

Education  
Programme

[www.bmw-education.co.uk](http://www.bmw-education.co.uk)



The Ultimate  
Driving Machine



**BMW** Young Academy

# Basic Electrics & Electronics

Lesson 1:  
Basic Electrical Theory

## Student Workbook

Jointly funded by the Quality Improvement  
Agency and BMW (UK) Ltd



## About Young Academy

Discover the skills needed to work in the automotive industry and learn about the science and technology behind the cars with Young Academy, BMW Education's online resource for 14 to 16 year olds.

**Young Academy** is a series of lessons based on BMW Academy's own award-winning apprenticeship programme. By working through the lessons, you will take a journey from learning about the principles of electrical theory, to developing an understanding of the skills and knowledge needed to become a motor industry technician.

The Young Academy lessons are available from the BMW Education website at: [www.bmweducation.co.uk/YoungAcademy](http://www.bmweducation.co.uk/YoungAcademy).

## About Lesson 1: Basic Electrical Theory

Electricity is an important part of everyday life. We need electricity to give us light and heat and to power computers, televisions and other electronic equipment. Electricity also plays an important role in modern day cars.

In this lesson you will find out how electricity is created from electrons, the tiny particles found in atoms, how electrons can be moved from one place to another and how electrons flow through electrical circuits. As you work your way through the lesson you will learn about electricity and electronics and find out what it is like to train as a technician.

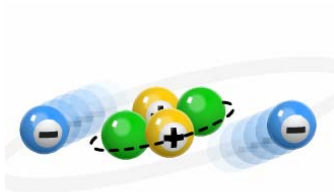
# Lesson 1: Basic Electrical Theory

## Overview



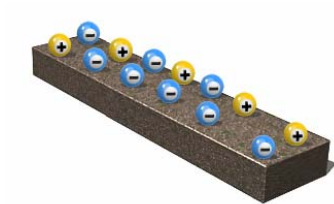
Objectives

Page 3



Part 1: Electrical Theory

Page 4



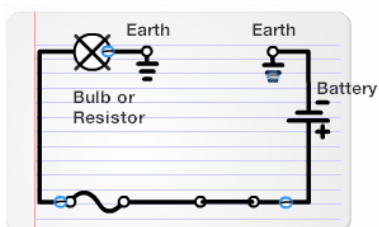
Part 2: Electron Displacement

Page 6



Part 3: Electrical Flow

Page 7



Part 4: Automotive Circuits

Page 8

# **Lesson 1: Basic Electrical Theory**

## **Objectives**

At the end of this lesson you should be able to:

- Explain the basic structure of atoms
- Explain the behaviour of ions
- Explain why various types of materials have an effect on resistance
- Explain the definitions of voltage and current resistance.

# Lesson 1: Basic Electrical Theory

## Electrical Theory

### Atomic Structure

The basis for electricity is the electron. Electrons are extremely small particles that are part of an atom. An atom is basically composed of electrons, protons and neutrons.

Each proton has one unit of positive charge and each electron has one unit of negative charge. The atom is balanced (the number of electrons is the same as the number of protons). A neutron, as its name suggests, has no charge.

- The major sub-atomic particle with no charge is the neutron.
- The part of the atom that contains both positively charged particles and neutral particles is called the nucleus.
- The major sub-atomic particle with positive charge is the proton.
- The particle with negative charge is the electron.

### Ions

- When the number of electrons equals the number of protons, the atom is balanced and there is no resultant charge.
- When electrons are taken away from an atom, the atom would have a resultant positive charge and would become a positive ion.
- When electrons are added to an atom, the atom would have a resultant negative charge and would become a negative ion.

### Charged Particles

- Ions with **UNLIKE** charges attract.
- Ions with **LIKE** charges repel.

## **Electrical Potential**

- The force exerted on groups of charged particles is called the electromotive force or EMF.
- The terms voltage and potential difference are sometimes used instead of EMF.
- EMF is measured in volts.

# Lesson 1: Basic Electrical Theory

## Electron Displacement

### Static Electricity

Static electricity is the build-up of an electrical charge in an object. Static electricity can sometimes suddenly discharge, for example, when a bolt of lightning flashes through the sky. At other times, static electricity can cause objects to cling to each other, like socks fresh out of the tumble dryer. The static cling is an attraction between two objects with different charges, positive (+) and negative (-). This can be caused by friction.

There are a number of ways that electrons can be moved from one material to another.

Friction is one way.

Rubbing a silk cloth over a glass rod causes electrons to move from the glass rod to the cloth.

When this happens, the glass rod becomes positively charged and the silk cloth becomes negatively charged.

### Chemical Action

The chemical action of a battery is another way to displace electrons.

When the circuit is complete, the electrolyte reacts with the negative electrode causing electrons to flow to the positive electrode.

Electrolyte is normally a liquid solution (sulphuric acid and distilled water) that enables a battery to supply electrical energy. Lead acid batteries have lead plates immersed in this solution and a reaction takes place between these lead plates and the solution when the battery is being discharged.

## **Lesson 1: Basic Electrical Theory**

### **Electrical Flow**

When the switch is closed on a circuit, the circuit is completed or 'closed' and electrons flow through the wire – a flow of electric current is taking place. The unit of current is called ampere or amp. The flow of electrons is from the negative electrode to the positive electrode.

However, many people wrongly believe that current flows from the positive terminal to the negative terminal. This assumption is called the conventional flow and it incorrectly assumes that the current will flow from the positive electrode to the negative electrode.

# **Lesson 1: Basic Electrical Theory**

## **Automotive Circuits**

Generally in automotive circuits, one side of the electrical component is connected to the battery, whilst the other side is earthed (which means it is connected to the ground).

Most vehicles use earth return systems where the metal body of the vehicle is used as part of the circuit. The vehicle body is called the earth (or ground) and is normally connected to the negative side of the battery terminal.

The use of the word 'return' is associated with the current flow in the circuit. When a lamp is connected to a battery by two cables, one cable is called the feed and the other the return. By substituting the vehicle body for the return cable, an earth return system is formed.

## **Resistance**

Electrical resistance is the property of a given material that determines how much current will flow when a given voltage is applied across it. Materials can be classified into three categories depending on their electrical resistance properties: conductor; insulator; or semi-conductor.

Conductors are materials that easily give up their electrons and will produce current flow even with a small EMF. Examples of conductors are copper, iron and aluminium.

Insulators have atoms that hold on tightly to their electrons. It takes a large EMF to force any electron movement in insulators, thus the current flow is small. Diamonds and glass are good insulators.

Semiconductors are elements with unique atomic structures. By combining semiconductors with other materials, the number of electrons available to create current flows can be modified. Silicon and germanium are semiconductors. Transistors are made from semiconductors.

Current will flow through the materials or path with least resistance.

A current will flow through a copper wire connected to a battery.

**You have now completed Lesson 1: Basic Electrical Theory.**