9-1 GCSE Physics

Electricity Revision Guide

Unit 2: Electricity

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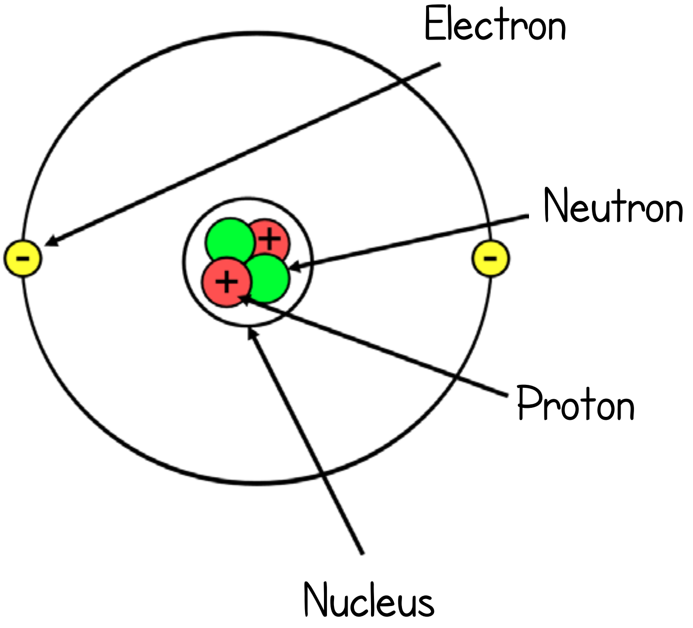
Static electricity

Physics Only Content

What is the atom made up of?

Atoms make up everything around us. They even make up us! There are over 100 different types of atoms; we call these elements.

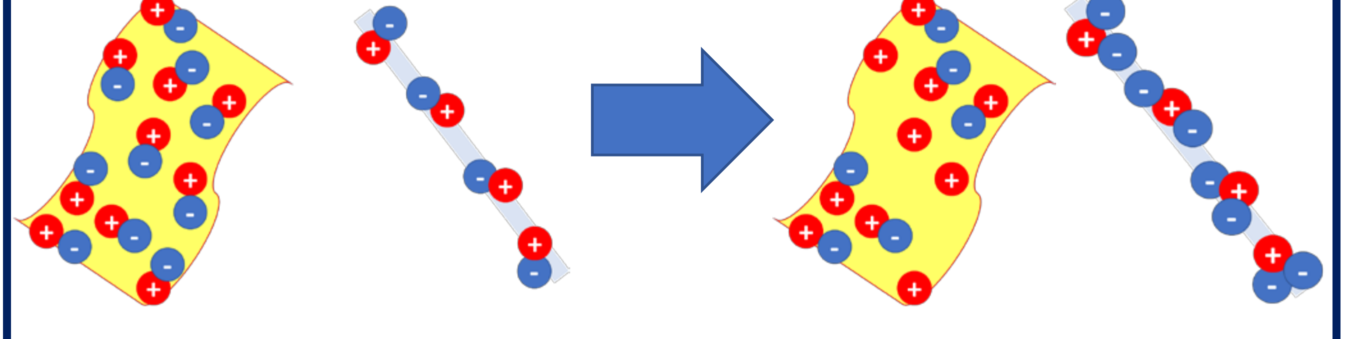


Atoms are made from 3 key parts; you need to know what an atom looks like and the names, charges and masses of the sub atomic particles.

	Charge	Mass
Proton	+1	1
Neutron	0	1
Electron	-1	1/2000

How do objects become charged?

Most objects have an equal amount of positive and negative charge. When insulating materials are rubbed together, electrons transfer from one material to another. This leaves one object with more electrons, causing one object to have a positive charge and the other object to have a negative charge.



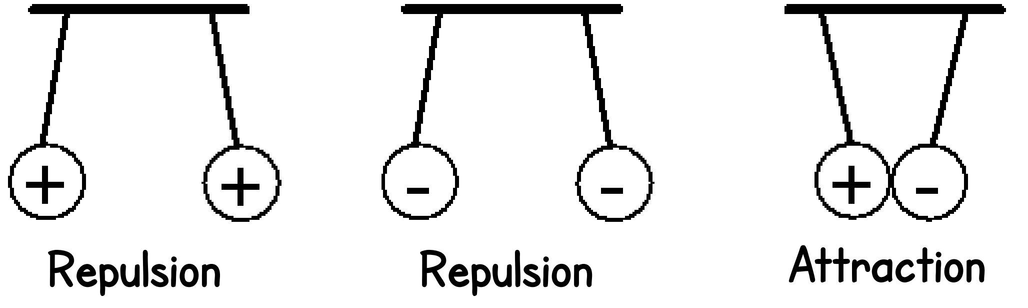
Static electricity

Physics Only Content

Static electricity can act like magnets!

We know that atoms can become positively or negatively charged. This depends on whether electrons are gained by a material, or lost.

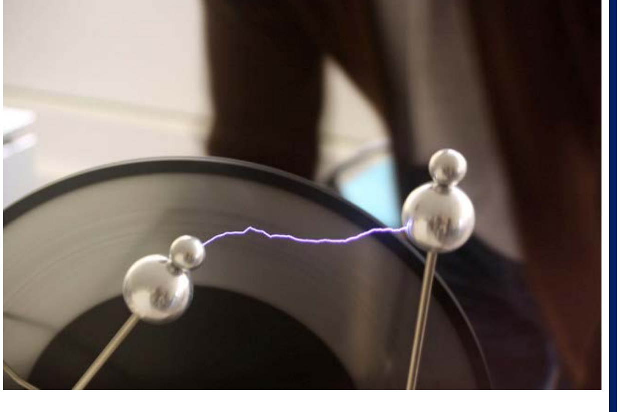
If two objects are brought together that have a similar charge, they will repel; if two objects are brought together with opposite charges, they will repel.



What happens to the build up of electrons?

After electrons have built up on an object, the potential difference builds up between the object and the Earth - this is at 0V.

When this potential difference gets big enough, electrons can jump from the object to the earth; we see this as a spark.



Learning Language

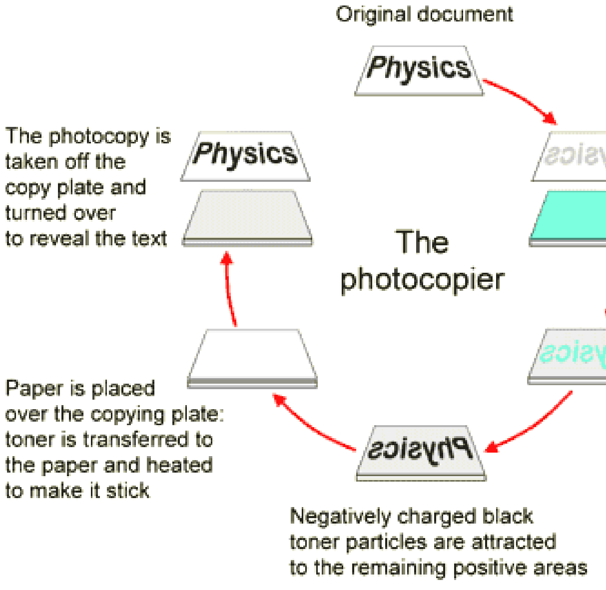
Attract, Conductor, Electron, Insulator, Repel.

Using static electricity

Physics Only Content

How do we use static electricity?

Photocopiers



Paint Spraying

Car manufacturers can save money by using charged paint spray guns. They work because like charges repel and unlike charges attract.

The spray gun is charged positively, which causes every paint particle to become positively charged. Like charges repel and the paint particles spread out creating a fine mist.

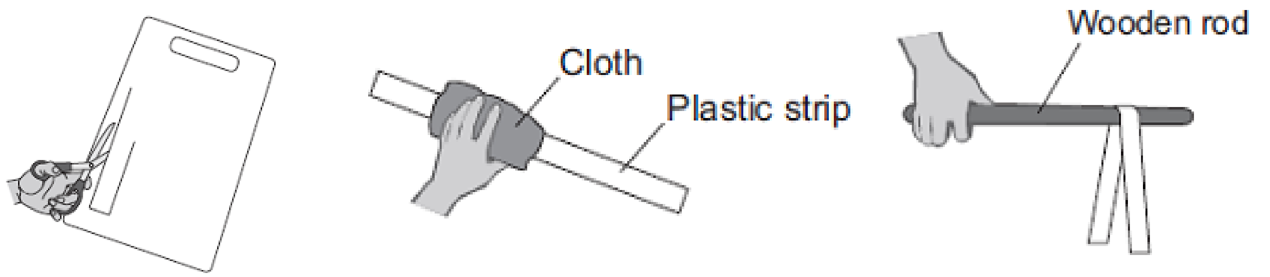
The object to be painted is given a negative charge and so attracts the paint particles to the surface.

The advantages of using this system are that less paint is wasted, the object receives an even coat and the paint covers awkward 'shadow' surfaces that the operator cannot see.

Q & A: Static electricity

Physics Only Content

1 A student uses some every day items to investigate static electricity.



1.1 Complete the sentences below.

Rubbing the plastic strip with a cloth causes the strip to become negatively charged. This happens because _ _ _ _ _ _ _ _ _ move from the cloth onto the plastic strip.

The cloth is then left with a _ _ _ _ _ _ _ _ charge.

1.2 When the plastic strip is hung over the wooden rod, the two halves of the strip move equally away from each other.

What conclusions can the student make about the forces acting on the two halves of the plastic strip?

1._ _

_ _

2._ _

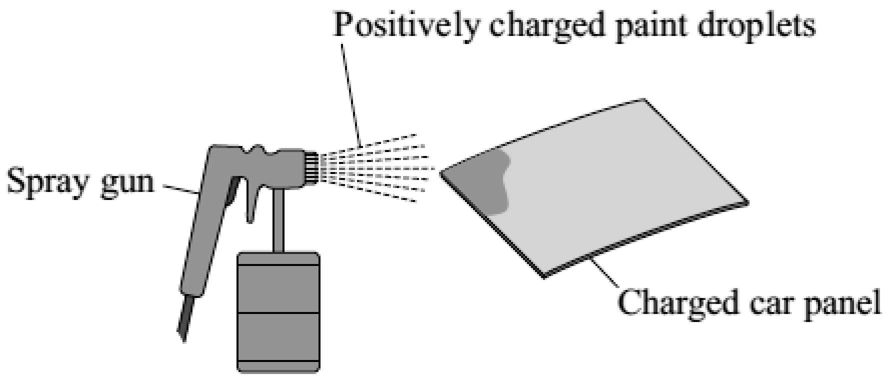
_ _

1.3 Electrical charges move more easily through some materials than through other materials. Through which one of the following materials would an electrical charge move most easily?

Draw a ring around your answer.

Aluminium Glass Rubber

2 The diagram shows how static electricity is used to paint a metal car panel.



2.1 Use the words from the box to complete the following sentences.

Attract	Opposite	Repel	Same

All of the paint droplets have the ________ type of charge. This makes the paint droplets ________ each other and spread out.

The car panel and the paint droplets have the ________ type of charge. This causes the car panel to ________ the paint droplets.

The car panel is covered by an even layer of paint.

2.2 In which one of the situations below is static electricity considered to be dangerous. Draw a ring around your answer.

Using a photocopier Refuelling an aircraft

Give a reason for your answer.

____

____

____

____

Q & A: Static electricity

Physics Only Content

3 A student takes off his nylon fleece and feels a small electrical shock. He then realises that this happens because his fleece becomes charged.

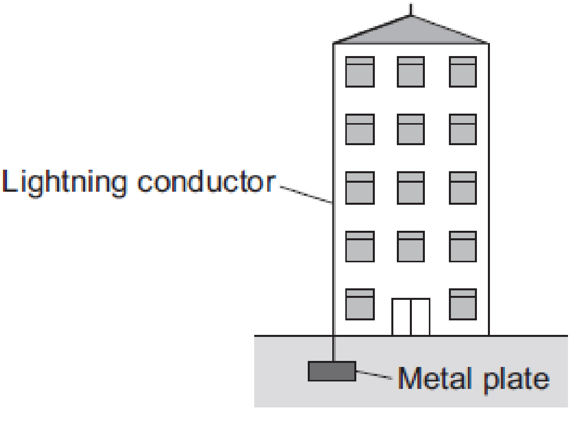
3.1 Explain how his fleece becomes charged.

____

____

____

3.2 The diagram shows a lightning conductor attached to the side of a building.



If the building is struck by lightning, the charge flows to the earth through the lightning conductor.

Which one of the materials below should be used to make the lightning conductor?

Copper Glass Plastic

Give a reason for your answer

____

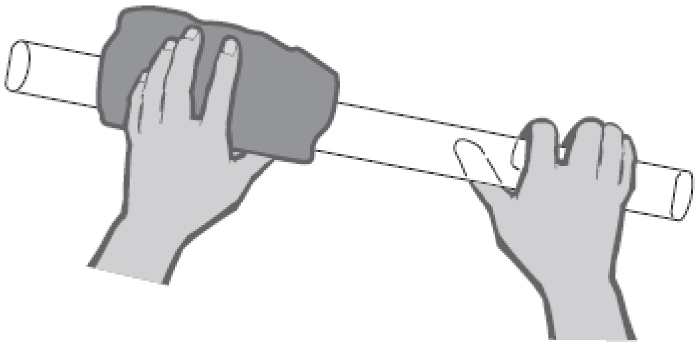
____

Q & A: Static electricity

Physics Only Content

4 The diagram shows a polythene rod being rubbed with a woollen cloth.

The polythene rod becomes negatively charged.



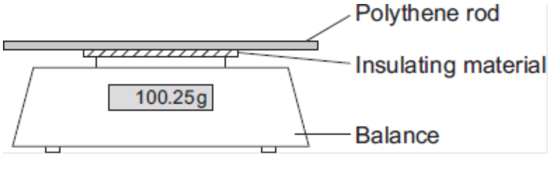
4.1 Explain how this happens.

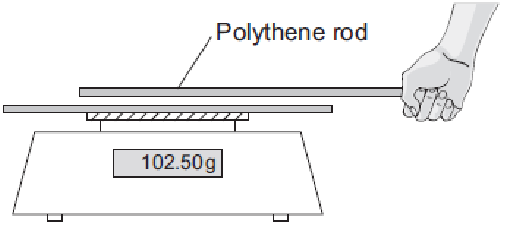
____

____

____

4.2 A student put the charged polythene rod on to a balance. The rod was separated from the metal pan of the balance by a thin block of insulating material. The student then held a second charged polythene rod above (but not touching) the first rod. The reading on the balance increased.





Explain why the reading on the balance increases.

____

____

____

Electric fields

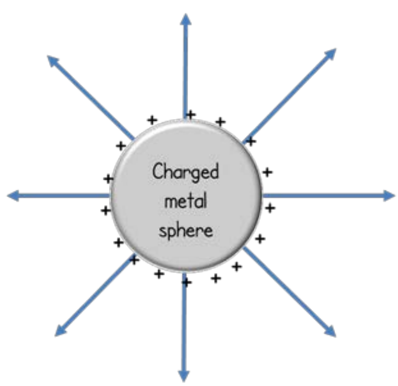
Physics Only Content

What is an electric field?

We know that charged objects exert a force on each other from a distance - they do not have to touch to feel the force. To do this, a charged object creates an electric field around itself. Any other charged object that moves into this field will then feel a force.

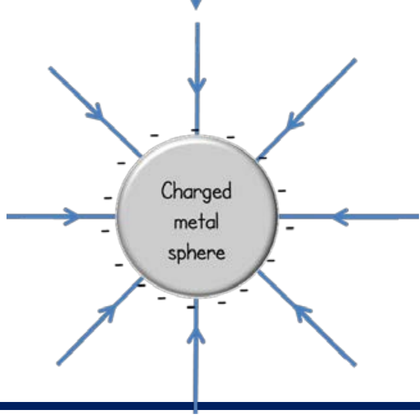
Remember! A positively charged object has lost electrons, and a negatively charged object has gained electrons!

How do we represent electric fields?



A positively charged surface would have field lines that point away from the surface of the object.

This shows the force that would be applied to a positive charge that was moved into the field of this object.



A negatively charged surface would have field lines that point towards the surface of the object.

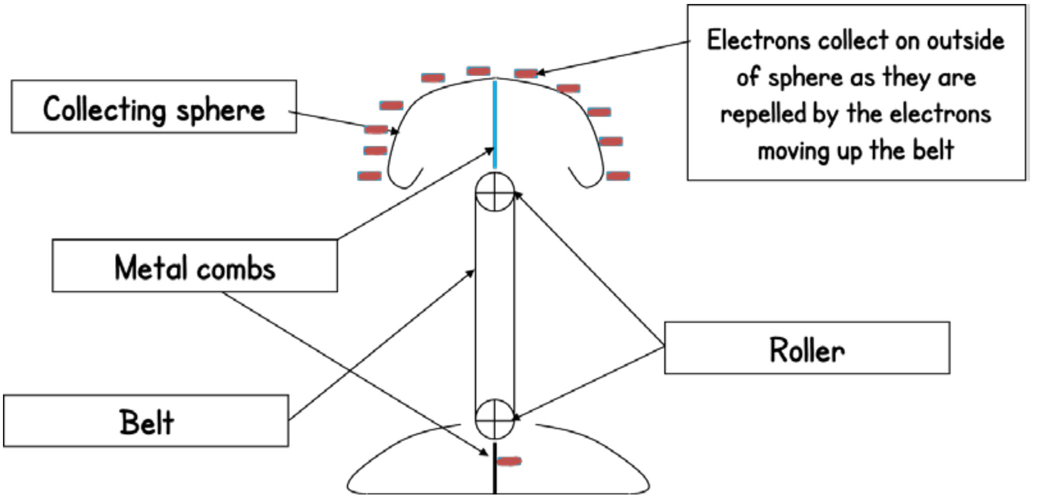
This shows the force that would be applied to a positive charge that was moved into the field of this object.

Field lines are always drawn at 90° to the surface of the charged object!

Electric fields

Physics Only Content

The van der Graaff generator



A van de Graaff generator works by rubbing together two insulating materials. The electrons transferred to the roller are moved to the sphere at the top of the van de Graaff.

On the sphere, the electrons will want to spread out as much as possible, as they have similar charges so repel. This gives the sphere an even charge all over.

From here, the electrons will try to find a way to the earth as quickly as possible. This will show as a spark.

Why does your hair stand on end when using a van de Graaff?

We know that the electrons try to spread out as much as possible, because similar charges repel. This causes the electrons to spread out onto you.

The charges eventually spread to your hair. The force of the electrons repelling is greater than the weight of your hair, causing it to stand on end!

Q & A: Electric fields

Physics Only Content

1 A van de Graaff generator that is used to investigate static electricity. Before it is switched on, the metal dome has no overall charge. After it is switched on, the metal dome becomes negatively charged.

1.1 Explain how an uncharged object may become positively charged.

____

____

____

____

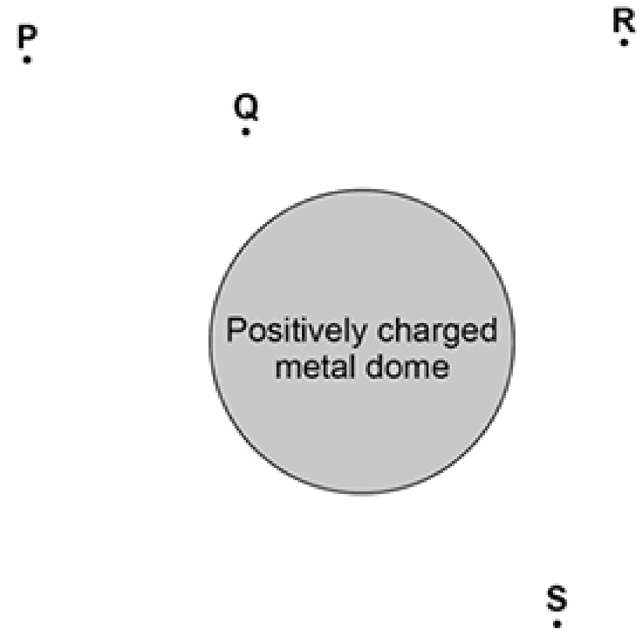
____

____

1.2 The image below shows a plan view of the positively charged metal dome of a van de Graaff generator.

Draw the electric field pattern around the metal dome when it is not interacting with anything from its surroundings.

1.3 Another positively charged object is placed in the electric field.



In which position would the object experience the greatest force?

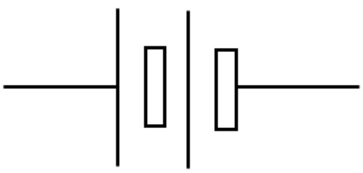
Explain your choice

Circuit Symbols

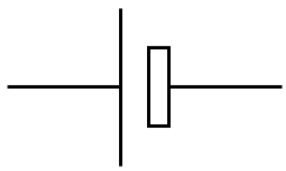
What circuit symbols are there?

There are many different circuit symbols that scientists use when drawing out a circuit. The ones below are the most commonly used, and you must know for your exam.

You must also be able to identify them and draw them out when asked.

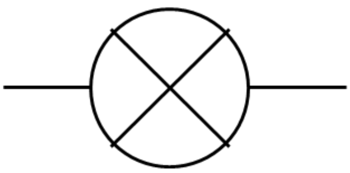


Battery

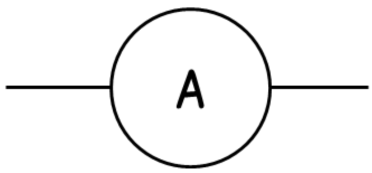


Cell

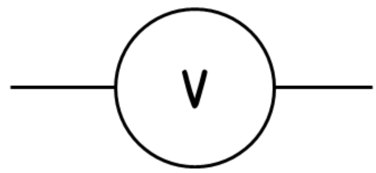
Resistor



Bulb

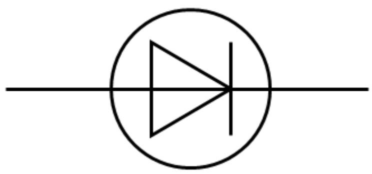


Ammeter

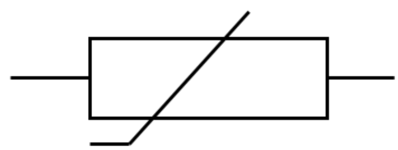


Voltmeter

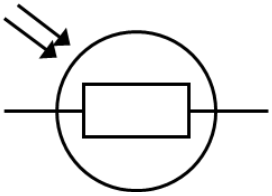
Switch



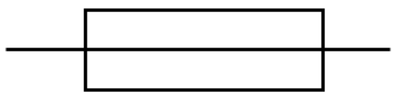
Diode



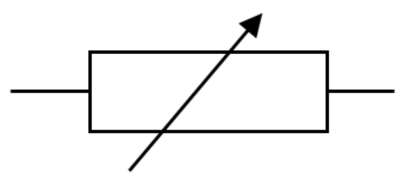
Thermistor



LDR



Fuse



Variable resistor

When you draw out your circuit, make sure that all wires are drawn with a ruler and sharp pencil. You must also make sure that the circuit is closed, and that you can follow all of the wires from the start to the end of your circuit with no breaks.

Current in circuits

What is current?

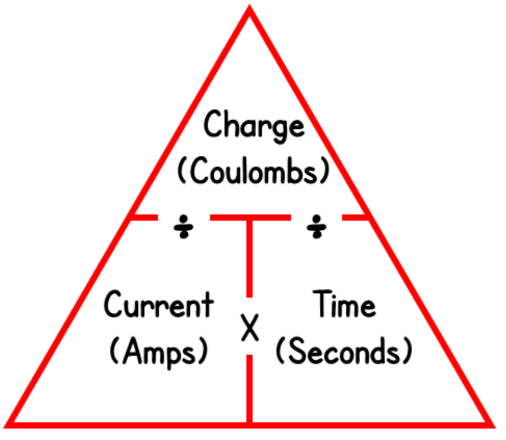
Current is the amount of charge (or electrons) that flow through any point of a circuit in one second.

How do we measure the current flowing in a circuit?

Current is measured in amperes (which is often abbreviated to amps or A).
The current flowing through a component in a circuit is measured using an ammeter.
This must be connected in series with the component.

How can we calculate the current flowing in a circuit?

When current flows past a point in a circuit for a length of time, then the charge (in coulombs) that has passed is given by the formula triangle:



The more charge that passes through a circuit, the larger the current that flows.

Example:

The current at a point in a circuit is 5A for 20 seconds. How much charge passes?

$$Q = It = 5A \times 20s = 100C$$

Q & A: Circuit symbols and current

1 Name a circuit component that is used to provide a current in a circuit.

____

2 Current, charge and time are linked together by the equation:

Charge = Current x time

Write down the units that we measure each quantity in from the equation.

Charge: _______

Current: _______

Time: _______

3 A circuit has a current of 3 amps.

3.1 Calculate the charge that flows in the circuit in 20 seconds.

____

____

3.2 Calculate the charge that flows in the circuit in 10 minutes.

____

____

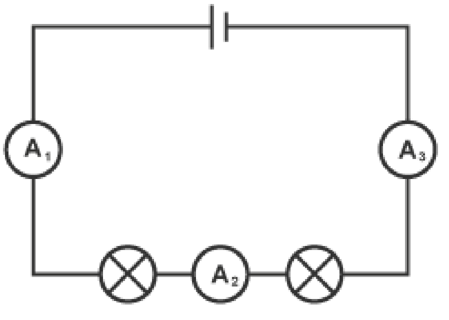
4 Draw the circuit symbols for the following components:

Ammeter	Resistor	LDR	Bulb	Voltmeter

Q & A: Circuit symbols and current

5 A circuit is needed to measure the current through a light emitting diode. A battery is provided. Draw the circuit diagram in the box below.

6 Use the diagram below to help you answer this question.



6.1 The current flowing through A1 is 5A. What would the current be that is flowing through A3?

____

Justify your answer

____

____

6.2 Calculate the current that flows through each lightbulb in 1 hour. Give a unit for your answer.

____

____

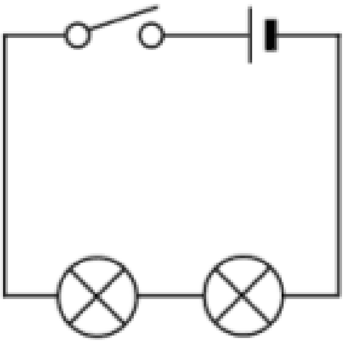
Charge _______

Unit _______

Series circuits

What does a series circuit look like?

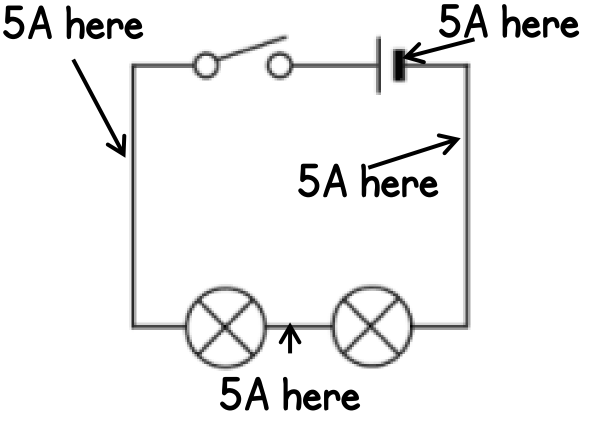
A parallel circuit has all of the components in the circuit on one main loop. These types of circuits are useful for simple, battery powered devices (such as torches).



What happens to the current in a series circuit?

The current in a series circuit is the same all of the way around the circuit. This means that, if 5A of current is being produced by the battery, 5A of current will pass through every component that is in the circuit.

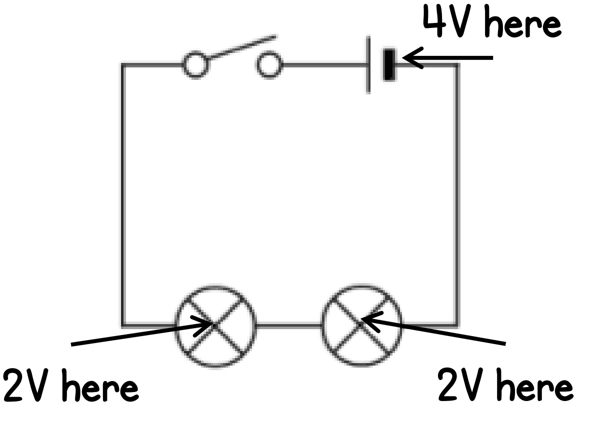
$$I_1 = I_2 = I_3 = I_4 ...$$



What happens to the potential difference in a series circuit?

In a series circuit, the total potential difference is shared between all of the components in a circuit. These always add up to the potential difference provided by the source.

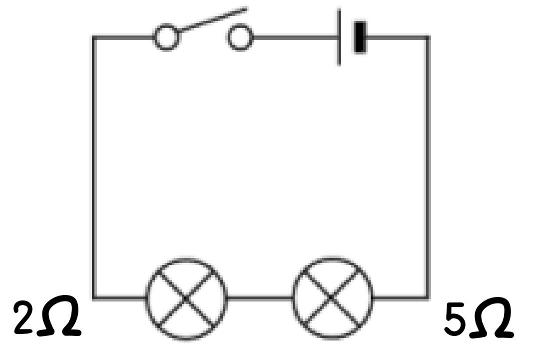
$$V_{Total} = V_1 + V_2 + V_3 + V_4 + ...$$



Series circuits

What happens to the resistance in a series circuit?

In a series circuit, the total resistance of the components in a circuit is just the sum of each of their individual resistances.

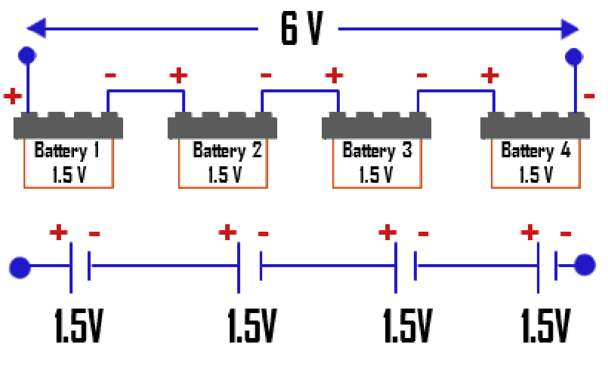


$$R_{Total} = R_1 + R_2 + R_3 + R_4 + \ldots$$

In the circuit above, the bulbs each have a resistance: one has 2Ω resistance, and the other 5Ω resistance. This means that the total resistance in the circuit would be 2Ω + 5Ω = 7Ω

What happens of there is more than 1 source potential difference?

In some circuits, more than one battery will be used.
As we add more and more batteries, we increase the potential difference. Because they are in series, we can just add them together.



$$\text{Source PD}_{Total} = \text{Source PD}_1 + \text{Source PD}_2 + \ldots$$

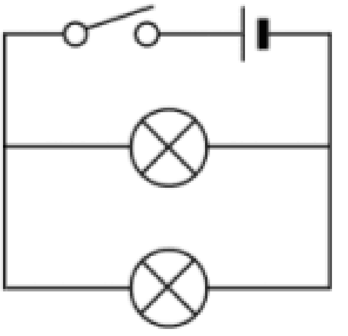
Learning Language

Circuit, Current, Potential difference, Battery, Charge, Ohms, Resistance.

Parallel circuits

What does a parallel circuit look like?

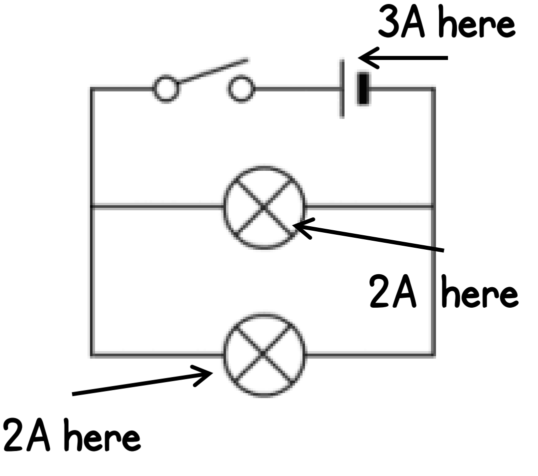
A parallel circuit has all of the components in the circuit on one main loop. These types of circuits are useful for simple, battery powered devices (such as torches).



What happens to the current in a parallel circuit?

The current in a parallel circuit will add up to the total current that passes through the power source. So, if 3A passes through the cell, and 2A passes through 1 bulb, 2A of current passes through the other bulb.

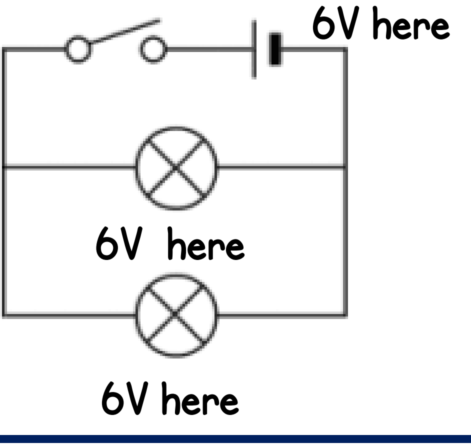
$$I_{Total} = I_1 + I_2 + I_3 \ldots$$



What happens to the potential difference in a parallel circuit?

The potential difference in a parallel circuit is the same all of the way around the circuit. This means that, if 6V of PD is being produced by the battery, 6V of PD will pass through every component that is in the circuit.

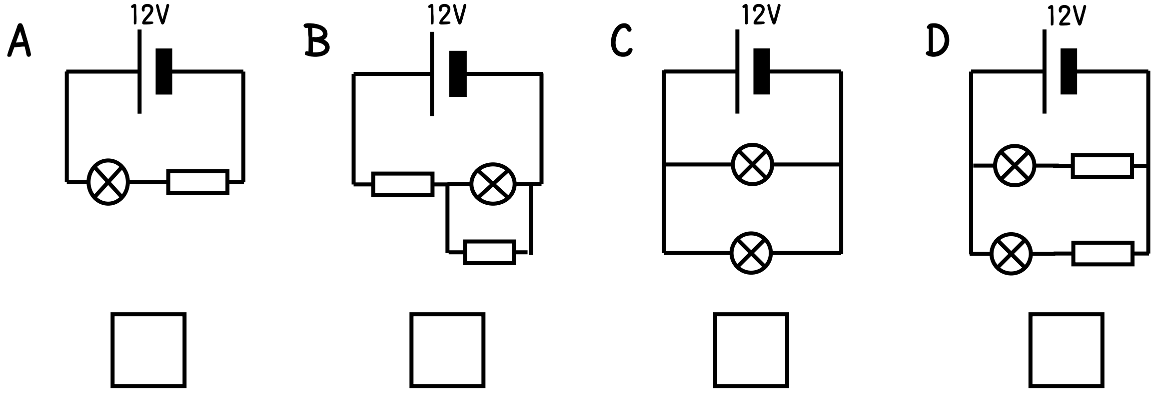
$$V_{Source} = V_1 = V_2 = V_3 = \ldots$$



If resistors are put in parallel with each other, the overall resistance of the circuit drops!

Q & A: Series and parallel

1 Look at the circuits below.



1.1 Put a tick in the box that shows the circuit with all of the components in series.

1.2 In circuit A, the potential difference across the resistor is 8V. What is the potential difference across the lightbulb?

Potential difference = _________V

1.3 Explain your answer to 1.2

____

____

1.4 In circuit C, the two bulbs are identical. What is the potential difference across each of the bulbs?

Potential difference = _________V

1.5 In circuit A, the current through the resistor is 1.5A. What is the value of the current that is flowing through the bulb?

Current= _________A

Q & A: Series and parallel

1.6 Explain your answer to question 1.5.

____

____

2 A 13A current flows from a 230V mains electricity supply to a kettle. The kettle is on for 180s. Calculate:

2.1 The charge that flowed from the plug socket to the kettle:

____

____

2.2 The energy that is transferred from the kettle to heat the water:

____

____

Challenge

If all of the energy in 2.2 was transferred to heat the water, use the following information to find the mass of water that was in the kettle.

- The starting temperature of the water was 22°C, and the kettle turned off when the water was boiling.
- The specific heat capacity of water is 4200J/kg.°C
- The equation for specific heat capacity is $E = m \times c \times \Delta T$

____

____

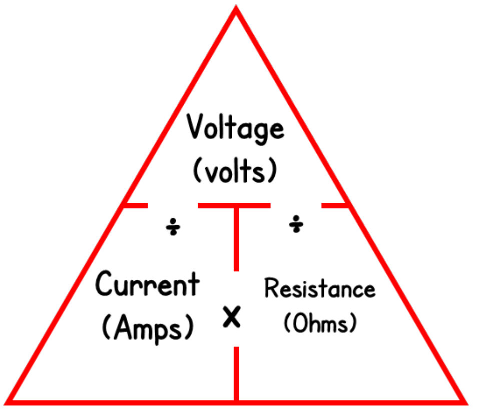
____

Mass: ________kg

Current, Voltage and Resistance

What is resistance?

Resistance is how hard it is for electricity to flow around a circuit.
Some devices, like wires, let electricity pass through easily - we say that they have a low resistance.
Some other components make it difficult for electricity to pass through - we say that these components have a high resistance.
We can calculate the resistance by thinking about the amount of potential difference that we need to make one amp of current flow



Factors affecting resistance

What would you do to a watering hose to make it more difficult for the water to flow through a hose?
You could:

- Make the hose thinner
- Add lots of twists to the hose
- Increase the water flow through the hose

We could use these factors when thinking about increasing the resistance in a wire:

- We could use a thinner wire
- We could add more components to the circuit (like twists in a hose)
- We could increase the power pack to increase the flow of electrons.

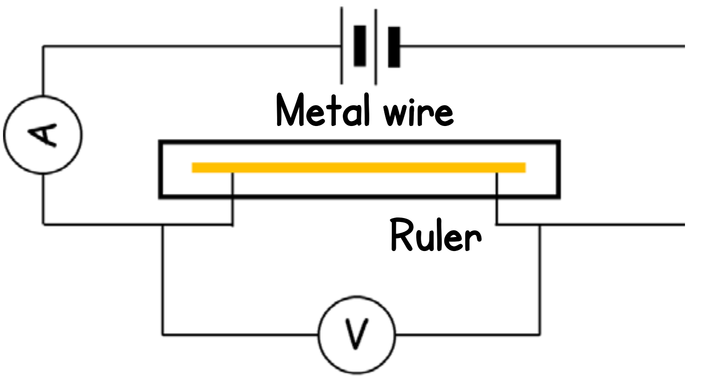
Learning Language

Current, Parallel, Potential difference, Resistance, Series

Current, Voltage and Resistance

Investigating how length of wire affects resistance

You can easily find the resistance of a component in a circuit by finding the current through the component, and looking at the potential difference of the component. You will have set up a similar practical to this one in class:



By using the values from the ammeter and voltmeter, you can find the resistance in the wire for different lengths.

As you increase the length of the wire, you will increase the number of collisions that each of the electrons will have in the wire. This means that you will decrease the current, increasing the resistance.

Length of wire and resistance in series

If we were to imagine that 10cm of wire had the resistance of a 10 ohm resistor, we would be able to say that 20cm would have a resistance of 20 ohms and 30cm would have a resistance of 30 ohms.

Now lets replace the wire with resistors...

10Ω $10\Omega + 10\ \Omega$ $10\Omega + 10\Omega + 10\Omega$

So the resistance increases with the "length": as we increase the number of resistors in series with each other, we increase the resistance.

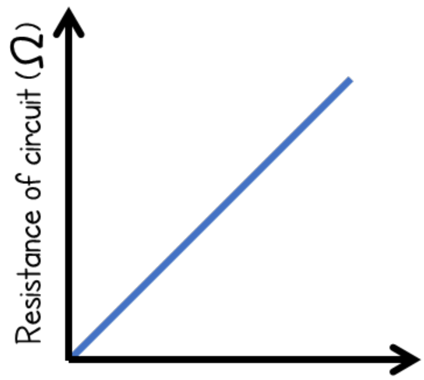
$$R_{Total} = R_1 + R_2 + R_3 + ...$$

Current, Voltage and Resistance

Length of wire and resistance in series continued

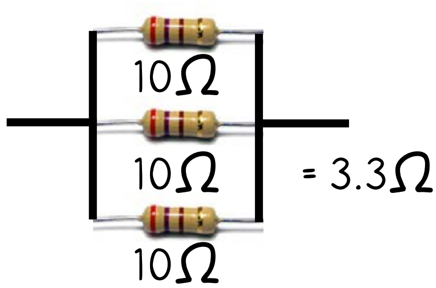
When you investigate the resistors in series, you should find that adding resistors in series increases the total resistance in the circuit. This is because the increase in resistors decreases the current in the circuit. This would be shown as a straight line graph, as it would show a proportional relationship.

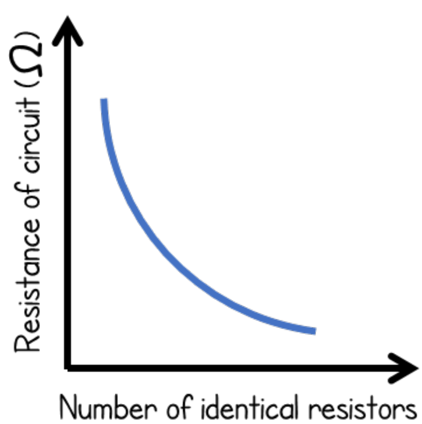
$10\Omega + 10\Omega + 10\Omega = 30\Omega$



Resistors in parallel

When you add resistors in parallel, the total resistance decreases - this is because there are more routes for the current to take in the circuit.
The overall resistance in the circuit would be smaller than the smallest resistor in the circuit.
If you plot a graph of the number of identical resistors in series against the total resistance of the circuit, you would end up with a graph that looks like this:





Learning Language

Current, Parallel, Potential difference, Resistance, Series

Q&A: Current, Voltage and Resistance

1 Complete the sentences below by using the words given.

Coulombs Current Voltage Increases Decreases

1.1 The potential difference is sometime called the ___________.

1.2 If the potential difference in a circuit increases, the current ___________.

1.3 If the resistance is increased for the same potential difference, the current ___________.

2 A circuit has a resistance of 20Ω.

Calculate the potential difference needed to give a current of 4A in the circuit.

____

____

Potential Difference = ________V

3 A cell in a circuit provides a potential difference on 12V. The current in the circuit is 3A.

Calculate the resistance of the circuit. Give units with your answer.

____

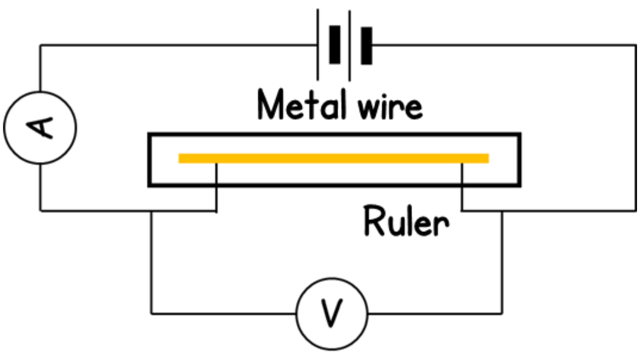
____

Resistance = ________

Unit = ________

Q&A: Current, Voltage and Resistance

4 A student investigated how the resistance of a piece of wire depends on its length. The circuit used for this investigation and the results that were collected are shown below.



Length (m)	Resistance (Ω)
0.1	0.6
0.2	1.3
0.3	1.7
0.4	2.4
0.5	3.0

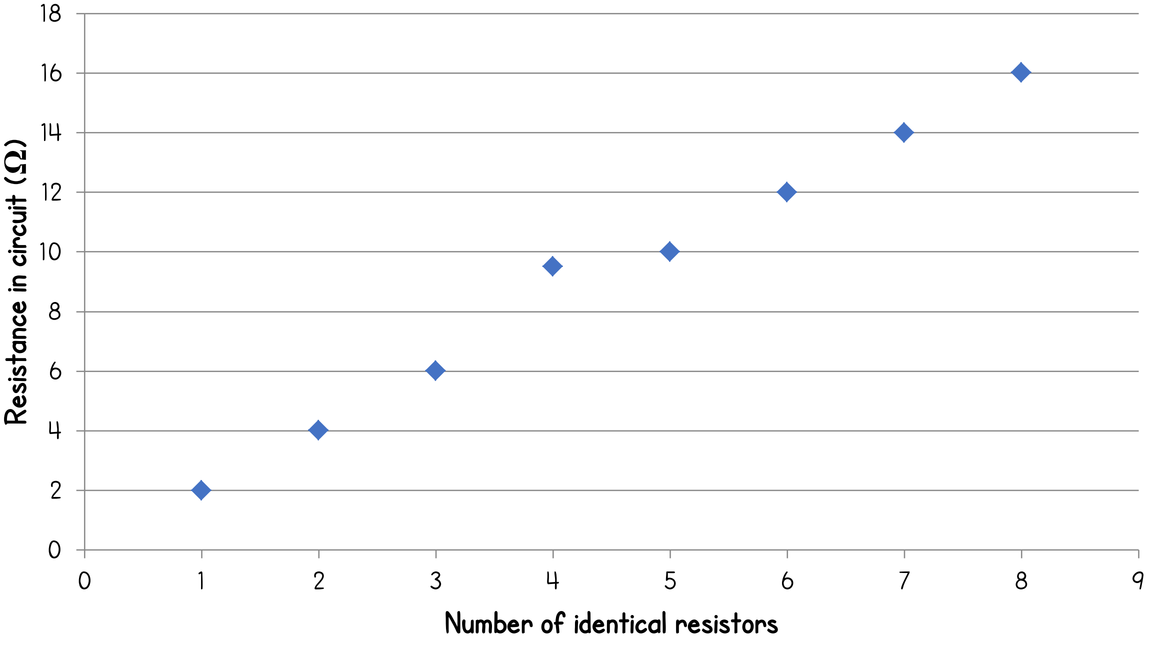
4.1 Describe how the student could have used the equipment above to collect the results in the table.

4.2 Plot a graph of the data from the table in 4.1 onto the grid. Label the axes correctly and add a line of best fit.

4.3 State one conclusion that the student can make about the relationship between the resistance of a wire and the length of it.

Q&A: Current, Voltage and Resistance

5 Another student completed another practical where they investigated how adding identical fixed resistors in series affected the resistance of a circuit. Each resistor had a resistance of 2 Ohms. The results produced the following graph.



5.1 The student made a mistake when plotting their results. Circle to anomalous result.

5.2 Add a line of best fit to the students graph.

5.3 Using the line of best fit, predict the value of the correct resistance of the circuit for the incorrectly plotted result.

Resistance = ________Ω

5.4 This student now repeats the experiment using 1Ω and 5Ω resistors. Draw a line of best fit onto the graph above of the results you expect the student to obtain from the new investigations.

Q&A: Current, Voltage and Resistance

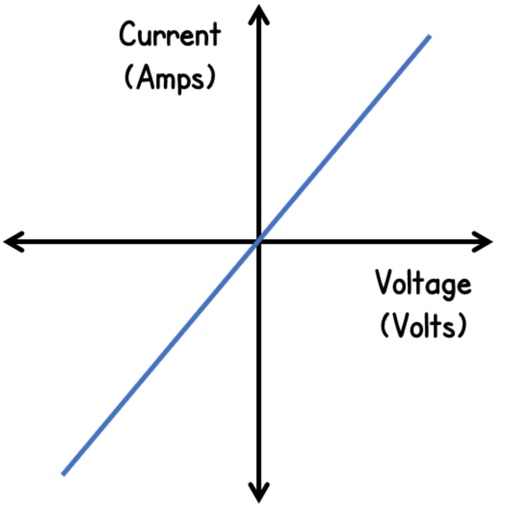
6 A student wants to investigate how adding resistors in parallel affects the overall resistance of a circuit. Describe an experiment you could do to investigate this. You must include:

- A list of the equipment you would use
- A diagram of the circuit you would use
- A method of how you would intend to collect your results.

Ohmic conductors and Semiconductors

Ohmic conductors

For most electrical components, as the current increases through them changes, the resistance of the component changes aswell.
For an Ohmic conductor (like a wire or a resistor), the resistance stays the same, as long as the temperature does not change.
When we plot a current-voltage graph for an Ohmic conductor, we get a straight line graph. This shows a proportional relationship.



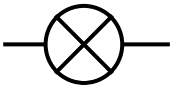
Semiconductors

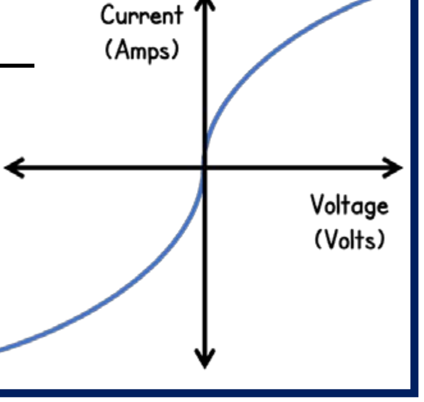
The resistance of semiconducting components changes depending on the environment. There are 4 different semiconducting components you need to know about:

- The filament lamp (an old fashion style light bulb)
- A diode (a component that only allows current through in one direction)
- A Thermistor (resistance changes with temperature)
- An LDR (resistance changes with light intensity)

Filament lamp:

As the current increases, the temperature of the filament increases; this increases the resistance. This means that there is less current that can flow through the wire for the same potential difference, creating a curve.

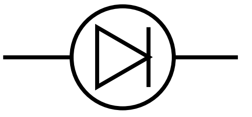


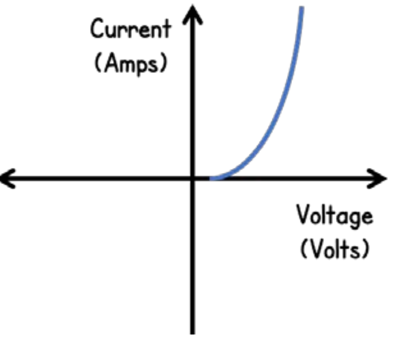


Ohmic conductors and Semiconductors

Semiconductors

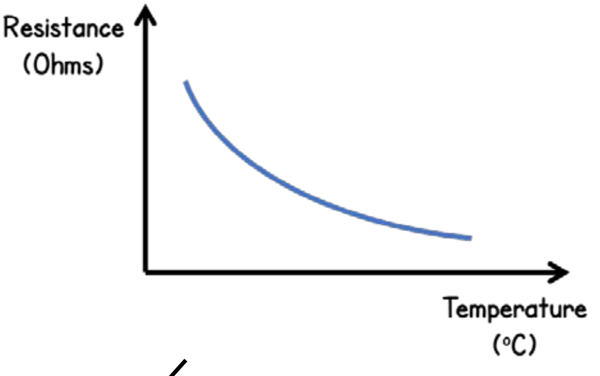
Diode:



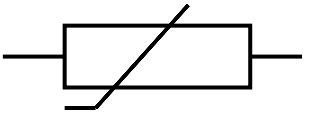


Current is only allowed to flow through a diode in the one direction. In the opposite direction, a diode has a really high resistance.

Thermistor:

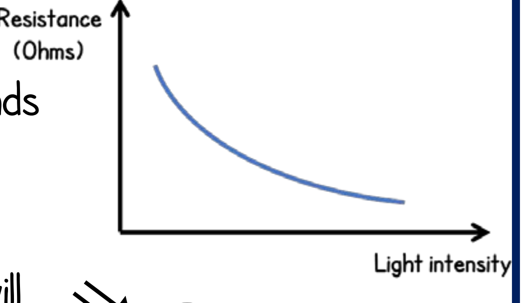


A thermistor is a "thermal resistor", and the resistance of the thermistor depends on the temperature.
As the temperature increases, the resistance drops: as the temperature decreases, the resistance becomes greater.

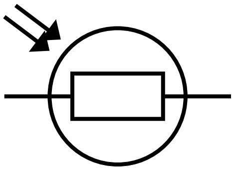


Thermistors are great at detecting temperature, and are used as thermostats and car engine temperature sensors.

LDR:

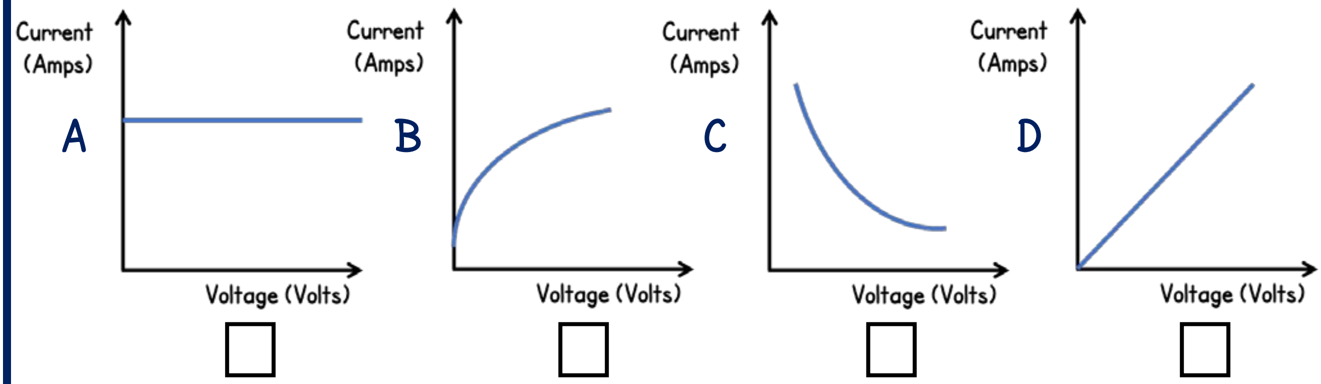


An LDR is a resistor is a resistor that depends on how much light there is on the resistor.
In bright conditions, the resistance will decrease: in dim conditions, the resistance will increase.
LDR's are used for street lamps.



Q&A: Ohmic conductors and Semiconductors

1.1 Select the graph below that shows the correct results for a resistor that is at a constant temperature. Tick one box.



1.2 Name the type of relationship that is shown in 1.1.

____

1.3 Use the words below to complete the sentences

Linear   Non-Linear   Non-Ohmic   Ohmic

A resistor at a constant temperature is an example of a(n) ________ conductor. This produces a ________ graph.

2.1 Draw the circuit symbol for a diode.

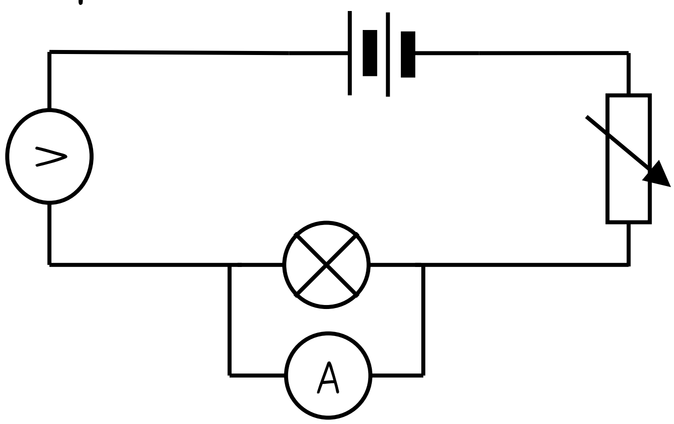
2.2 A student measured the resistance of an LDR using an electric circuit. He found the resistance to be 0.02Ω. The next day he measured the resistance again and found it to be $1000k\Omega$. Suggest why the results were so different. Assume that the circuit was working perfectly on both occasions.

____

____

Q&A: Ohmic conductors and Semiconductors

3 A student set up the circuit below to find the I-V characteristic of a filament lamp.

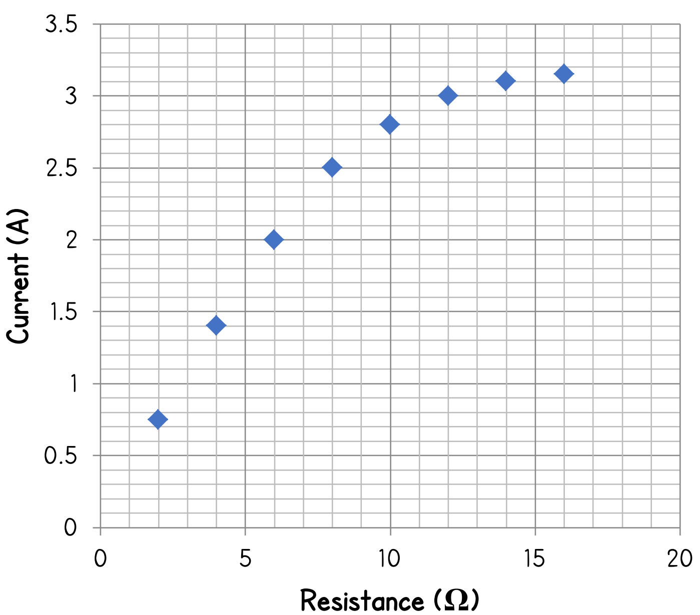


3.1 Explain what is wrong with this circuit.

____

____

3.2 After correcting the circuit, the student obtained the following graph of results.



Use this graph to find the PD of the lamp at 3A.

PD= ________V

3.3 Add a line of best fit to the graph of the students results.

3.4 Using the graph, predict what the PD of the bulb would be when 1A of current is flowing through it.

PD= ________V

Q&A: Ohmic conductors and Semiconductors

3.5 What does the graph tell you about the lamp's resistance as the current increases? Explain why the resistance behaves in this way.

____

____

3.6 The student states that lamp behaves like an Ohmic conductor up until a certain potential difference.

Explain what is meant by an Ohmic conductor.

____

____

3.7 Give an example of an Ohmic conductor.

____

3.8 Up to what potential difference does this filament lamp act like an Ohmic conductor?

Potential differece = ________V

3.9 Explain your answer to 3.8

____

____

Sensor circuits

Using LDR's and thermistors

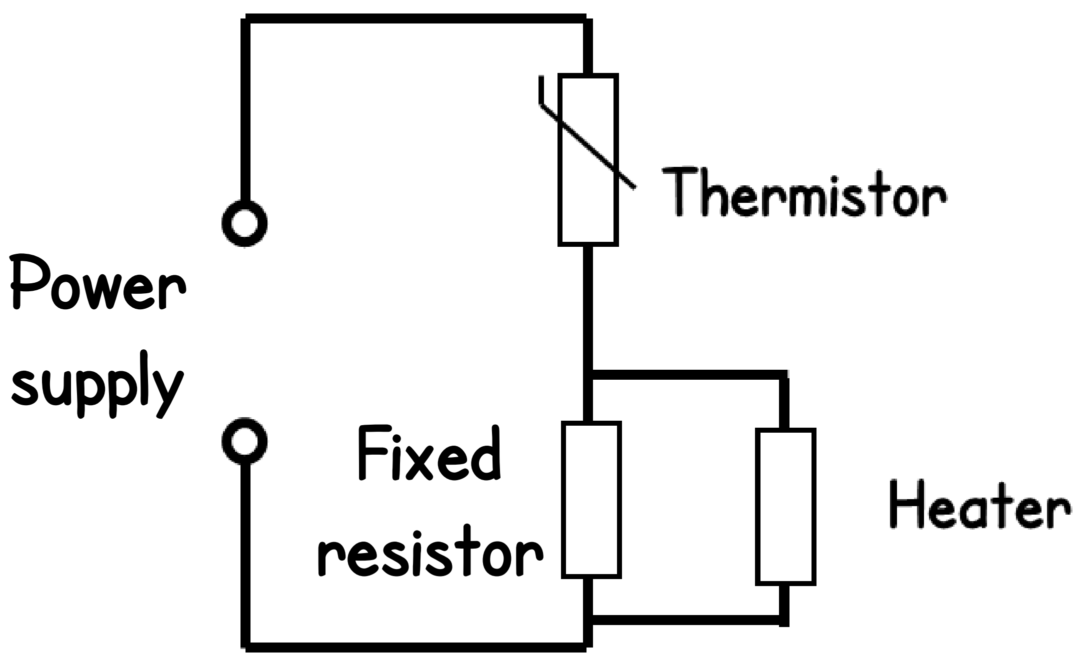
Sensor circuits can be used to either turn a circuit on or off, or increase the current through the circuit. This depends on the conditions that the circuits are in.

Turning on a heater:

The fixed resistor and the heater are in parallel with each other, so will always have the same potential difference across them.

This PD of the power supply is shared between the thermistor and the loop made out of the fixed resistor and the heater according to their resistances - the bigger the resistance of the component, the larger the PD that the component takes.

As the room gets hotter, the resistance of the thermistor drops; this means that the PD over the fixed resistor and the heater increase. When the PD reaches a certain level, the heater will switch off.



Sensor circuits

Using LDR's and thermistors

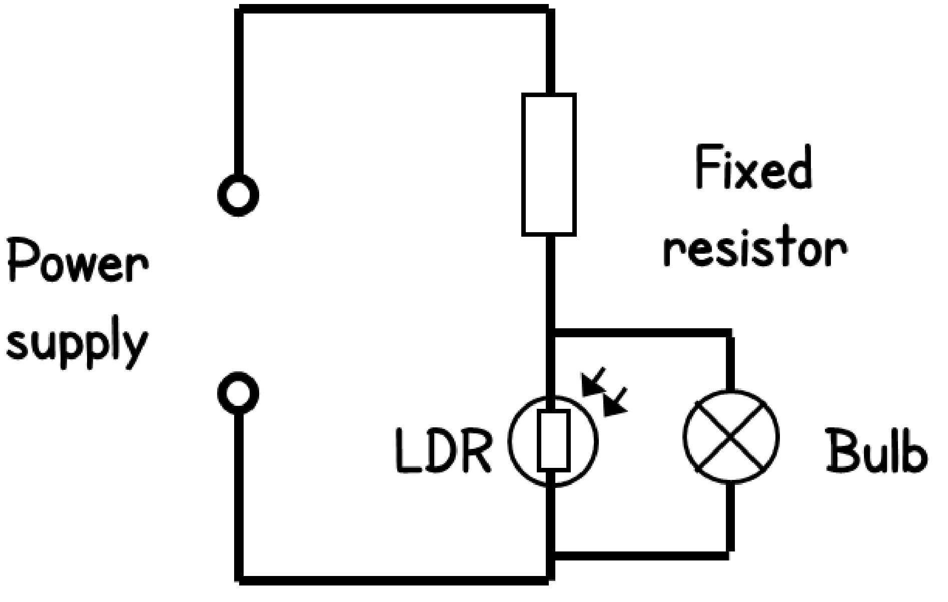
Sensor circuits can be used to either turn a circuit on or off, or increase the current through the circuit. This depends on the conditions that the circuits are in.

Turning on a street lamp

You can also connect a component in parallel with an LDR instead of a fixed resistor.

If a bulb is connected in parallel with an LDR, the PD across both the bulb and the LDR will be high when it is dark - this is because the LDR has a high resistance when it is dark.

The greater the PD across a component, the more energy it gets. So a bulb connected across an LDR would get brighter as it gets darker.



Learning Language

Parallel, LDR, Thermistor, Fixed resistor, Potential difference

Q&A: Sensor circuits

1 A pair of students investigate how the resistance of a thermistor changes when its temperature changes. They use a cell, an ammeter, a voltmeter, a thermistor and some connecting wires.

1.1 Draw the circuit they should use in the box below.

1.2 Explain why the students need to measure both the voltage and current across the thermistor.

____

____

2 Complete the sentences below using the words given. You may use a word more than once, or not at all.

Brightness Decreases Increases Temperature

2.1 When the potential difference across a filament lamp ________, its resistance ________.

2.2 When the ________ of the thermistor increases, its resistance ________ .

2.3 When the ________ decreases, the resistance of an LDR ________.

Q&A: Sensor circuits

3 A simple fire alarm sounds a buzzer if there temperature gets too high. These sentences explain how it works.

Number the sentences to put them in order.

☐ If there is a fire, the temperature rises and so the resistance of the thermistor goes down.

☐ When the thermistor is cold, the resistance is high.

☐ The circuit includes a cell, a thermistor, and a buzzer.

☐ This allows a bigger current to flow in the circuit, so the buzzer sounds.

☐ Only a very small current can flow in the circuit, so the buzzer does not sound.

4 A fridge has a thermostat that turns the cooling system on if the temperature of the fridge gets too high.

A thermistor can be used in this circuit to make sure that the fridge stays at a constant temperature.

Explain how this circuit works.

____

____

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Q&A: Sensor circuits

5 Most street lamps have a sensor that switches the lights on when it gets too dark. Before LDR's were used, street lamps would have been switched on manually.

5.1 Suggest why street lights have been fitted with LDR's.

_ _

_ _

5.2 The circuit that controls the street lamp is made from a fixed resistor, and LDR, a lamp, and some connecting wires.

In the box below, sketch the circuit that is used in street lamps to turn them on when it gets too dark.

5.3 Explain, in words, how this circuit works.

_ _

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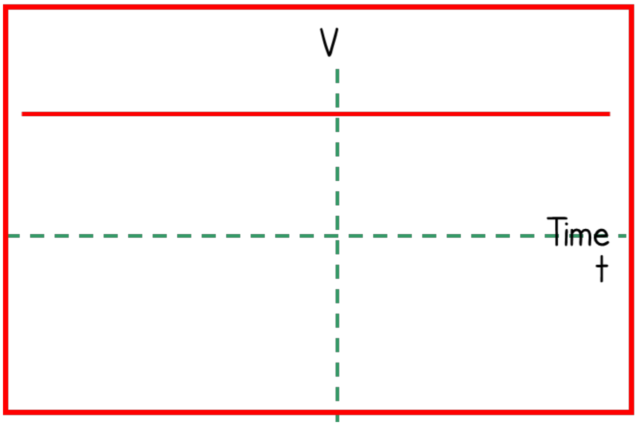
AC and DC

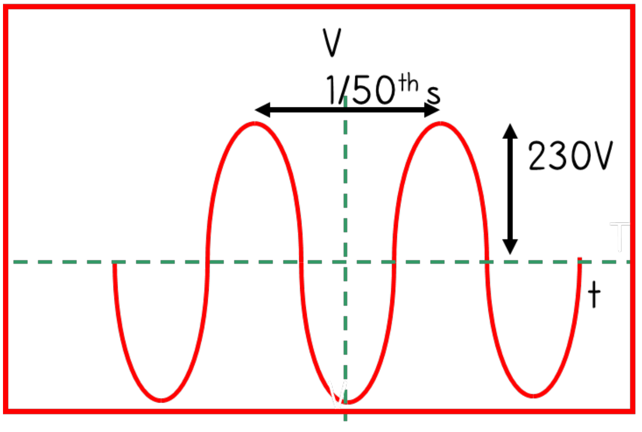
Direct Current

A cell or a battery provides a potential difference to a circuit. This potential difference always flows in the same direction. This causes a current to flow in the one direction. This is a direct current.



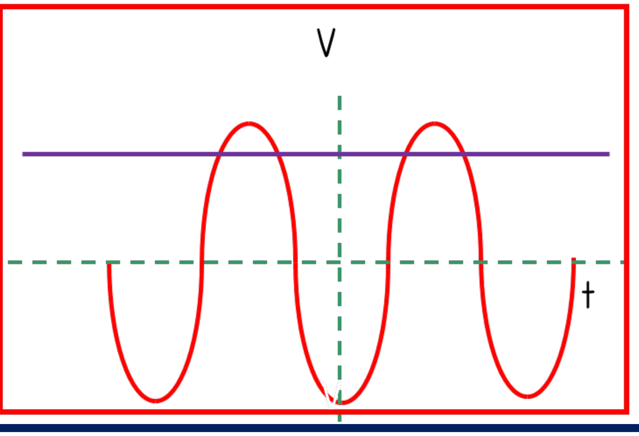
Alternating Current

When an alternating current is used in a circuit, the potential difference changes direction many times each second. This produces an alternating current. This current also changes direction many time. In the UK, the current changes direction 50 times every second.



AC vs DC

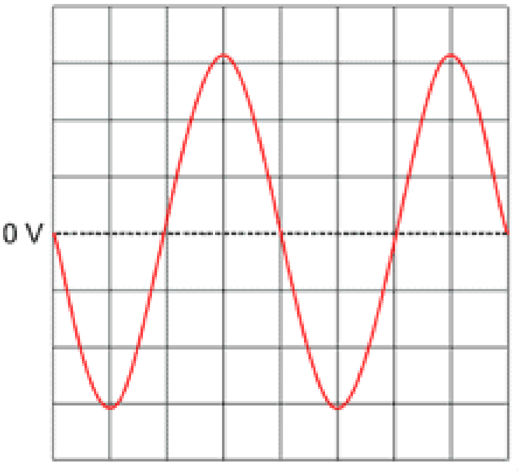
When a graph of AC and DC is compared, AC will appear to be slightly higher. This is to make up for AC changing direction.
However, an AC supply will power a device just as well as a DC device.



AC and DC

Reading from an oscilloscope

You will need to be able to read the time period, frequency, and peak of an alternating current supply from an oscilloscope trace. Let's use this one as an example.



Time period

The time period of an AC supply is the time take for one complete oscillation. You can find this by looking at the time difference between 2 peaks.

On the oscilloscope screen, each horizontal division (the difference between 2 squares along the x-axis) represents 5ms.

There are 4 divisions between each peak, so the time period is:

$$4 \times 5\text{ms} = 20\text{ms}$$

Frequency

The frequency of the source can be found by using the time period. It is measured in Hertz (Hz).

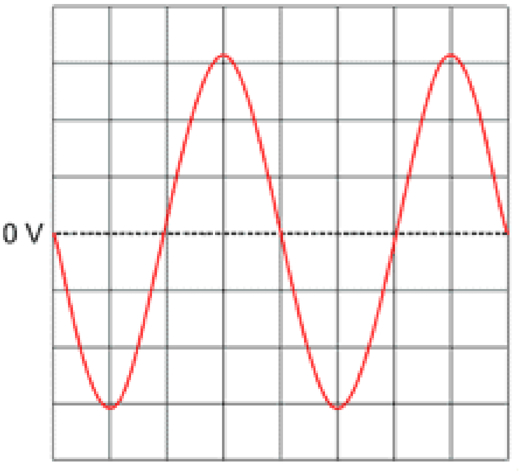
$$\text{Frequency} = 1 \div \text{time period}$$

Don't forget that the time period must be in seconds for use to find the frequency. To convert from ms to s, we must divide by 1000. This means that the time period of this trace is 20 ÷ 1000 = 0.002s. So the frequency of this trace is:

$$1 \div 0.002\text{s} = 50\text{Hz}$$

AC and DC

Peak potential difference (Amplitude)



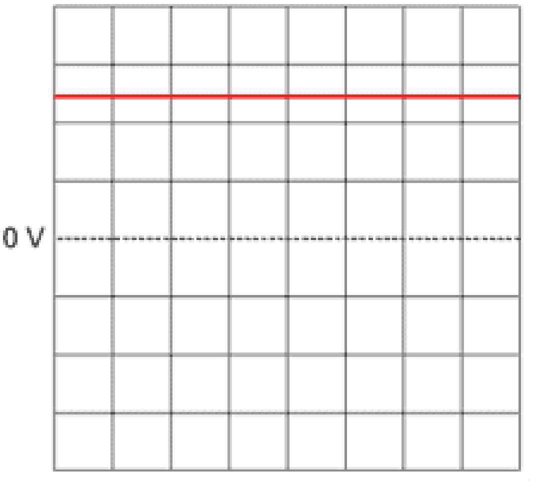
To find the amplitude of the trace, we need to look at how 'tall' the wave is from the centre.
Each vertical division (each of the squares in the direction of the y-axis) represents 5mV. Using this, we can find the maximum potential difference supplied to the circuit by the AC.

There are 3 squares between the middle of the trace (0V) and the peak. As we know that each one represents 5mV, the peak potential difference would be:

$$3 \times 5mV = 15mV$$

We can convert this into V, as we know that 1mV is the same as 0.001V. This means that 15mV is the same as 0.015V.

Reading a DC trace

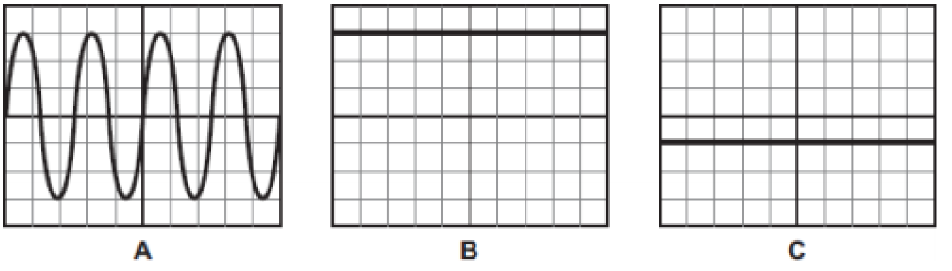


DC traces are far easier to read as we only need to find the peak potential difference supplied. This is where the trace crosses the y-axis.
There are 2.5 squares between 0V and the peak, so the potential difference supplied by the battery is:

$$2.5 \times 5mV = 12.5V$$

Q & A: AC and DC

1 The diagram shows the traces produced on an oscilloscope when it is connected across different electricity supplies.



1.1 Which of the traces could have been produced by a mains electricity supply?

____

____

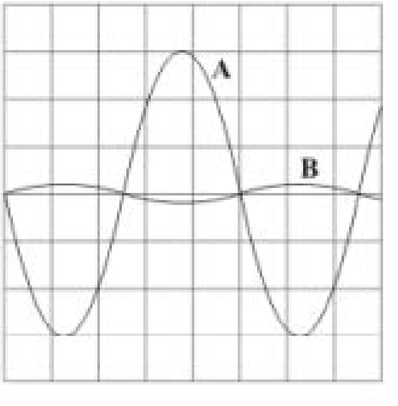
1.2 Give a reason for your answer.

____

____

2 Two oscilloscope traces are shown in the diagram.

2.1 Each division represents 0.005s.
What is the time period of this electricity supply?



____

____

Time period: ________s

Q & A: AC and DC

2.2 What is the frequency of this electricity supply?

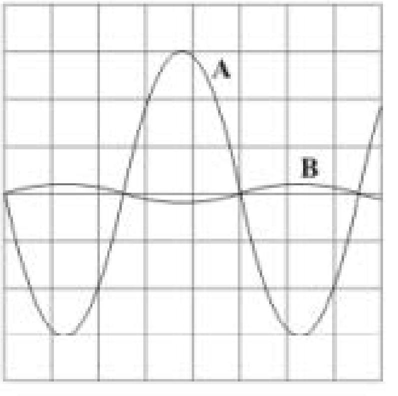
____

____

Frequency: ________Hz

2.3 Trace A shows how the potential difference between the live and neutral terminals of an electricity supply changes with time.

Describe how the potential difference of the live terminal varies with respect to the neutral terminal of the electricity supply



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3 A student wants to investigate the how the current through a diode varies with the resistance in a circuit.

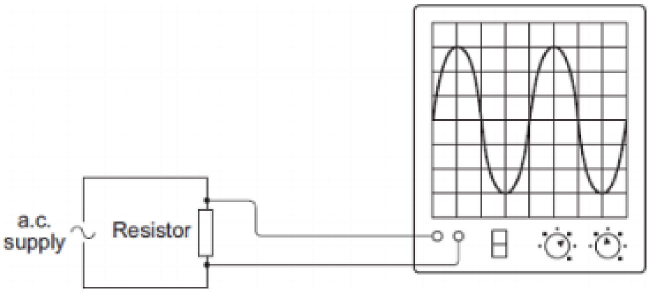
3.1 In the boxes below, draw the symbol for a diode and a variable resistor.

Diode	Variable resistor

Q & A: AC and DC

3.2 The diagram shows the trace produced by an AC supply on an oscilloscope.

Each horizontal division on the oscilloscope screen represents a time of 0.1s. What is the frequency of this supply?

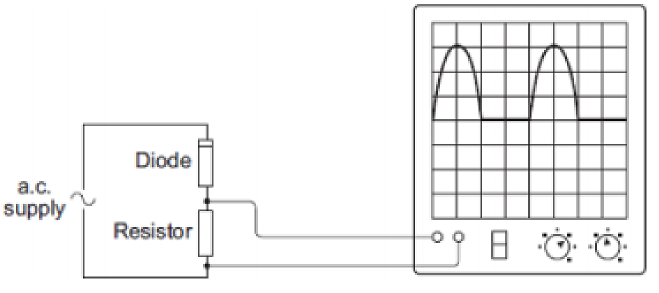


_ _

_ _

Frequency: _ _ _ _ _ _ _ _Hz

3.3 A diode is now connected in series with the AC power supply.



Why does the diode cause the trace on the oscilloscope screen to change?

_ _

_ _

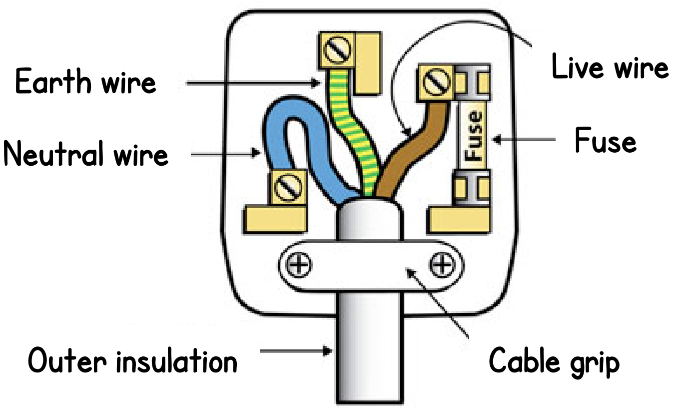
_ _

_ _

Plugs and the earth wire

What is inside a 3 pin plug?

Most electrical appliances are connected to a mains power supply by three-core cables. This means that they have three wires inside of them, each with a core of copper and a coloured plastic coating. The colour of the coating represents the job that each wire has. These colours are always the same for every appliance, so that you can tell the wires apart from each other. You need to know the colour of each of the wires, and the potential difference of each of the wires.



The live wire

This is a brown wire that provides the alternating potential differences from the mains. This is around 230V.

The earth wire

This is a green and yellow wire that is used for protecting the device from an excess current. If the fuse breaks, the electricity will flow along the earth wire to prevent the user from receiving an electric shock. The potential difference of this wire is around 0V.

The fuse

This is a thin piece of wire that is designed to melt when too much current flows through it. This protects the device against current surges.

The neutral wire

This is a blue wire that carries the current back to the source. This has a potential difference that is close to 0V.

The outer insulation

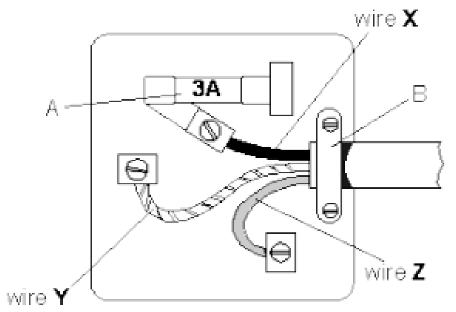
A plastic cover that protects the user against an electric shock.

The cable grip

This is a piece of plastic that is used to help keep everything in place.

Q & A: Plugs and the earth wire

1 The diagram below shows an electric mains plug.



1.1 Name the parts of the plug labelled A and B.

A _ _ _ _ _ _ _

B _ _ _ _ _ _ _

1.2 Name the colour of each of the wires X, Y, and Z.

X _ _ _ _ _ _ _

Y _ _ _ _ _ _ _

Z _ _ _ _ _ _ _

1.3 Suggest a material that the case of the plug can be made from.

_ _

1.4 Define what electric current is, and state the equation that links together current, charge, and time.

_ _

_ _

Power, energy and charge

Energy and charge

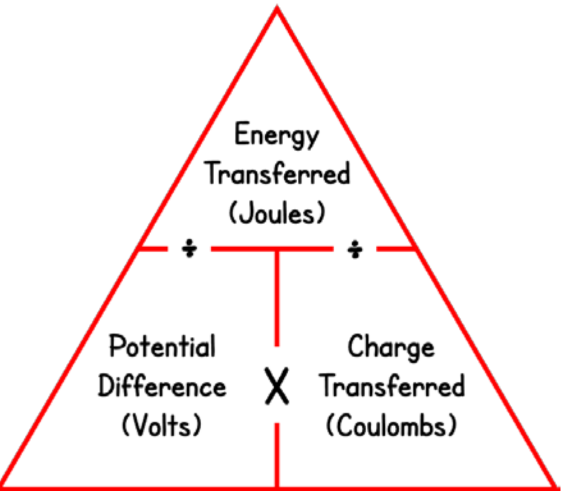
When charge is passed through a component in a circuit, it warms up. This is because the electrons collide with the atoms that are in the components.

The atoms turn this energy from kinetic into thermal energy, so vibrate faster and cause the component to get hotter. This shows scientists that energy is being transferred.

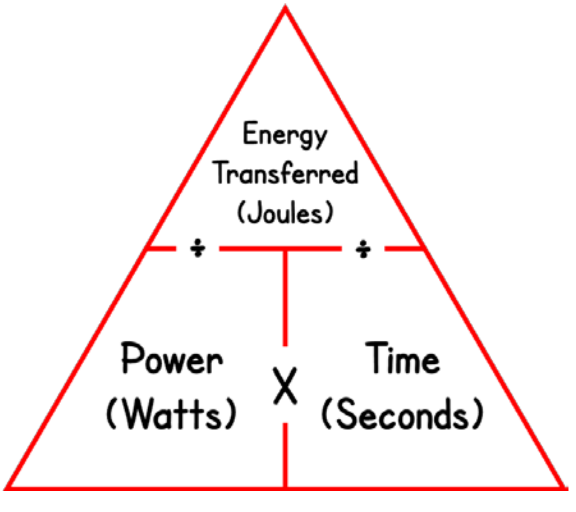
The amount of energy transferred in a circuit depends on 2 things:

- The potential difference, V, across the battery
- How much charge, Q, that flows through the circuit

This gives us the equation triangle:



Power and energy



When you turn on an electrical appliance, electrical energy starts to be converted. Depending on the appliance you are using, this could be to kinetic energy (to turn a fan in a hairdryer), or thermal energy (like in a heater).

The energy converted by a device depends on:

- The power of the device
- How long the device is being used for

This gives the equation triangle:

Power, energy and charge

Linking power, energy, and charge.

We can link together the main equations from the electricity:

$$E = P \times t \qquad E = V \times Q \qquad Q = I \times t \qquad V = I \times R$$

By linking these equations together, we can form three new equations to find the power of a device:

$$P = I \times V \qquad P = V^2/R \qquad P = I^2 \times R$$

Each equation is independent of one of the key components of a circuit. This means that we can one of the equations, even if we do not know either the current, resistance of the voltage.

Power, energy, charge, and fuses.

Most electrical items have an information plate on them. This shows the key information about the device, such as the working voltage and current. This information can be used to decide what size of fuse to put into a device.

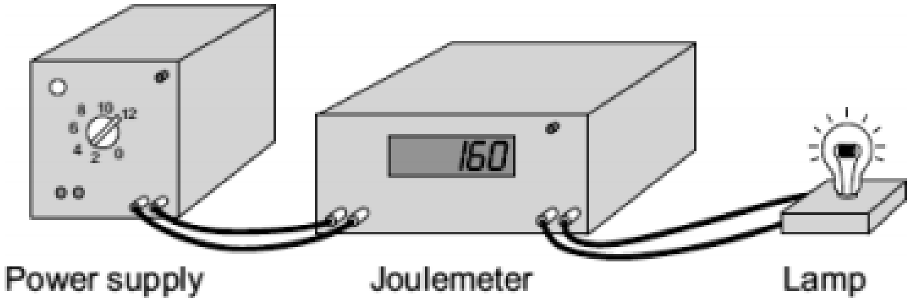
This device has a power rating of 2000W when it is using 240V. This is the potential difference supplied by plug sockets in the UK, at a frequency of 50Hz. We can use the equation $P = I \times V$ to find the maximum current that can flow through the device.

$$2000W = I \times 240V \rightarrow 2000W/240V = I = 8.33A$$

So the maximum current that can flow through this device is 8.3A. In this device, you would need to use a 13A fuse.

Q & A: Power, energy and charge

1 A student used a joule meter to measure the energy transformed by a lamp.



The student set the joule meter to 0, and then switched on the power supply. After 120 seconds, the reading on the joule meter had increased to 2880.

1.1 In the box below, draw the circuit symbol that is used to represent a lamp.

1.2 Use the equation below to calculate the power of the lamp

$$\text{Power} = \frac{\text{energy transformed}}{\text{time}}$$

Show clearly how you calculate your answer.

Include a unit in your answer.

____

____

Power = ________

Q & A: Power, energy and charge

1.3 Complete the following sentence by using one of the phrases from below.

Larger than | The same as | Smaller than

If the lamp was switched on for 10 minutes, the amount of energy transformed would be ___________ the amount of energy transformed in 2 minutes.

2.1 Write down the equation that shows the relationship between the electric current, the power and the voltage.

____

____

2.2 Calculate the energy transferred by a device that has a potential difference of 400,000V, that has transferred 2000C of charge. Show clearly how you work out your answer. Give a unit to your answer

____

____

Energy: __________

Unit: __________

3.1 State the potential difference of the UK mains electricity supply.

____

Q & A: Power, energy and charge

3.2 A cooker is connected to the UK mains supply. This electricity supply causes a current of 11 amps to flow to the cooker.

Calculate the amount of charge that flows through the cable when the cooker is switched on for 2 hours.

____

____

Charge: ________ C

3.3 Calculate the energy transferred by the cooker in 2 hours.

____

____

Energy transferred: ________ J

3.4 A device like a cooker will have an earth wire attached to the casing. This will prevent the user from receiving an electric shock if the live wire was to touch the casing. Explain how the earth wire works to prevent the user from being electrocuted.

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Electricity Unit Summary

	Covered in Lesson	Reviewed at Home	Questions Answered
Static electricity			
Using static electricity			
Electric fields			
Circuit symbols			
Current in circuits			
Series circuits			
Parallel circuits			
Current, voltage and resistance			
Ohmic conductors and semiconductors			
Sensor circuits			
AC and DC			
Plugs and the earth wire			
Power, energy and charge			

Electricity Unit Summary

Towards a grade 5	I have practiced this	I have reviewed this again	I can do this
I can identify some circuit components from their symbols.			
I can describe the interactions between positively charged and negatively charged objects (Physics Only).			
I can identify the key components of a typical three-pin plug socket.			
I can describe that current is the amount of charge that flows per second.			
I can describe what potential difference is.			
I can describe simple differences between alternating and direct current.			
I can describe the factors that affect the rate of energy transfer by a current in a circuit.			

Towards a grade 5	I have practiced this	I have reviewed this again	I can do this
I can describe the key differences between series and parallel circuits.			
I can describe how the potential difference changes with current components, including a diode, fixed resistor, filament bulb, and thermistor.			
I can explain how objects become charged in terms of electron transfer (Physics Only).			

Electricity Unit Summary

Towards a grade 5	I have practiced this	I have reviewed this again	I can do this
I can explain some of the dangers of static electricity (Physics Only).			
I can explain how to build a series circuit from a schematic diagram.			
I can explain why particular materials are used for different parts of the three-pin plug.			
I can explain why different fuses are required for different devices.			

Above a grade 5	I have practiced this	I have reviewed this again	I can do this
I can explain why sparks can be produced by charged materials in terms of charge build up (Physics Only).			
I can explain what happens to the magnitude of an electric field with the distance between charged objects (Physics Only)			
I can link my understanding of potential difference in series and parallel circuits to explain observations of the brightness of bulbs in both types of circuit.			
I can link my knowledge of the structure of metals to explain how the resistance in a filament bulb increases.			

Answers: Static Electricity

1.1 Electrons [1]

Positive [1]

1.2 The forces are the same size [1]; the strips move the same distance apart [1].

The charges are opposite [1]; the strips are repelling [1].

1.3 Aluminium [1]

2.1 Same [1]

Repel [1]

Opposite [1]

Attract [1]

2.2 Refuelling an aircraft [1]

Static electricity can create a spark [1]; this could cause the fuel to catch fire [1].

3.1 Electrons are transferred [1] from the student to the fleece [1].

3.2 Copper [1]

Copper is a conductor [1]

Allowing electrical energy to flow easily to the ground. [1]

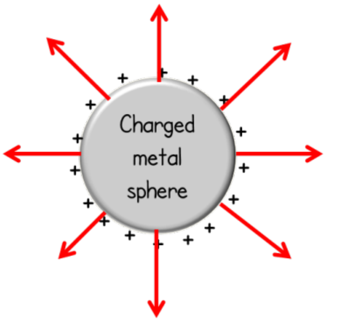
4.1 Electrons are transferred [1] from the rod to the cloth [1].

4.2 The charges on the rods repel [1] increasing the downward force on the balance [1].

Answers: Electric Fields

1.1 Electrons are transferred [1] from one object to another [1]. This creates more negative charge than positive charge on one of the objects [1], creating an overall negative charge on one of the objects [1], and an overall positive charge on the other object [1].

1.2



Straight lines pointing away [1]

Equally spaced [1]

1.3 Q

Q is closest to the sphere [1]

The closer the charges, the stronger the force felt [1]

OR

The force felt decreases with the distance between the objects [1].

Answers: Circuit Symbols and Current

1 Cell/Battery/Power pack [1]

2 Coulombs

2 Contd. Amps

Seconds

3.1 $Q = 3 \times 20$ [1]

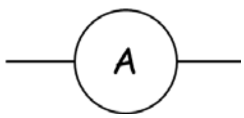
60(C) [1]

3.2 10 mins = 600s [1]

$Q = 3 \times 600$ [1]

1800 (C) [1]

4 Answers left to right



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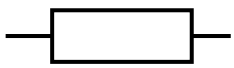

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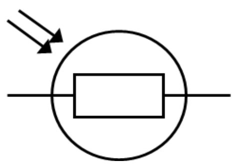

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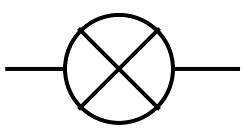

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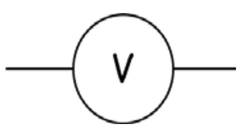
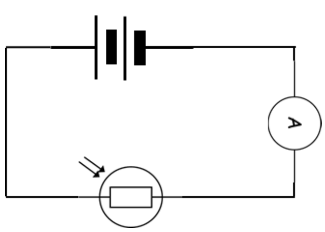


[1]

5 1 mark for each correct component (max. 3), 1 mark for the ammeter in series.



6.1 5A [1]

The current flowing in a series circuit is the same at all points. [1]

6.2 $Q = I \times t$ [1]

1 hour = 3600s [1]

5A x 3600s [1]

18,000 [1]

C/Coulombs [1]

Answers: Series and Parallel

1.1 A [1]

1.2 4V [1]

1.3 The potential difference is shared across all components in series/PD over components is equal to PD of battery in a series circuit [1].

1.4 12V [1]

1.5 1.5A [1]

1.6 The current flowing in a series circuit is the same at all points [1].

2.1 $Q = I \times t$ [1]

13A x 180s [1]

2340 (C) [1]

2.2 $E = V \times Q$ [1]

230V x 2340 [1]

538,200 (J) [1]

Chlng. $\Delta T = (100-22) = 78°C$ [1]

538,200J = m x 4200J/kg°C x 78°C [1]

538,200J/(4200J/kg°C x 78°C) [1]

m = 1.64kg [1]

Answers: Current, Voltage and Resistance

1.1 Voltage [1]

1.2 Increases [1]

1.3 Decreases [1]

2 V = I x R [1]

20Ω x 4A [1]

80V [1]

3 R = V/I [1]

12V/3A [1]

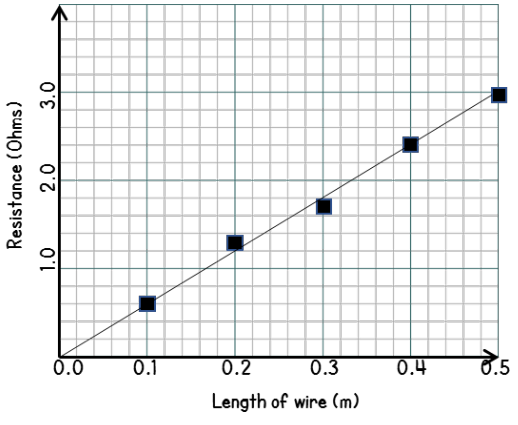
4Ω [1]

4.1 Record current and voltage for different lengths of wire [1], then used R = V/I to calculate the resistance [1].

4.2 Points correctly plotted [1]

Straight line of best fit from bottom left to top right [1].

Axes [1] and titles [1].



4.3 As the length of the wire increases, the resistance increases [1].

5.1 Anomalous result circled at 4 resistors [1].

5.2 Line of best fit as a straight line, from 0,0 to top right through all points, ignoring anomalous result. [1]

5.3 8Ω

5.4 Line of best fit for 1Ω resistors to be less steep/be drawn below the line of best fit for 2Ω resistors

Line of best fit for 5Ω resistors to be more steep/drawn above the line of best fit for 2Ω resistors.

6 Equipment list 2 marks for all equipment; 1 mark for 3 pieces of relevant equipment; 0 marks for less than this. List should include: Ammeter, Voltmeter, Wires, Power pack, Resistors.

2 marks for a correct circuit, 1 mark for all circuit symbols drawn correctly. 0 marks for a circuit that has either - less than 1 piece of equipment drawn correctly OR a circuit that does not include a voltmeter AND an ammeter.

Instructions:

1) Turn on the power pack and measure the current flowing through the resistor [1].

2) Measuring the PD across the resistor [1].

6 contd. 3) Use R= V/I to calculate the resistance of the circuit [1].

4) Turn off the power pack. No mark awarded.

5) Add another resistor and repeat the previous steps [1].

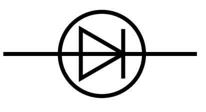
Answers: Ohmic Conductors and Semiconductors.

1.1 Graph D ticked [1].

1.2 A proportional relationship [1].

1.3 Ohmic [1]

Linear [1]

2.1  [1]

2.2 The resistance of an LDR is dependent on light [1], so it will have been darker in the room [1].

3.1 Ammeter should be in series [1] and voltmeter should be in parallel [1].

3.2 12 (V) [1]

3.3 A smooth curve [1] going through all points AND 0,0 [1].

3.4 2.5-3.5V [1]

3.5 As the current increases, the resistance increases [1], resistance increases with temperature in a filament lamp [1].

3.6 A component where the current is *proportional* to the PD [1] at a constant temperature [1].

3.7 Resistor/Variable resistor [1].

3.8 6V [1]

3.9 Up until this point, the current is *proportional* to the PD [1].

Answers: Sensor Circuits

1.1 2 marks for a correct circuit, 1 mark for all circuit symbols drawn correctly. 0 marks for a circuit that has either - less than 1 piece of equipment drawn correctly OR a circuit that does not include a voltmeter AND an ammeter.

1.2 You need voltage and current to calculate resistance [1].

2.1 Increases [1]

Increases [1]

2.2 Temperature [1]

Decreases [1]]

2.3 Brightness [1]

Increases [1]

3 4 [1]

2 [1]

3 contd. 1 [1]

5 [1]

3 [1]

4 At low temperatures, the resistance of the thermistor is high [1]

As the fridge gets warmer, the resistance decreases [1]

This allows current to power the cooling system [1]

5.1 To reduce turning them on too early [1]/so people don't forget to turn them off [1]/ to save electricity [1]. Any other reasonable explanation.

5.2 2 marks for a correct circuit, 1 mark for all circuit symbols drawn correctly. 0 marks for a circuit that has either - less than 1 piece of equipment drawn correctly.

5.3 When it is light, the resistance of the LDR is low [1] allowing current to flow through the LDR [1]. As it gets darker, the resistance of the LDR increases [1] causing more current to flow through the bulb [1], turning the bulb on.

Answers: AC and DC

1.1 A [1]

1.2 As the direction of the trace is constantly changing [1]

2.1 5 squares across [1]

time period of 5 x 0.005s

T = 0.025s [1]

2.2 f = 1/T [1]

f = 1/0.025s

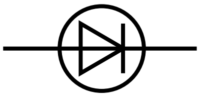
f = 40Hz [1]

2.3 The live terminal varies between a large positive value and a large negative value [1]

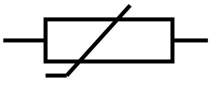
The neutral terminal is close to 0V [1]

When the live reading is at a maximum, the neutral reading is at a minimum [1].

3.1 Diode [1]



Variable resistor [1]



3.2 4 squares across [1]

T = 4 x 0.1s = 0.4s [1]

f = 1/T = 1/0.4 = 2.5 (Hz) [1]

3.3 Diode only allows a current to flow in one direction [1]

This means that only the current in one direction will be allowed through [1] from the ac power supply

Anything below 0V will appear flat [1]

Answers: Plugs and the Earth Wire.

1.1 A Fuse [1]

B Cable grip [1]

1.2 X Brown [1]

Y Green & Yellow [1]

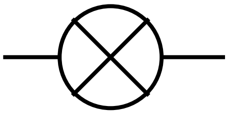
Z Blue [1]

1.3 Plastic/Ceramic [1]

1.4 Electric current is how much charge flows past a point in one second [1].

I = Q/t OR Q = I x t [1]

Answers: Power, Energy and Charge

1.1  [1]

1.2 P = E/t

P = 2880J/120s [1]

P = 24 [1] W [1]

1.3 Larger than [1]

2.1 V = E/Q [1]

2.2 V x Q = E [1]

400,000V x 2000C [1]

E = 800,000,000[1]

Accept answers in standard form.

J [1]

3.1 230V [1]

Q = I x t [1]

t = 2 x 60 x 60 = 7200s [1]

Q = 7200s x 11A [1]

79,200 (C) [1]

3.3 V x Q = E [1]

230V x 79,200C (or other answer from 3.2 [1]

E = 18,216,000 (J) [1]

Accept answers that have been rounded to sensible SF.

3.4 Earth wire is connected to the ground (0V) [1]

And provides a safe route for current to flow if live wire touches casing [1].

The earth wire has a low resistance to make it easier for current to flow through it [1].