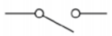
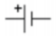
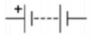
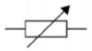
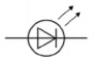
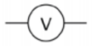
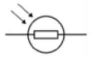
Electricity P2

1. Circuit symbols

	Open switch	
	Closed switch	
	Cell	
	Battery	
	Diode	Used in a circuit to prevent electricity flowing the wrong way.
	Fixed resistor	Used in a circuit to reduce the flow of current.
	Variable resistor	Used in a circuit so more or less current can flow as desired. Adjusted manually.
	LED (Light emitting diode)	An alternative source of light to a bulb. Only works when connected in the correct direction, like a diode, it only allows current to flow one way.
	Lamp	
	Fuse	Used to break the circuit by melting when the current flowing is too high.
	Voltmeter	Measures potential difference in Volts. Must be connected in parallel.
	Ammeter	Measures current in Amps. Must be connected in series.
	Thermistor	Used in a circuit when you want the amount of current flowing to automatically change when the temperature changes.
	LDR (Light dependent resistor)	Used in a circuit when you want the amount of current flowing to automatically change when the light intensity changes.

2. Conversions

Prefix	Full name	What it means	Example
k	kilo	1,000	e.g. 2kΩ = 2,000Ω
M	mega	1,000,000	e.g. 3MJ = 3,000,000J
m	milli	$\frac{1}{1000}$ = 0.001	e.g. 6mA = 0.006A

3. Formulae

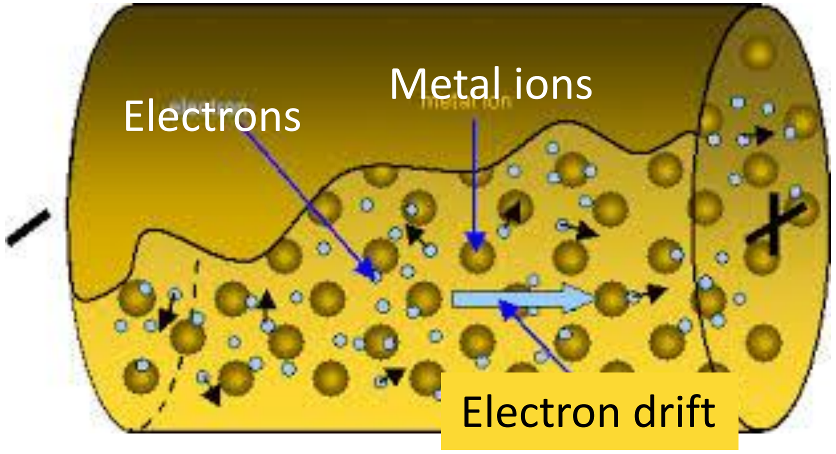
1. V = I x R (Ohm's law)	Potential difference (V) = Current (A) x Resistance (Ω)
2. Q = I x t	Charge (C) = Current (A) x Time (seconds)
3. E = V x Q	Energy (J) = Potential difference (V) x Charge (C)
4. P = E ÷ t	Power (W) = Energy transferred (J) ÷ Time (seconds)
5. P = W ÷ t	Power (W) = Work done (J) ÷ Time (seconds)
6. P = V x I	Power (W) = Potential difference (V) x Current (A)
7. P = I^2 x R	Power (W) = Current^2 (A) x Resistance (Ω)

4. Definitions

1. Current	The rate of flow of charge/electrons. Measured in amps with an ammeter connected in series.
2. Potential difference	The energy transferred per coulomb of charge that has passed. Measured in volts with a voltmeter connected in parallel.
3. Resistance	A measure of a substance's opposition to the flow of charge/electrons. Measured in Ohms (Ω)
4. Charge	A measure of how much negative or positive charge has passed through. Measured in Coulombs (C)
5. Connected in series	Components are connected next to each other, in a line, end to end.
6. Connected in parallel	Components are connected on separate parallel branches that are all connected to the power supply.
7. Alternating current	Current that changes its direction repeatedly, so the charge/electrons move forwards and backwards. Produced by an alternating voltage.
8. Direct current	Current that has a constant direction, the charge/electrons move only towards the side that they are attracted to. Produced by a direct voltage.
9. National grid	A system of pylons, cables and transformers that are used to efficiently deliver electricity from power stations to consumers.
10. Transformer	A device used to change the value of the potential difference (and current) of the electricity being delivered.
11. Power	The rate of transfer of energy. Measured in Watts (or Joules per second).
12. Electric field	An area around an electrically charged object within which other charged objects experience a force.

5. Resistance

Resistance is caused by the electrons colliding with the metal ions in the wire and consequently losing energy from their kinetic energy store and transferring it to the thermal energy store of the material by making the ions vibrate more.



6. The factors that affect resistance

- Length of wire – longer means more ions for the electrons to collide with.
- Cross-sectional area/diameter of wire – thinner means increased chance of electrons colliding with ions because they all have to move through a small area.
- Type of conductor – different substances have different numbers of free electrons. More free electrons means more have a chance of passing through without colliding.
- Temperature – hotter means the ions vibrate on the spot with larger vibrations, so there is an increased chance of the electrons colliding with them.

7. Required practical: the effect of length of wire on its resistance

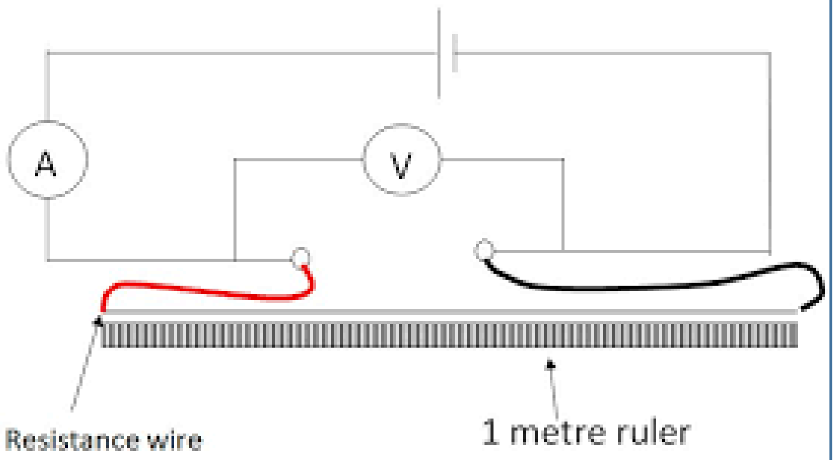
Independent variable: Length of wire

Dependent variable: Resistance

Control Variables: Temperature/time power left on, diameter of wire, type of metal

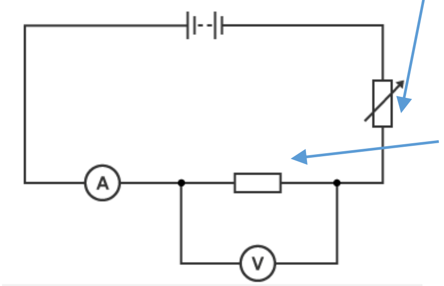
- Measure out a length of wire 100cm long.
- Connect one end of it with a crocodile clip to an ammeter and then a power supply and then the other end of the wire to the other side of the power supply.
- Switch on the power and take readings of current and potential difference.
- Calculate resistance by dividing potential difference by current.
- Move the crocodile clip on one end of the wire until it is now 90cm long and take new readings.
- Repeat, making the wire 10cm shorter every time.
- Repeat the whole experiment three times so anomalous results can be spotted and a more accurate mean value calculated.
- Plot a line graph, because the data is continuous, with length on the x axis and resistance on the y axis.

Errors: The main errors are likely to come from the wire getting hotter whilst it is switched on and the length measurements/placement of the crocodile clip not being accurate. The readings on the ammeter and voltmeter may also fluctuate.



8. Current – Potential difference (I-V) Graphs

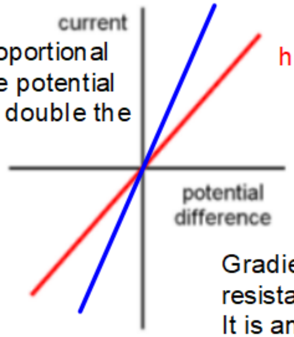
Investigate the relationship between the potential difference and current for different components using the following circuit. The variable resistor can be adjusted to change the potential difference and current values.



Change the component here to collect data for a different component

Fixed resistor

Directly proportional (double the potential difference, double the current)

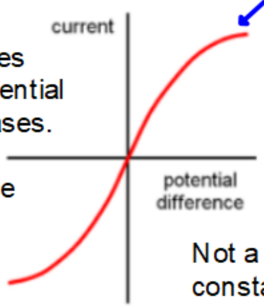


Gradient is constant, so resistance is constant. It is an Ohmic conductor.

Filament lamp/bulb

Gradient becomes shallower as potential difference increases.

Shallower = more resistance.

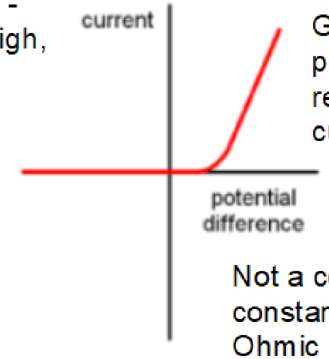


More potential difference, means the bulb is brighter and hotter, so the ions vibrate more, the electrons collide with the ions more and the resistance is higher.

Not a constant gradient = not a constant resistance = non-Ohmic resistor

Diode

Gradient flat in negative potential difference - resistance is very high, no current can flow



Gradient very steep in positive potential difference - resistance is very low, lots of current flows.

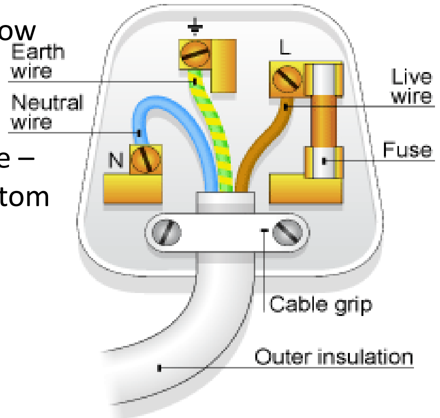
Not a constant gradient = not a constant resistance = non-Ohmic resistor

10. Plugs

Plugs may use two core cable or three core cable. Two core cable does not have an Earth wire in it. This sort of cable can only be used in appliances with plastic casing – this is called double insulation.

Green/yellow stripy - top

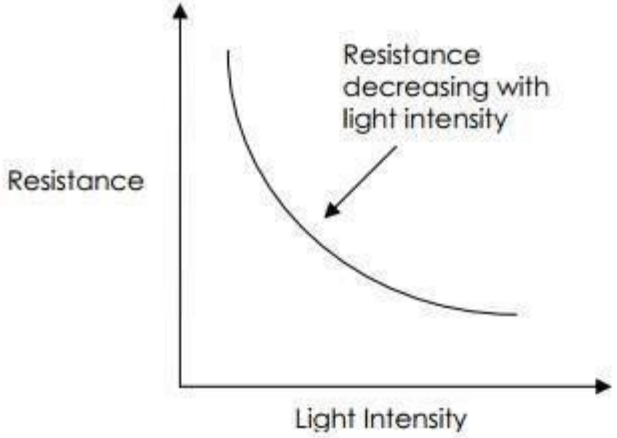
Blue – bottom left



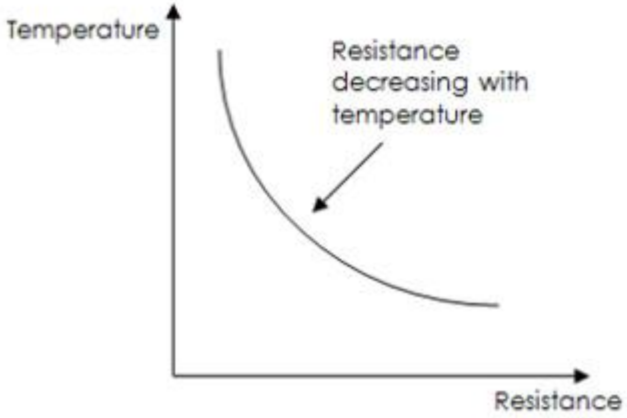
Brown – bottom right

9. LDRs and Thermistors

LDRs – change resistance automatically when light intensity changes. Could be used in circuits for street lights etc.



Thermistors - change resistance automatically when light intensity changes. Could be used in circuits for kettles, fire alarms, incubators etc.



11. Resistors in series and parallel circuits required practical

Aim: to find out how connecting resistors in series and parallel affects the total resistance

- Take two 100Ω resistors and connect them in series with an ammeter in series and a voltmeter in parallel across both resistors.
- Record the current and potential difference readings.
- Calculate the total resistance by taking the potential difference and dividing by the current.
- Then change the circuit so the two resistors are connected in parallel, with the ammeter connected immediately next to the battery and the voltmeter across the battery.
- Again record the readings and calculate the total resistance.

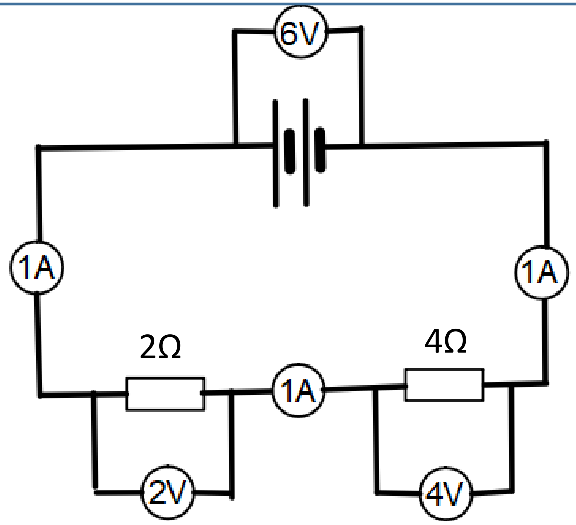
Conclusion: in series circuits the total resistance is equal to the resistance of the individual resistors added together e.g. 100Ω + 100Ω = 200Ω. Whereas in parallel, the total resistance is actually less than either of the resistors e.g. with 100Ω and 100Ω in parallel the total resistance is 50Ω.

12. Series circuits

In a series circuit the CURRENT remains the SAME throughout because there is only one path round the circuit.

However, the POTENTIAL DIFFERENCE from the battery is SPLIT across the components.

The total resistance is found by simply adding the values of the resistors. $R_T = R_1 + R_2 + \ldots$ e.g. Total resistance in the circuit below = 100 + 50 = 150Ω. If more resistors are added the total resistance goes up and the current goes down.

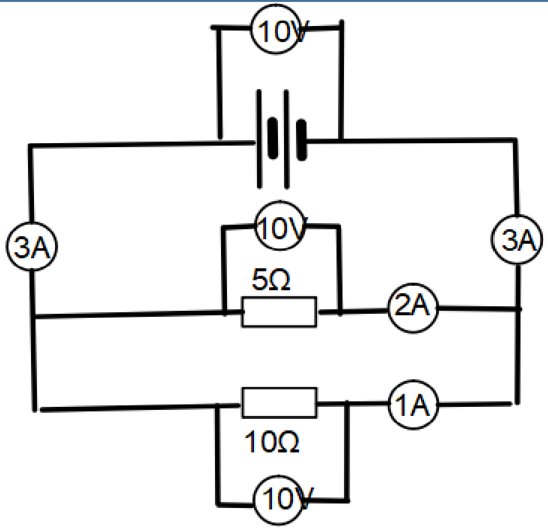


13. Parallel circuits

In a parallel circuit the POTENTIAL DIFFERENCE across the battery and components remains the SAME.

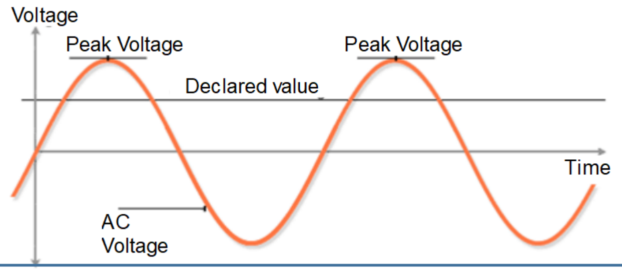
However, the CURRENT from the battery is SPLIT into the separate branches.

The total resistance doesn't add up in the same way as series circuits, in fact the total resistance decreases when more resistors are added. This is because the branches draw the same current as before and then with another branch there is more current drawn from the battery; with more current comes less resistance.



14. UK Mains Supply

UK mains supply operates at 50Hz and an average of 230V (but the actual potential difference alternates between 325V and -325V).



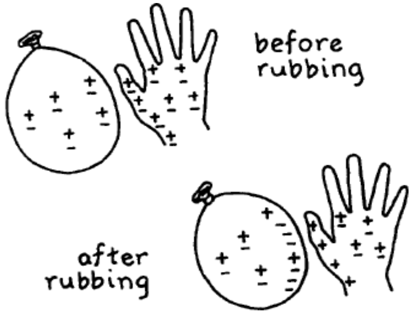
15. The Earth Wire

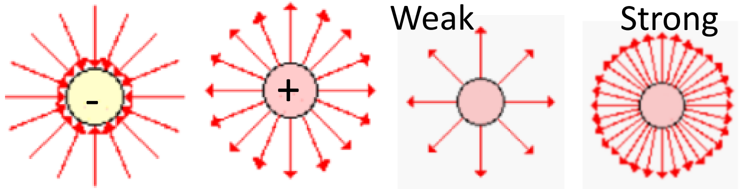
If you touch the live wire or the metal case of an appliance where the live wire is touching the case, current will flow through your body and into the ground. To help prevent this the Earth wire is connected to the INSIDE OF THE METAL CASE and allows current to flow through it instead. This current would be very large and will cause the FUSE WIRE TO MELT.

17. Static – SEPARATES ONLY

Static charge builds up when ELECTRONS TRANSFER between two objects, usually because they have been rubbed together. The object that gains electrons becomes negatively charged and the object that loses electrons becomes positively charged.

ELECTRIC FIELD LINES POINT FROM POSITIVE TO NEGATIVE. They are always at right angles to the surface. If a charged object is placed inside an electric field it will experience a



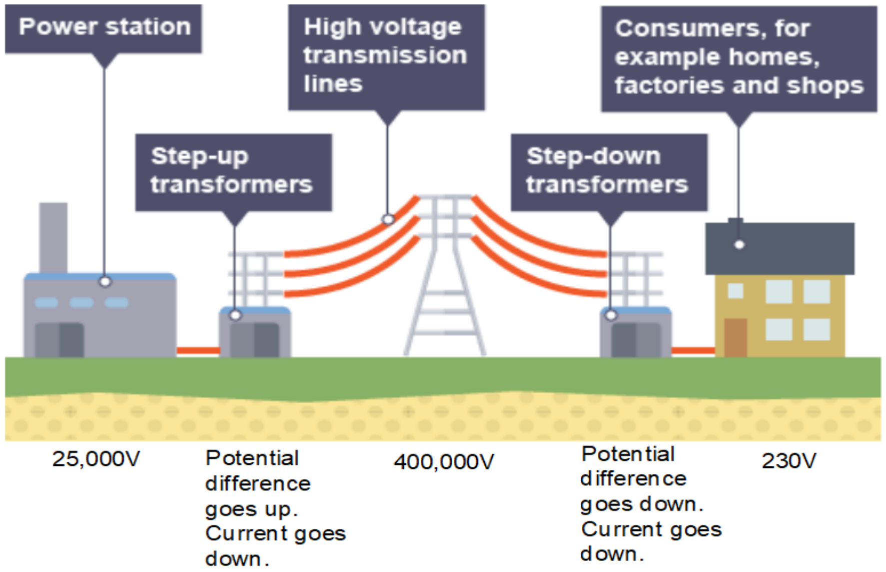


The CLOSER together the electric field lines are the STRONGER the electric field. As you move away from a charged object the field lines get further apart from one another, showing the field getting weaker.

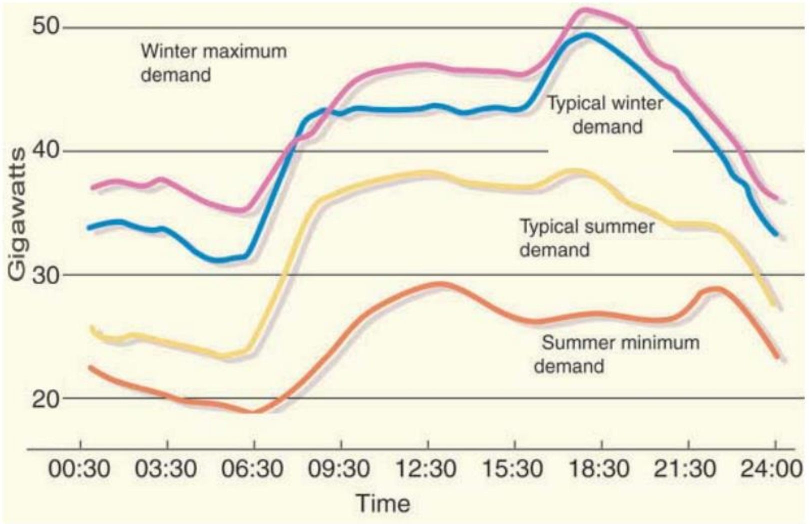
If the electric field is strong there is a large potential difference between the charged object and Earth. This can cause IONISATION (removal of electrons) of the air molecules between the charged object e.g. storm cloud, and Earth. This ionisation makes the air a BETTER CONDUCTOR and so a current can flow through it and discharge the object – this will be observed as a SPARK.

16. The National Grid

The STEP UP transformers are needed so they REDUCE THE CURRENT, resulting in less resistance and less energy transferring to the thermal energy store of the environment. The system is more EFFICIENT.



The STEP DOWN transformers are needed to REDUCE THE POTENTIAL DIFFERENCE back down to safe and usable levels that do not result in electrocution, electrical fires or damage to electrical appliances.



The national grid ensures that electrical SUPPLY KEEPS UP WITH DEMAND. They turn on and off some power stations e.g. gas-fired power stations and can store some surplus energy in hydroelectric dams by pumping water back into the top reservoir. Demand varies with season, time of day and events.