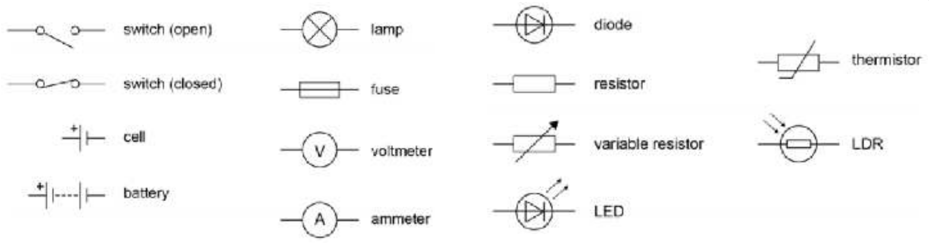
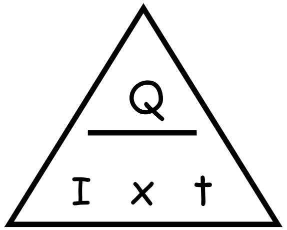
P2



Wires are represented by straight, horizontal or vertical lines drawn with a ruler.
The circuit must form a loop for the current to be able to flow and the components to function.

The size of the electric current is the rate of flow of electrical charge.
The equation for charge flow is:
Q = I x t
Charge flow = Current x time

Q = Charge flow (C)
I = Current (A)
t = time (s)



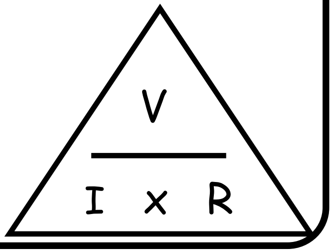
For electrical charge to flow through a closed circuit the circuit must include a **source of potential difference**. A source of potential difference could be a cell/battery or mains power (from a socket).

Electric current is a flow of electrical charge (electrons).

Current is the same at any point in a series circuit.

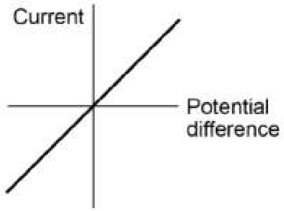
Ohm's law links current, potential difference and resistance. The equation for Ohm's law is: V = I x R
Potential difference = Current x Resistance

V = Potential difference (V)
I = Current (A)
R = Resistance (Ω)



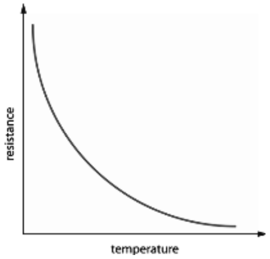
The **current (I)** through a component **depends on both the resistance (R)** of the component **and the potential difference (V)** across the component.
The **greater the resistance** of the component the **smaller the current** for a given potential difference (PD) across the component.

The current through an **ohmic conductor** (at a constant temperature) is directly proportional to the potential difference across the resistor. This means that the **resistance remains constant** as the current changes.



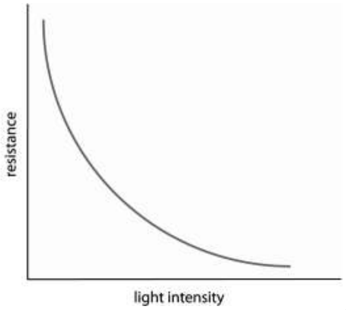
The **resistance of a thermistor decreases** as the **temperature increases**.

A thermistor could be used in a thermostat to detect changes in temperature.



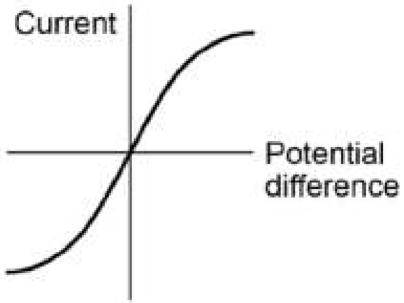
The **resistance of an LDR decreases as light intensity increases** .

An LDR could be used to switch on lights when it gets dark.

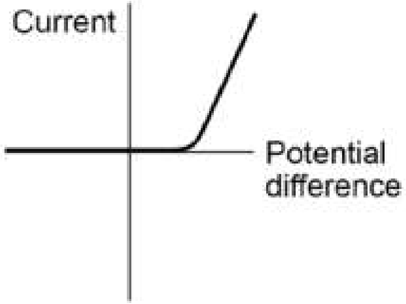


The **resistance of components such as lamps, diodes, thermistors and LDRs is not constant**; it changes with the current through the component.

The **resistance** of a filament lamp **increases as the temperature** of the filament **increases**.



The **current** through a diode flows **in one direction only**. The diode has a very high resistance in the reverse direction.

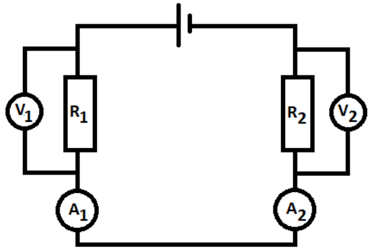


P2

In a series circuit there is a single loop, the current has **only one path** to take.
In a parallel circuit the current has a choice of paths.

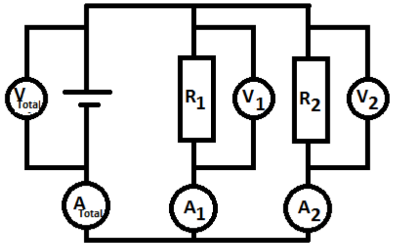
For components **in series**:

- there is the **same current through each component**
  $I_1 = I_2$
- the **total potential difference** of the power supply is **shared between the components**
  $V_{Total} = V_1 + V_2$
- the **total resistance** of two components is the **sum of the resistance of each component**
  $R_{total} = R_1 + R_2$



For components **in parallel**:

- the **potential difference across each component is the same**
  $V_1 = V_2$
- the **total current through the whole circuit is the sum of the currents** through the separate components
  $I_{Total} = I_1 + I_2$
- **the total resistance of two resistors is less than the resistance of the smallest individual resistor**.

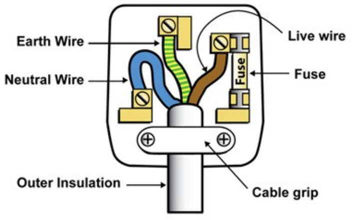


Mains electricity is an AC supply. In the United Kingdom the **domestic electricity supply** has a **frequency of 50 Hz** and is about **230 V**.

The insulation covering each wire is colour coded for easy identification:

- live wire – brown
- neutral wire – blue
- earth wire – green and yellow

The **live wire carries the alternating potential difference** from the supply.
The **neutral wire completes the circuit**. The neutral wire is at, or close to, earth potential (0 V).
The potential difference between the live wire and earth (0 V) is about 230 V.
The **earth wire is a safety wire** to stop the appliance becoming live. The earth wire is at 0 V, it only carries a current if there is a fault.

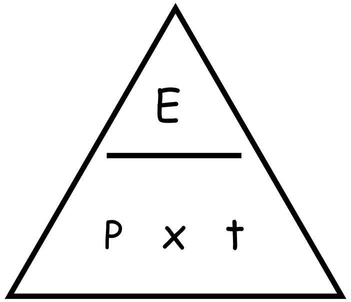


Remember the equation linking power, energy transferred and time which we have met before:

$E = P \times t$

Energy transferred = Power x time

P = Power (W)
E = Energy transferred (J)
t = time (s)

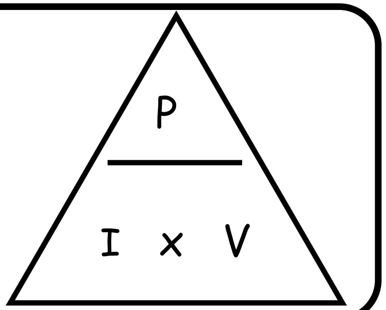


We can also link the power, potential difference and current in an equation:

$P = V \times I$

Power = Potential difference x Current

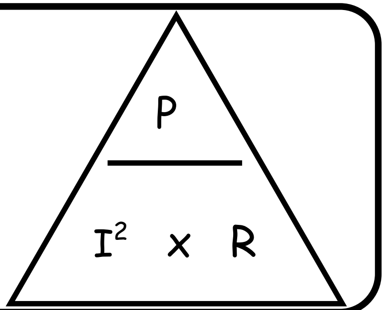
P = Power (W)
V = Potential difference (V)
I = Current (A)



We can also link the power, resistance and current in an equation: $P = I^2 \times R$

Power = Current^2 x Resistance

P = Power (W)
R = Resistance (Ω)
I = Current (A)

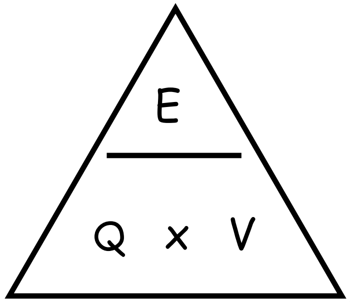


We can also find energy transferred from the potential difference and the charge:

$E = Q \times V$

Energy transferred = Charge x Potential difference

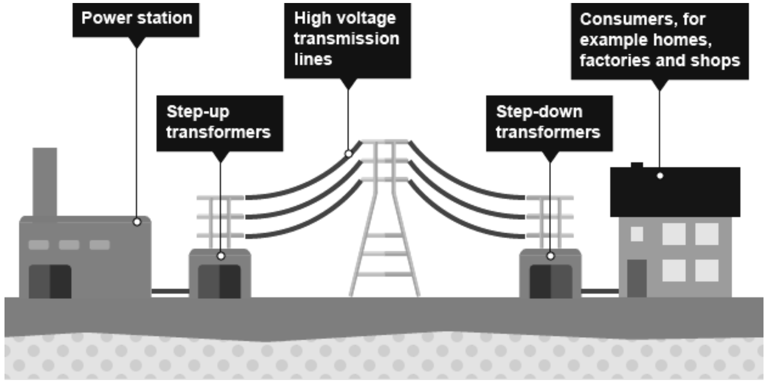
E = Energy transferred (J)
Q = Charge (C)
V = Potential difference (V)



Everyday electrical appliances are designed to bring about energy transfers.
Work is done when charge flows in a circuit. The **work done is the same as the energy transferred**.

P2

The **National Grid is a system of cables and transformers** linking power stations to consumers.
Electrical power is transferred from power stations to consumers using the National Grid.
Step-up transformers are used to increase the potential difference from the power station to the transmission cables then step-down transformers are used to decrease, to a much lower value, the potential difference for domestic use.



There are two types of transformers:

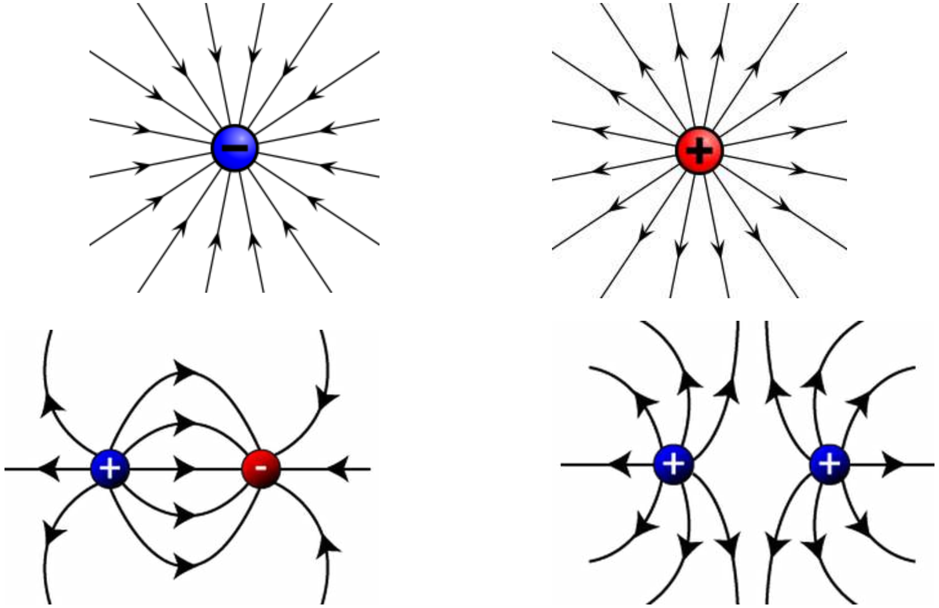
- Step up transformers (Increase voltage, decrease current)
- Step down transformers (Decrease voltage, increase current)

You can have the same amount of power with a high voltage and low current or a high current and a low voltage. (P = IV)

Transformers are important because is **if an overhead line is carrying a large electric current, it heats up and energy is wasted** by heating.

If instead, the electricity is transmitted at a really high voltage, the current we need to transfer the same amount of energy can be much less and so less energy is wasted as heat.

A charged object creates an electric field around itself.
The **electric field is strongest close to the charged object**. The further away from the charged object, the weaker the field.
A second **charged object placed in the field experiences a force**. The force gets stronger as the distance between the objects decreases.



When certain insulating materials are rubbed against each other they become electrically charged.

Negatively charged electrons are rubbed off one material and on to the other. The **material that gains electrons becomes negatively charged**. The material **that loses electrons is left with an equal positive charge**.

When two electrically charged objects are brought close together they **exert a force on each other**. Two objects that carry the **same type of charge repel**. Two objects that carry **different types of charge attract**. Attraction and repulsion between two charged objects are examples of **non-contact force** (they don't have to be touching for there to be a force).

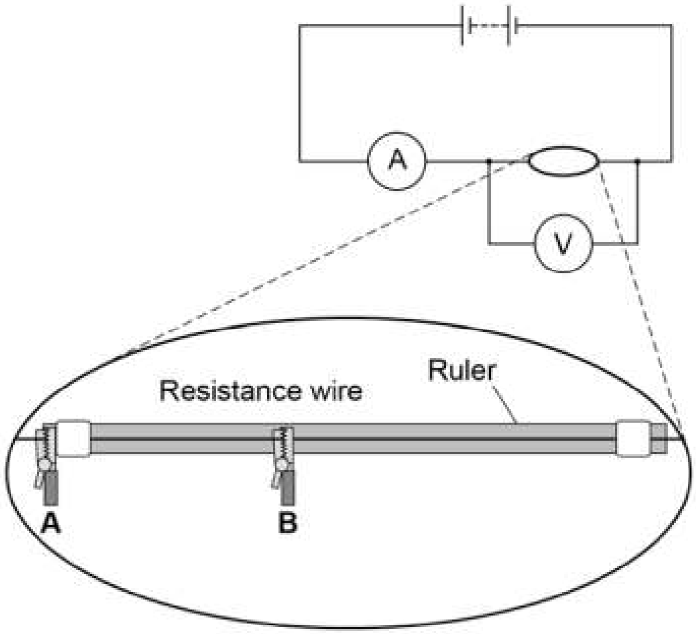
P2

Required practical: resistance Wire

1. Use the circuit diagram to set up and connect the circuit.
2. Connect a lead from the negative side of the ammeter to the crocodile clip at the zero end of the ruler. Connect a lead from the other crocodile clip to the negative side of the battery. Use this lead as a switch to disconnect the battery between readings.
3. Decide the interval distance (eg 10cm) you will investigate and connect the first distance to be tested between crocodile clips A and B.
4. Measure the readings on the voltmeter and ammeter at this distance.
5. Record your results.
6. Move crocodile clip B and record the readings for the different lengths of wire e.g. 20cm, 30cm etc.
7. Calculate the resistance for each length of wire using the equation:

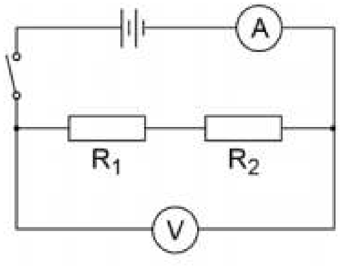
$$\text{resistance in } \Omega = \frac{\text{potential difference in V}}{\text{current in A}}$$

8. Plot a graph of resistance against length of wire.
9. You should be able to draw a straight line of best fit although it may not go through the origin.

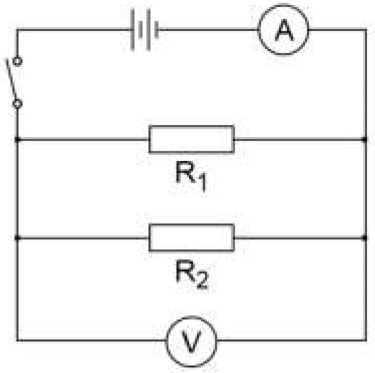


Required practical: Resistors in series and parallel

1. Use the circuit diagram to set up and connect the circuit for two resistors in series $R_1=R_2$



2. Switch on and record the readings of the ammeter and the voltmeter.
3. Calculate the total resistance of the series circuit.
4. Set up the circuit for two resistors in parallel. Use the circuit diagram below. $R_1=R_2$



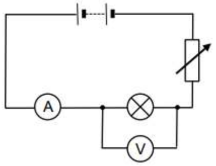
5. Switch on and record the readings of the ammeter and the voltmeter.
6. Calculate the total resistance of the parallel circuit.

When wired in series, the total resistance of two resistors is found by adding the resistance of each resistor.

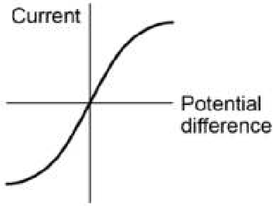
When wired in parallel, the total resistance of two resistors is smaller than the resistance of the smallest resistor.

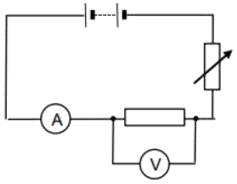
P2

Required practical: IV Graphs

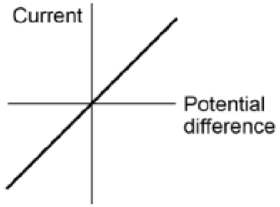


1. Use the circuit diagram shown to set up your circuit.
2. Record the readings on the ammeter and voltmeter in a suitable table.
3. Adjust the variable resistor and record the new readings on the ammeter and voltmeter.
4. Repeat this to obtain several pairs of readings.
5. Swap the connections on the battery/power supply. The ammeter is now connected to the negative terminal and variable resistor to the positive terminal. The readings on the ammeter and voltmeter should now be negative.
6. Continue to record pairs of readings of current and potential difference with the battery reversed.
7. Plot a graph of current against potential difference. As the readings include negative values the origin of your graph will be in the middle of the graph paper. You should be able to draw a line of best fit through the origin. This is the characteristic of a filament lamp.

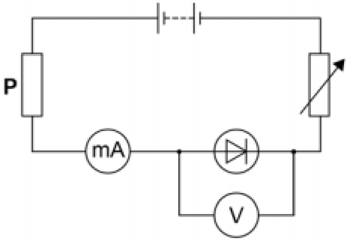




1. Swap the leads on the battery/power supply back to their original positions.
2. Replace the filament lamp with the resistor.
3. Record the readings on the ammeter and voltmeter in a suitable table.
4. Adjust the variable resistor and record the new ammeter and voltmeter readings. Repeat this to obtain several pairs of readings.
5. Swap the connections on the battery/power supply. Now the ammeter is connected to the negative terminal and variable resistor to the positive terminal. The readings on the ammeter and voltmeter should now be negative.
6. Continue to record pairs of readings of current and potential difference with the battery reversed.
7. Plot a graph of current against potential difference. As the readings include negative values the origin of your graph will be in the middle of the graph paper. You should be able to draw a straight line of best fit through the origin. This is the characteristic of a resistor.



Required practical: IV Graphs



1. Swap the leads on the battery/power supply back to their original positions.
2. If you can, reduce the battery/power supply potential difference to less than 5 V.
3. Connect the extra resistor labelled P.
4. Replace the ammeter with a milliammeter.
5. Replace the resistor used in activity 2 with the diode.
6. Record the readings on the milliammeter and voltmeter in a suitable table.
7. Adjust the variable resistor and record the new milliammeter and voltmeter readings.
8. Repeat this to obtain several pairs of readings.
9. Swap the connections on the battery/power supply. Now the milliammeter is connected to the negative terminal and variable resistor to the positive terminal. The readings on the milliammeter and voltmeter should now be negative.
10. Continue to record pairs of readings of current and potential difference with the battery reversed.
11. Plot a graph of current against potential difference. As the readings include negative values the origin of your graph will be in the middle of the graph paper. This is the characteristic of a diode.