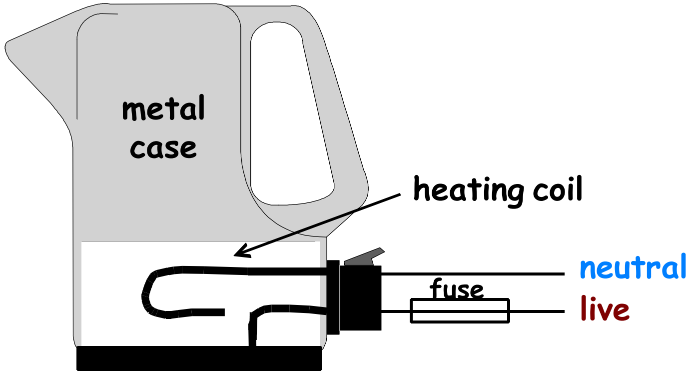
The **earth wire** is connected to the **m** _ _ _ _ **c** _ _ _ of an electrical appliance.

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**.

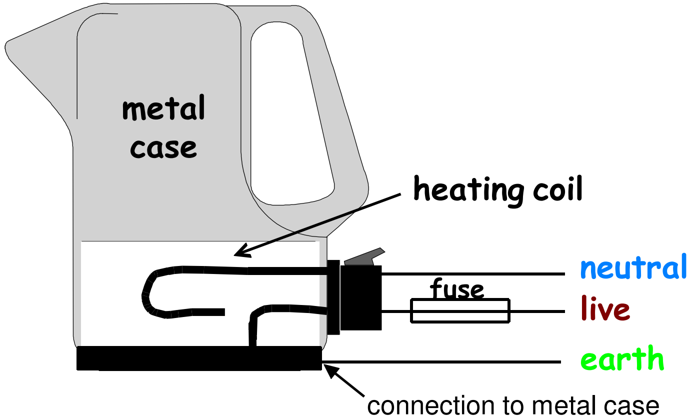
(a) NO earth wire



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.

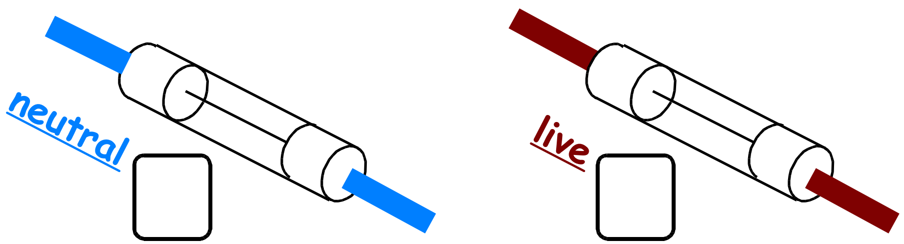
THIS ALL TAKES PLACE IN A FRACTION OF A SECOND, SO ANYONE TOUCHING THE METAL CASE WILL NOT RECEIVE AN **E** _ _ _ _ _ _ _ _ **S** _ _ _ _.

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**:

____

____

____

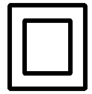
____

____

____

____

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:

____

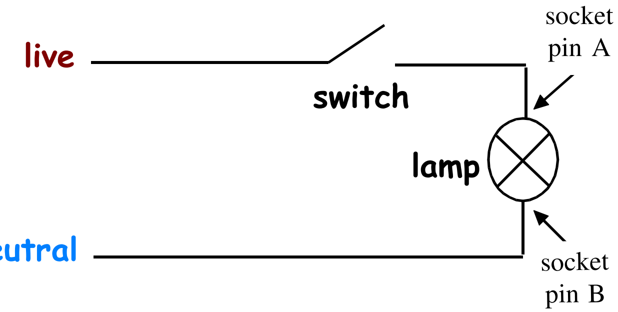
10. SWITCHES

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

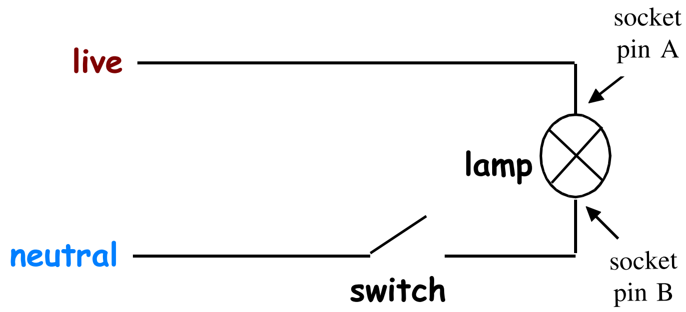
The lighting circuit shown below is **safe** because the switch is connected in the **l _ _ _ wire**:



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**?

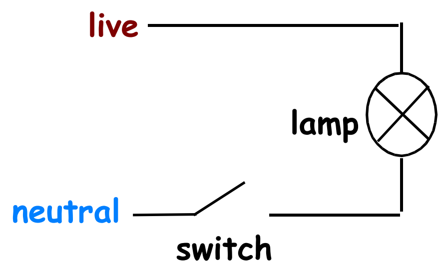
____

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

____

____

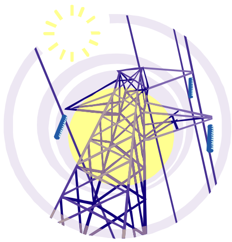
____



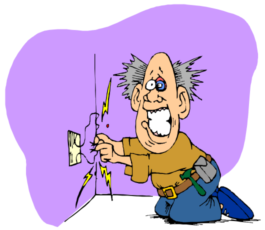
11. ELECTRICAL SAFETY HAZARDS

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**:

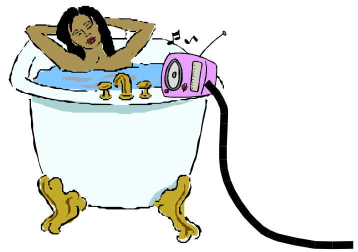


- Coming into contact with overhead power lines.

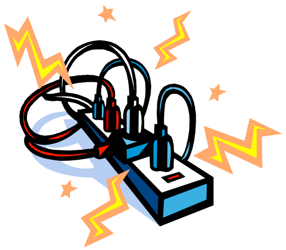


- Touching bare metal wires.

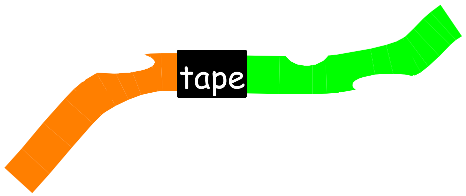
- Touching switches with wet hands.



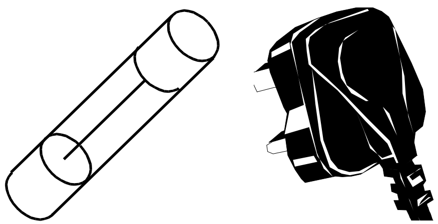
- Using, in the bathroom, appliances connected to the mains supply.



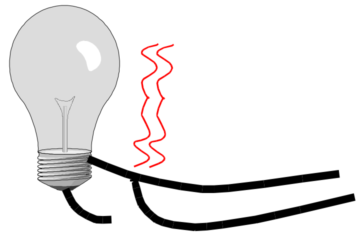
- Connecting too many appliances to a multiway adaptor.



- Using wrong, frayed or badly connected flexes.



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



- Short circuits.