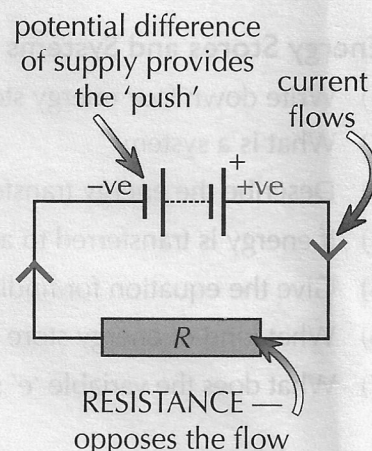


Current and Circuit Symbols

Isn't electricity great? Mind you it's pretty bad news if the words don't mean anything to you...

Current is the flow of Electric Charge

- 1) Electric current is the flow of electric charge round the circuit. Current will only flow around a complete (closed) circuit if there's a potential difference. So a current can only flow if there's a source of potential difference. Unit of current: ampere, A.
- 2) In a single, closed loop (like the one on the right) the current has the same value everywhere in the circuit (see p.48).
- 3) Potential difference (or voltage) is the driving force that pushes the charge round. Unit of potential difference: volt, V.
- 4) Resistance is anything in the circuit which slows the flow down. Unit of resistance: ohm, Ω .
- 5) The current flowing through a component depends on the potential difference across it and the resistance of the component (see next page).



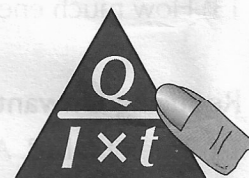
The greater the resistance across a component, the smaller the current that flows through it (for a given potential difference across the component).

Total Charge Through a Circuit Depends on Current and Time

- 1) The size of the current is the rate of flow of charge. When current (I) flows past a point in a circuit for a length of time (t) then the charge (Q) that has passed is given by this formula:

$$\text{Charge (C)} = \text{Current (A)} \times \text{Time (s)}$$

$$Q = It$$



- 2) Current is measured in amperes (A), charge is measured in coulombs (C), time is measured in seconds (s).
- 3) More charge passes around the circuit when a bigger current flows.

EXAMPLE:

A battery charger passes a current of 2.0 A through a cell over a period of 2.5 hours. How much charge is transferred to the cell?

$$Q = It = 2.0 \times (2.5 \times 60 \times 60) = 18\,000\text{ C}$$

Learn these Circuit Diagram Symbols

You need to be able to understand circuit diagrams and draw them using the correct symbols. Make sure all the wires in your circuit are straight lines and that the circuit is closed, i.e. you can follow a wire from one end of the power supply, through any components, to the other end of the supply (ignoring any switches).

Cell 	Battery 	Switch open 	Switch closed 	Filament lamp (or bulb) 	Fuse 	LED
Resistor 	Variable resistor 	Ammeter 	Voltmeter 	Diode 	LDR 	Thermistor

Resistance

Prepare yourself to meet one of the most important equations in electronics. It's all about resistance, current and potential difference... Now if that doesn't tempt you on to read this page, I don't know what will.

There's a Formula Linking Potential Difference and Resistance

The formula linking potential difference, current and resistance is very useful (and pretty common):

You may see potential difference called voltage.

$$\text{Potential difference (V)} = \text{Current (A)} \times \text{Resistance (}\Omega\text{)}$$

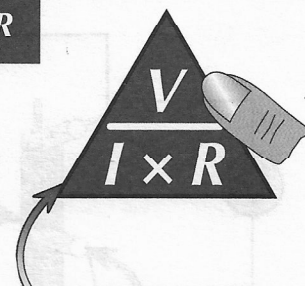
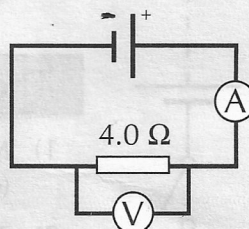
$$V = IR$$

EXAMPLE:

Voltmeter V reads 6.0 V and resistor R is 4.0 Ω .
What is the current through ammeter A?

- 1) Use the formula triangle for $V = I \times R$.
- 2) We need to find I ,
so the version we need is $I = V \div R$.
- 3) The answer is then:

$$I = 6.0 \div 4.0 = 1.5 \text{ A}$$



Use this formula triangle to rearrange the equation. Just cover up the thing you're trying to find, and what's left visible is the formula you're after.

Ohmic Conductors Have a Constant Resistance

For some components, as the current through them is changed, the resistance of the component changes as well.

- 1) The resistance of ohmic conductors (e.g. a wire or a resistor) doesn't change with the current. At a constant temperature, the current flowing through an ohmic conductor is directly proportional to the potential difference across it. (R is constant in $V = IR$.)
- 2) The resistance of some resistors and components does change, e.g. a filament lamp or a diode.
- 3) When an electrical charge flows through a filament lamp, it transfers some energy to the thermal energy store of the filament (p.17), which is designed to heat up. Resistance increases with temperature, so as the current increases, the filament lamp heats up more and the resistance increases.
- 4) For diodes, the resistance depends on the direction of the current. They will happily let current flow in one direction, but have a very high resistance if it is reversed.

Resistance can be temperamental when it comes to temperature...

Remember that ohmic conductors will only have a constant resistance at a constant temperature. In general, resistance increases with temperature (though there are some exceptions, like thermistors — see p.45). So if the temperature is changing, the resistance of your component will be changing too.

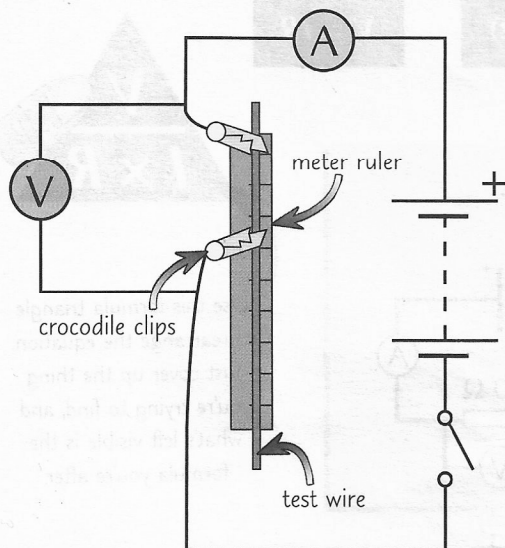
PRACTICAL

Investigating Resistance

Resistance can depend on a number of factors. Here's an experiment you can do to investigate one of them — how the resistance varies with the length of the conductor.

You Can Investigate the Factors Affecting Resistance

The resistance of a circuit can depend on a number of factors, like whether components are in series or parallel, p.50, or the length of wire used in the circuit. You can investigate the effect of wire length using the circuit below.



The Ammeter

- 1) Measures the current (in amps) flowing through the test wire.
- 2) The ammeter must always be placed in series with whatever you're investigating.

The Voltmeter

- 1) Measures the potential difference (or pd) across the test wire (in volts).
- 2) The voltmeter must always be placed in parallel around whatever you're investigating (p.49) — NOT around any other bit of the circuit, e.g. the battery.

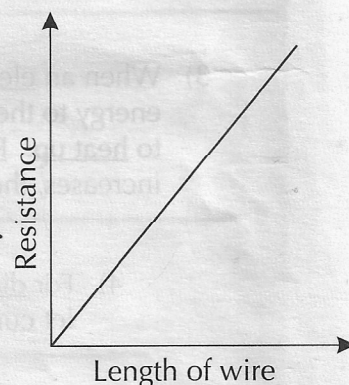
See pages 47-49 for more on series and parallel circuits.

Method

- 1) Attach a crocodile clip to the wire, level with 0 cm on the ruler.
- 2) Attach the second crocodile clip to the wire, e.g. 10 cm away from the first clip. Write down the length of the wire between the clips.
- 3) Close the switch, then record the current through the wire and the pd across it.
- 4) Open the switch, then move the second crocodile clip, e.g. another 10 cm, along the wire. Close the switch again, then record the new length, current and pd.
- 5) Repeat this for a number of different lengths of the test wire.
- 6) Use your measurements of current and pd to calculate the resistance for each length of wire, using $R = V \div I$ (from $V = IR$).
- 7) Plot a graph of resistance against wire length and draw a line of best fit.
- 8) Your graph should be a straight line through the origin, meaning resistance is directly proportional to length — the longer the wire, the greater the resistance.
- 9) If your graph doesn't go through the origin, it could be because the first clip isn't attached exactly at 0 cm, so all of your length readings are a bit out. This is a systematic error (p.7).

A thin wire will give you the best results. Make sure it's as straight as possible so your length measurements are accurate.

The wire may heat up during the experiment, which will affect its resistance (p.41). Leave the switch open for a bit between readings to let the circuit cool down.



Be careful with the temperature of the wire...

If a large current flows through a wire, it can cause it to heat up (there's more on this on page 41). So use a low pd to stop it getting too hot and turn off the circuit between readings to let it cool.

I-V Characteristics

PRACTICAL

You've met ohmic conductors already on page 41, but most circuit components aren't ohmic. You can see how circuit components behave by plotting an I-V characteristic.

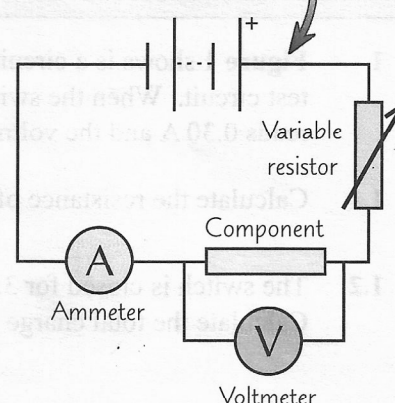
Three Very Important I-V Characteristics

- 1) The term 'I-V characteristic' refers to a graph which shows how the current (I) flowing through a component changes as the potential difference (V) across it is increased.
 - 2) Linear components (e.g. an ohmic conductor) have an I-V characteristic that's a straight line.
 - 3) Non-linear components (e.g. a filament lamp or a diode) have a curved I-V characteristic.
- You can do this experiment to find a component's I-V characteristic:

Method

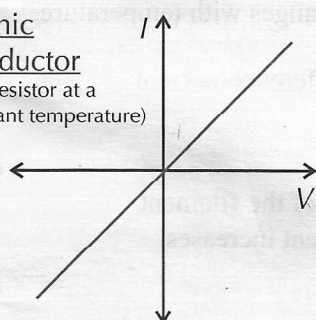
- 1) Set up the test circuit shown on the right.
- 2) Begin to vary the variable resistor. This alters the current flowing through the circuit and the potential difference across the component.
- 3) Take several pairs of readings from the ammeter and voltmeter to see how the potential difference across the component varies as the current changes. Repeat each reading twice more to get an average pd at each current.
- 4) Swap over the wires connected to the cell, so the direction of the current is reversed.
- 5) Plot a graph of current against voltage for the component.

This type of circuit uses direct current (dc) (p.52) and is a series circuit (p.47).



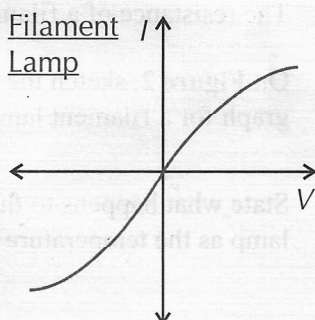
The I-V characteristics you get for an ohmic conductor, filament lamp and diode should look like this:

Ohmic Conductor
(e.g. resistor at a constant temperature)



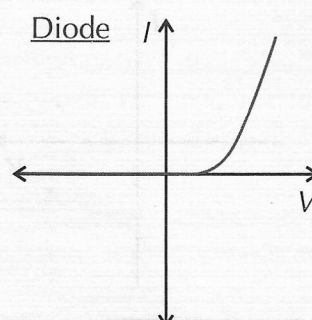
The current through an ohmic conductor (at a constant temperature) is directly proportional to potential difference, so you get a straight line.

Filament Lamp



As the current increases, the temperature of the filament increases, so the resistance increases. This means less current can flow per unit pd, so the graph gets shallower — hence the curve.

Diode



Current will only flow through a diode in one direction, as shown. The diode has very high resistance in the reverse direction.

Since $V = IR$, you can calculate the resistance at any point on the I-V characteristic by calculating $R = V \div I$.



You may be asked to interpret an I-V characteristic...

Make sure you take care when reading values off the graph. Pay close attention to the axes, and make sure you've converted all values to the correct units before you do any calculations.