D1: Electrical concepts
D2: Electrical terms

Length: 120 minutes

Theory

Learning outcomes

- Understand the origins of electricity
- Understanding the difference between insulators and conductors
- Knowing about the link between magnetic fields and electricity
- Knowing about electrical symbols for technical communication
- Understand the main electrical terms
- Measure resistance, voltage and current
- Learn to apply Ohm's law
- Work out equivalent resistance of resistors in series/parallel circuits
- Learn to apply the power calculation methods

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Agenda Module D

⊠ Electrical concepts – introduction

Electrical terms

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Electrical concepts – introduction
Electricity

- Michael Faraday discovered electricity in 1831.

- He inserted a bar magnet into a coil of copper wire, which generated a brief wave of electricity.

- He was able to see this on his meter, which was connected to the two ends of the coil of copper wire.

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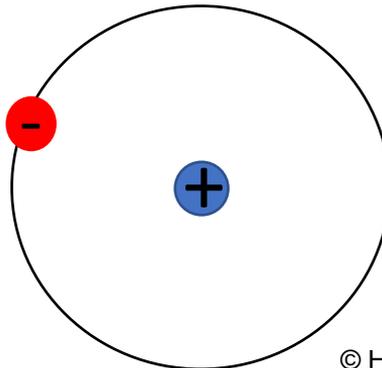# Electrical concepts – introduction
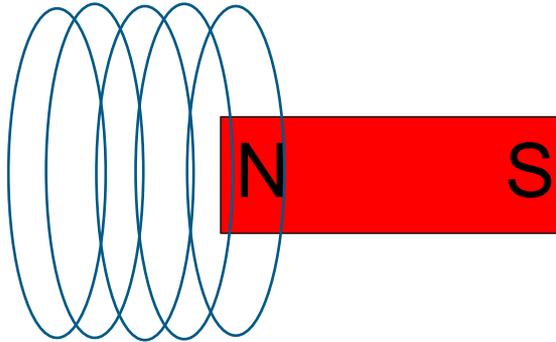
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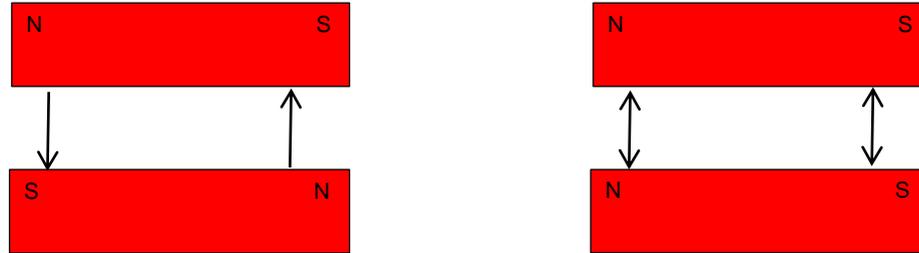
Electrical charge

- The basis of all electrical energy is the electric charge.

- There are two kinds of electric charge: positive (protons) and negative (electrons).

- Everything is made up of minute particles called atoms.

- Materials which consist of the same kind of atom are called elements.

- Hydrogen is the simplest atom

  - made up of a single proton in its nucleus and a single electron orbiting around it.

A hydrogen atom

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Electrical concepts – introduction

Electrical charge

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- Electric charges share with magnetic poles the property of exerting forces upon one another.

- It must be remembered that like charges repel one another and unlike charges attract one another.

- This rule applies to the charges of the electron and proton.

- As the nucleus of the atom is positive and the electron is negative, the electron is bound in orbit

- The Electron is normally prevented from flying off because of the attraction between the two particles

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Commonly used electrical symbols

Symbol	Name	Symbol	Name	Symbol	Name	Symbol	Name	Symbol	Name
	Make contact		Break contact		Change-over brake before make contact		Manually operated switch, general		Push-bottom switch, automatic return
	Turn-switch without automatic return		Fuse switch		Self-operating thermal switch		Emergency stop switch		Starting relay
	Battery of primery or secondary cell		Signal lamp, general symbol	Ⓐ	Ampere-meter	Ⓥ	Voltmeter	Ⓞ	Ohm-meter
	Adjustable resistor		Earth, general symbol		Protective earth		Frame Chassis		Equipotentiality
	Rectifier		Inverter		Rectifier in bridge connection		Capacitor		Inductor Coil Winding Choke
	Inductor Coil Winding Choke		Resistor		Fuse		Operating coil general		Controller
	Transformer with two windings	M 1~	Motor single phase	M 3~	Motor three phase	●	Junction connection point	○	Terminal

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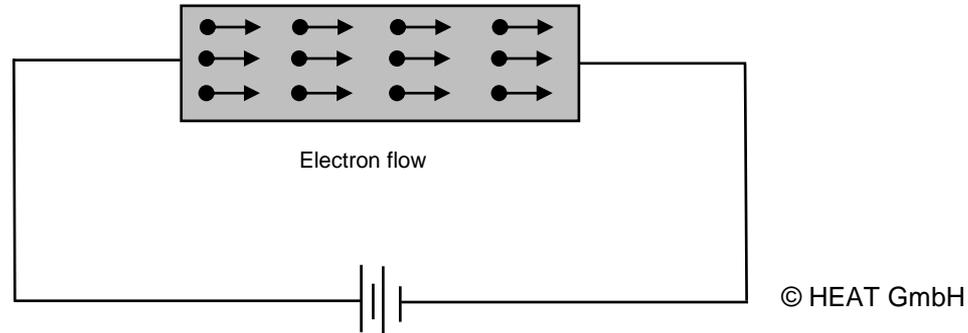
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Electrical concepts – introduction

Free electrons

- 29 orbiting electrons arranged in four shells

Copper (Cu) atom

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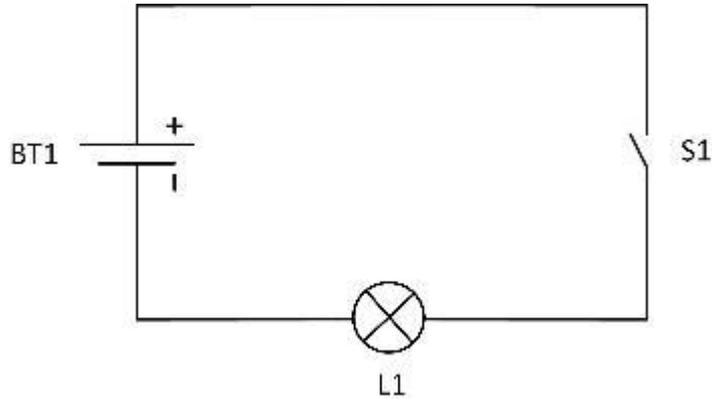# Electrical concepts – introduction

Electron flow
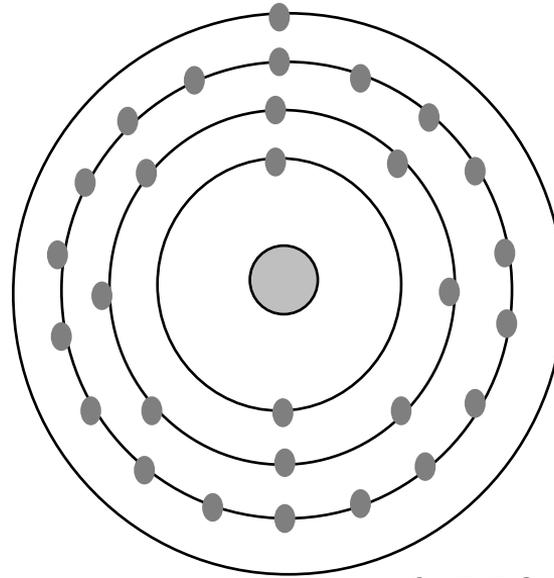
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- If the free electrons are encouraged to move in the same general direction within the component,

- By placing a plate with an abundance of electrons at one end of the component,

- And a plate with a deficit of electrons at the opposite end of the component (i.e. a battery)

- Electrons are forced to enter and leave it,

- This flow constitutes an electric current.

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Electrical concepts – introduction

A simple electrical circuit with battery, switch and lamp

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Electrical concepts – introduction

Conductors and insulators

- Where the outer electrons of a material are not tightly bound in their orbits and can easily be dislodged to produce free electrons, these materials are called conductors (e.g. copper and aluminium).

- If the orbiting electrons are tightly bound that they cannot easily be encouraged to break away from their orbits these materials are called insulators.

- Insulators have virtually no free electrons available to form an electric current (e.g. plastics and ceramics).

- The most common types of conductors found in electrical installations are:

    - Copper: found in cable and flex

    - Brass: found in electrical accessories, such as terminal blocks

- The most common types of insulators used in electrical installations is plastic, of which polyvinyl chloride (PVC), a thermoplastic, is the most widely used.

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Agenda Module D

Electrical concepts – introduction

⊠ Electrical terms

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Electrical terms

Voltage

- Voltage is the force behind electricity.

- It is sometimes referred to as electric pressure and can be compared with the water pressure in a plumbing system.

- The pressure which drives the water is due to the difference of levels between the tank and the tap.

- The difference in the voltage levels between two points is called the potential difference (p.d.) and is measured in Volts (U)

Voltage

Voltage
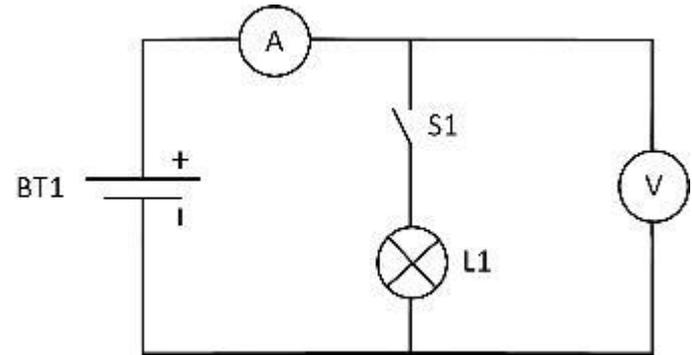
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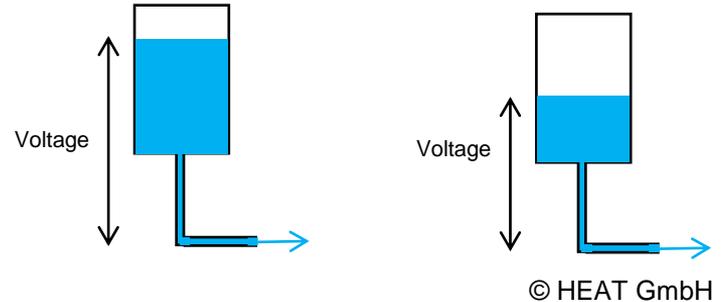
Electrical terms

Electric current

- When charge moves from one place to another, an electric current is said to flow.

- Electric current is always regarded as flowing from the more positively charged object to the more negatively charged object.

- In a conventional circuit, an electric current will only flow if it can return to its source.

- The route it takes is known as a circuit.

- If you break a circuit by cutting a wire that forms that circuit (i.e. the switch), the current stops.

- The unit of current is the ampere, and this is measured in amps (A)

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Electrical terms

Electric current

- Voltage appears across components and current flows through them.

- To measure voltage the meter is placed on terminals either side of the component,

- To measure current the electricity has to flow through the meter as well as the component.

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Positioning of Voltmeter (V) and Amperemeter (A)

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Electrical terms

Measuring current

- Measuring current this way is not practical and is only suitable for measuring small current flows.

- Therefore, most electricians will measure current using a clamp meter.

- To use a clamp meter to measure current you need to be able to clamp the meter around the live wire connected to the component as in the picture below.

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Electrical terms

Resistance

- Current is the flow of electricity through the circuit.

- The path it flows along, which is the electrical circuit, creates resistance to the flow through the system.

- The circuit conductors provide some degree of resistance to the flow of current.

- Also, every component the electricity flows through creates resistance.

- Therefore voltage is needed to push the current around the circuit to overcome the resistance.

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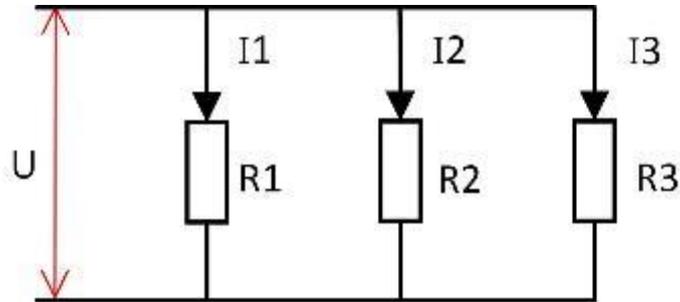# Electrical terms

Resistors

Resistors in series
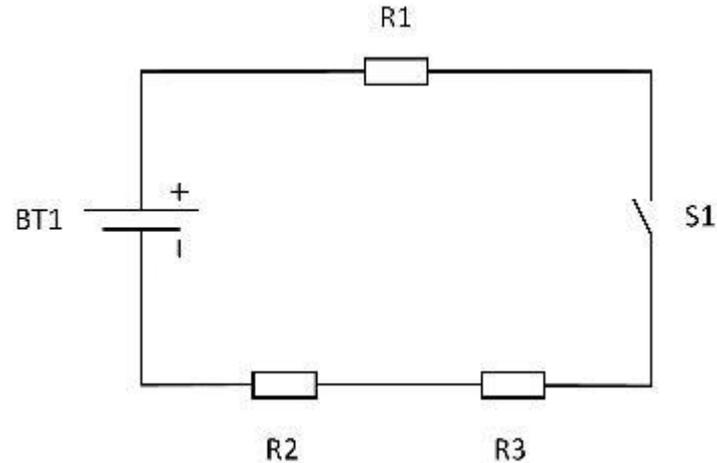
$$RT = R1 + R2 + R3$$
$$RT = 10\Omega + 10\Omega + 10\Omega$$
$$RT = 30\Omega$$

Simple electrical circuit with three resistors, battery and switch

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Electrical terms

Resistors

Resistors in parallel

For example: If R1 = 3Ω, R2 = 8Ω and R3 = 5Ω

$$\frac{1}{RT} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

$$\frac{1}{RT} = \frac{1}{3\Omega} + \frac{1}{8\Omega} + \frac{1}{5\Omega}$$

$$\frac{1}{RT} = \frac{40}{120\Omega} + \frac{15}{120\Omega} + \frac{24}{120\Omega}$$
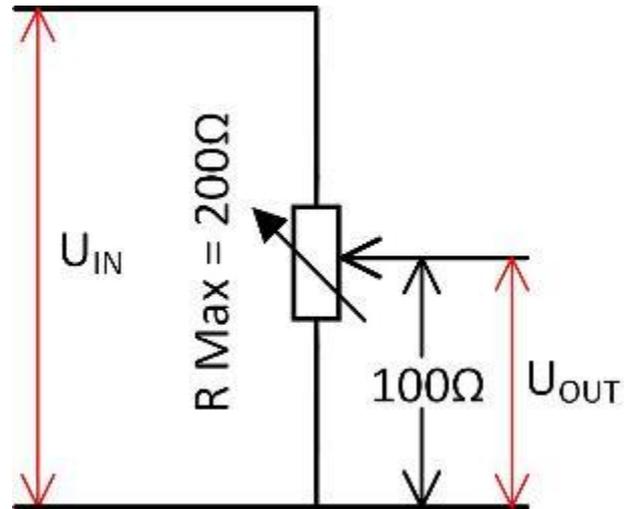
$$\frac{1}{RT} = \frac{79}{120\Omega}$$

$$RT = \frac{120\Omega}{79}$$

$$RT = 1.52 \ \Omega$$

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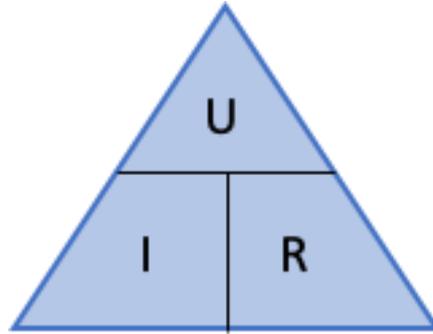# Electrical terms

Resistors

Variable resistors

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Electrical terms

Ohm's law

The Triangle of Ohm's Law

- Voltage is represented by U,
- Current is represented by I,
- Resistance is represented by R.

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Electrical terms

Ohm's law

Ohm's Law

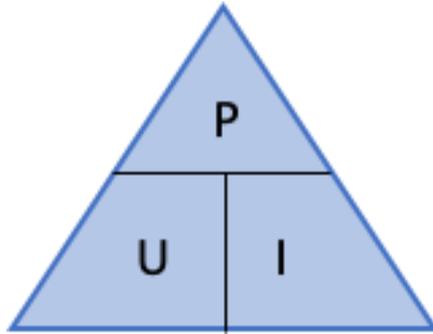Expressed mathematically:

$$I \ = \frac{U}{R}$$

or current in amperes $= \dfrac{U \ (in \ volts)}{R \ (\Omega)}$

alternatively, $U = R \times I$ or $\mathrm{R} \ = \dfrac{U}{I}$

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Electrical terms

Electric power

The Triangle of Electric Power calculation

- Power is represented by P
- Voltage is represented by U
- Current is represented by I

- To do work, electricity generates power
- Power is the rate at which electrical energy is converted into other kinds of energy, such as heat, light or movement (in the case of electric motors).
- The unit of power is the watt, and typical values of power used in electrical circuits are:
  - 1 Kilowatt   = 1,000 watts or 1 kW
  - 1 Megawatt   = 1,000,000 watts or 1 MW

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Electrical terms
Power

Expressed mathematically:

$$P = U \times I$$

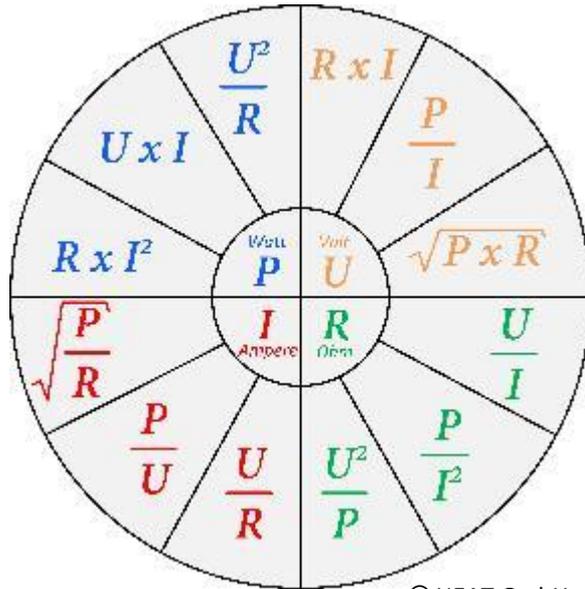or current, in amperes $= \dfrac{P}{U}$

or $U = \dfrac{I}{P}$

Example: What is the actual current taken by a 10.8 kW electric shower, if the supply system is 230 V?

$$I = \frac{P}{U}$$
$$I = \frac{10{,}800 \; VA}{230 \; V}$$
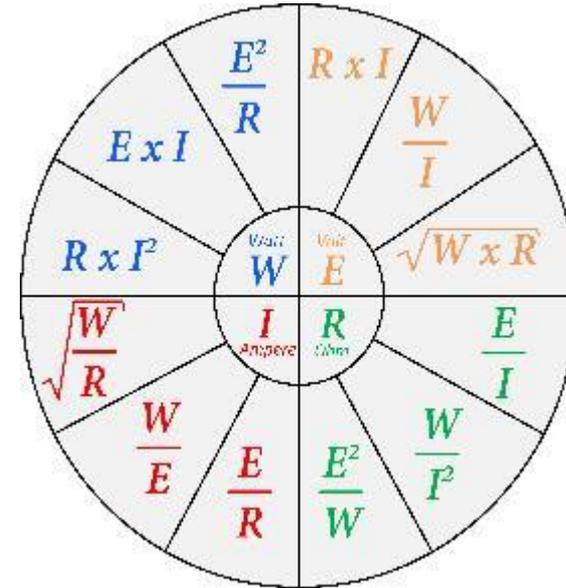$$I = 47 \; A$$

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Electrical terms

Electrical engineering formula wheel

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Electrical engineering Formula Wheel (EU)

Electrical engineering Formula Wheel (Latin America)

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GIZ Proklima

Contact:
Bernhard Siegele
E bernhard.siegele@giz.de
T +49 6196 79-1968
I www.giz.de/proklima

Author:
Anthony Darlow, Rolf Hühren
E anthony.darlow@heat-international.eu; rolf.huehren@heat-international.de
HEAT GmbH, Königstein i. Ts., Germany

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Registered offices
Bonn and Eschborn

Friedrich-Ebert-Allee 36 + 40 Dag-Hammarskjöld-Weg 1 - 5
53113 Bonn, Germany 65760 Eschborn, Germany
T +49 228 44 60 - 0 T +49 61 96 79 - 0
F +49 228 44 60 - 17 66 F +49 61 96 79 - 11 15

E info@giz.de
I www.giz.de