Potential Difference and Resistance

As current flows round a circuit, the charges transfer energy as they struggle against resistance.

Potential Difference is the Energy Transferred Per Unit Charge

1) The potential difference is the energy transferred per coulomb of charge that passes between two points in an electrical circuit.
2) You can calculate energy transferred, in joules, J, from charge moved, in C, and potential difference, in V, using this formula:

energy transferred = charge moved × potential difference $E = Q \times V$

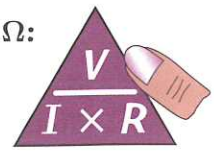
3) So, the potential difference (p.d.) across an electrical component is the amount of energy transferred by that electrical component (e.g. the amount of energy transferred by a motor to its kinetic energy store) per unit charge passed. One volt is one joule per coulomb.
4) Potential difference is sometimes called voltage. They're the same thing.

Resistance, Potential Difference and Current: $V = I \times R$

For potential difference (V) in volts, V, current (I) in amps, A, and resistance (R) in ohms, Ω:

potential difference = current × resistance

As a formula triangle:

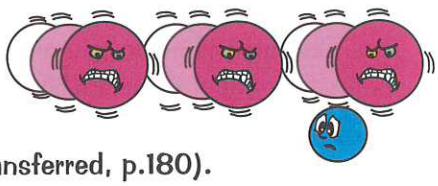


If you rearrange this equation, you can use it to calculate the resistance of a component from measurements of potential difference and current (e.g. from the experiment on the next page).

EXAMPLE: A 4.0 Ω resistor in a circuit has a potential difference of 6.0 V across it. What is the current through the resistor?

Rearrange $V = IR$ to give $I = V \div R$, then substitute in the values you have. $I = 6.0 \div 4.0 = 1.5$ A

Resistance Increases with Temperature (Usually)



1) When an electrical charge flows through a component, it has to do work against resistance.
2) This causes an electrical transfer of energy (work done = energy transferred, p.180).
3) Some of this energy is transferred usefully (p.158) but some of it is dissipated to the thermal energy stores of the component and the surroundings.
4) So when a current flows through a resistor, the resistor heats up.
5) This happens because the electrons collide with the ions in the lattice that make up the resistor as they flow through it. This gives the ions energy, which causes them to vibrate and heat up.
6) The more the ions vibrate, the harder it is for electrons to get through the resistor (because there are more collisions). This means that for a given p.d. the current decreases as the resistor heats up.
7) If the resistor gets too hot, no current will be able to flow. There is one exception to this — the resistance of a thermistor decreases with an increase in temperature (p.187).

Low resistance wires (p.199) reduce the energy dissipated to thermal stores as the current flows between components.

In the end you'll have to learn this — resistance is futile...

$V = IR$ is one of the most useful equations in electricity — it crops up in a bunch of different places. So make sure you can bring it to mind super quickly and use it without trouble. Have a quick practise before moving on.

Q1 A current flowing through a resistor transfers 360 J of energy when 75 C of charge are passed through it. Calculate the potential difference across the resistor. [2 marks]

Q2 A potential difference of 4.25 V is applied across a resistor, causing a current of 0.25 A to flow. Calculate the resistance, in ohms, of the resistor. [2 marks]

Potential Difference and Resistance

Warm-Up

For each statement, circle whether it is true or false.

Potential difference is the energy transferred per coulomb of charge.	**True / False**
One volt is one ampere per coulomb.	**True / False**
Potential difference is also known as voltage.	**True / False**

1 A kettle needs 276 000 J of energy to be electrically transferred to it in order to bring water to the boil. It is connected to the mains supply which has a voltage of 230 V.

Grade 6-7

a) Calculate the amount of charge that passes through the kettle to bring the water to the boil.

Charge = ... C
[3]

b) A toaster is connected to the same mains supply. When a slice of bread is toasted, the charge that passes through the toaster is 1000 C.

Calculate the energy transferred to toast the slice of bread. Give your answer in kJ.

Energy transferred = ... kJ
[2]

[Total 5 marks]

2 When a potential difference of 18 V is applied across a resistor, a current of 3 A flows through it.

Grade 6-7

a) Calculate the resistance of the resistor. State the units of your answer.

Resistance = ... Units .....
[4]

b) Over time, the current through the resistor begins to decrease. Explain why this happens.

.....

.....

.....

.....

.....
[4]

[Total 8 marks]