TRADE OF HEAVY VEHICLE MECHANIC

PHASE 2

Module 2

Basic Electricity/Batteries

UNIT: 1

Magnetism

Table of Contents

1.0 Lea	arning Outcome	1
1.1	Key Learning Points	1
2.0	Magnetism	2
2.1	What is Magnetism	2
2.2	Classification of Magnetic Materials	4
2.3	Method of Magnetising Soft Iron	5
2.4	Magnetic Fields	6
2.5	Theory of Magnet fields	6
2.6	Behaviour of Non-Magnetic Materials in a Magnetic Field	8
2.7	Behaviour of Magnetic Materials in a Magnetic Field	8
3.0	Electromagnetism	9
3.0 3.1	Electromagnetism Direction of Magnetic Fields and Currents	9 9
3.0 3.1 3.2	Electromagnetism Direction of Magnetic Fields and Currents Magnetic Field Strength between Current carrying Conductors	9 9 10
3.0 3.1 3.2 3.3	Electromagnetism Direction of Magnetic Fields and Currents Magnetic Field Strength between Current carrying Conductors Hand Rules	9 9 10 11
3.0 3.1 3.2 3.3 3.4	Electromagnetism Direction of Magnetic Fields and Currents Magnetic Field Strength between Current carrying Conductors Hand Rules Magnetic Field of a Straight Conductor	9 9 10 11 12
3.0 3.1 3.2 3.3 3.4 3.5	Electromagnetism Direction of Magnetic Fields and Currents Magnetic Field Strength between Current carrying Conductors Hand Rules Magnetic Field of a Straight Conductor Magnetic Field of a Coil	9 10 11 12 12
3.0 3.1 3.2 3.3 3.4 3.5 3.6	Electromagnetism Direction of Magnetic Fields and Currents Magnetic Field Strength between Current carrying Conductors Hand Rules Magnetic Field of a Straight Conductor Magnetic Field of a Coil The Solenoid	9 10 11 12 12 13
3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7	Electromagnetism Direction of Magnetic Fields and Currents Magnetic Field Strength between Current carrying Conductors Hand Rules Magnetic Field of a Straight Conductor Magnetic Field of a Coil The Solenoid Residual magnetism	9 10 11 12 12 13 14
3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8	Electromagnetism Direction of Magnetic Fields and Currents Magnetic Field Strength between Current carrying Conductors Hand Rules Magnetic Field of a Straight Conductor Magnetic Field of a Coil The Solenoid Residual magnetism Relays	9 10 11 12 12 13 14 15

1.0 Learning Outcome

By the end of this unit each apprentice will be able to::

- Describe the magnetic fields of bar and horseshoe magnets
- Distinguish between a magnetic and non magnetic materials
- Identify between natural, permanent and electro magnets
- Use compass and iron filings to detect magnetic fields
- Magnetise by torch
- De-magnetise by heat and shock
- State the molecular theory of magnetism

1.1 Key Learning Points

- Types of magnets: natural; man-made magnets
- Types of man-made magnets: bar, ring, horseshoe magnets
- Types of magnetic and non-magnetic materials
- Concentration of magnetism at poles
- Polar attraction, repulsion, compass
- Lines of force around bar, 2 together, end of bar, neutral point
- Lines of force around horseshoe
- Magnetic keeper, magnetic screening
- Effect of iron on lines of force, pole shoes
- Molecular theory of magnetism
- Method of magnetising and demagnetising
- Materials in permanent magnets tapes
- Function and operation electro magnets

2.0 Magnetism

Magnetism is an important concept in automotive technology. Magnets have many applications in a typical Modern vehicle these include:

- 1. Window lift motor
- 2. Starter motor
- 3. Cooling fan motor
- 4. Throttle and Crankshaft position sensors
- 5. Liquid level indicators
- 6. Windscreen washer pump
- 7. Electric sunroof motor
- 8. Ignition systems

2.1 What is Magnetism

Magnetism is a phenomenon that some materials, such as iron have, that causes them to attract or repel other materials. You can think of a material as being made up of a very large number of small magnetised "domains". When a bar of iron is not magnetised, the small magnetic domains are arranged in a random manner. But when the bar of iron becomes a magnet, the magnetic particles are aligned so that their individual effects are added together to form a strong magnetic force.



The magnetic effect within these small particles is caused by the spinning electrons within the atoms of the material. Electrons have a circle of force around them, and when these electron orbits are aligned, as in a bar of iron, so that the circles of force add together, the bar is magnetised.

The Earth's Magnetic Poles

The Earth behaves as if a huge bar magnet were inside it, the south pole of the magnet being near the geographic North Pole, and the North Pole at the geographic South Pole. The Earth is a truly permanent magnet.

Permanent magnets will attract objects made of iron. If a magnet is suspended in free air, it will come to rest with one end pointing North. This is called the North-seeking Pole, and the



opposite pole is the South-seeking Pole.

If two magnets are brought together, they obey the laws of magnetism. These are:

1. Like Poles Repel



North Poles or two South Poles will try to push apart or repel.

2. **Unlike Poles Attract**



North Pole and a South Pole will try to come together or attract.

2.2 Classification of Magnetic Materials

Not every material can be magnetised, some common magnetic and nonmagnetic materials are listed below:

- Magnetic Materials: Iron, Steel, Nickel, Cobalt.
- Non-Magnetic Materials: Air, Vacuum, Paper, Glass, Wood, Plastics, Brass.

Materials that make good permanent magnets are reluctant to change their magnetic direction. Such materials are said to be magnetically "HARD",

Some materials such as soft iron become magnetised more easily than other materials, but they also lose their magnetism easily, so magnets of soft iron are called temporary magnets.

When we consider materials simply as either magnetic or non-magnetic, this division is really based on the strong magnetic properties of iron. However, weak magnetic materials can be important in some applications.

For this reason, a more exact classification includes the following three groups:

• Ferromagnetic Materials

These include iron, steel, nickel, cobalt, and commercial alloys such as Alnico and Permalloy. They become strongly magnetised in the same direction as the magnetic field. For example, if a ferromagnetic material is placed in the magnetic field of a permanent magnet, then the lines of force, which are from the North Pole to the South Pole, are concentrated in the ferromagnetic material.

• Paramagnetic Materials

These include aluminium, platinum, Manganese and chromium. They become weakly magnetised in the same direction as the magnetising field.

• Diamagnetic Material

These include bismuth, antimony, copper, zinc, mercury, gold and silver. They become magnetised, but in the opposite direction from the magnetising field.

• Thermal-agitation, "Curie point"

A piece of iron will ordinarily be attracted to a magnet, but when you heat the iron to a high enough temperature (called the Curie point), it loses its ability to be magnetized. Heat energy scrambles the iron atoms so that they can't line up and create a magnetic field.

2.3 Method of Magnetising Soft Iron

The illustration below shows how it is possible to magnetise a piece of soft iron by repeatedly rubbing it in the same direction with a bar magnet. Soft iron magnetised in this manner will lose its magnetism slowly as time goes by. Soft iron is easily magnetised and demagnetised.



Loss of Magnetism

A magnet may lose its magnetism by two methods:

- 1. A sharp shock as a result of impact.
- 2. Heat.

Keepers

Magnets tend to lose their magnetism when stored for long periods. Keepers are pieces of soft iron, which are placed over the ends of the magnets to form a closed magnetic circuit, see below. This helps prevent the loss of magnetism from the magnets.

Note the polarity of both magnets.

Magnets which do not deteriorate with time, and which resist demagnetisation by ill treatment are now available.



2.4 Magnetic Fields

The space around a magnet where a magnetic effect can be detected is called a magnetic field.

The magnetic field around a bar magnet can be shown by sprinkling iron filings around a



magnet placed under a piece of paper. If the paper is tapped gently, the iron filings arrange themselves as shown in the figure below. This arrangement of iron filings shows the pattern of the magnetic field around the magnet.

The magnetic field appears to be a series of curved lines, which conventionally are drawn running from the North Pole to the South Pole external to magnet the as illustrated below. These lines are called the magnetic field



lines or magnetic lines of force. The arrows show the direction of the magnetic lines of force at each point.

2.5 Theory of Magnet fields

A magnetic field is made up of imaginary lines, which cannot be seen, felt or heard. Lines of magnetic force (called flux) have two proven characteristics:

- 1 They act in a certain definite direction.
- 2 They appear endless.

These lines of magnetic force are more concentrated around the North and South poles of a magnet and have the following properties:

- They always form complete loops.
- They never cross one another.
- They have a definite direction, North to South external to the magnet.
- They try to contract as if they were stretched elastic threads.
- They repel one another when lying side-by-side in the same direction.

When two bar magnets are placed close together with the North Pole of one facing the South Pole of the other, the lines of magnetic force in the fields inter-act and their directions are altered and appear to be as shown below. Lines of magnetic flux attempt to contract and the magnets attract and try to pull together.



If two bar magnets are placed so that their North poles are very close to each other, the magnetic lines of force will arrange them as shown below.



Since magnetic flux lines running side-by-side with the same direction repel each other, the two magnets try to push each other apart.

2.6 Behaviour of Non-Magnetic Materials in a Magnetic Field

When a non-magnetic material is placed into the magnetic field of a magnet, the magnetic field lines of the magnet are unaffected and they behave as though the non-magnetic material was not there, see below.



2.7 Behaviour of Magnetic Materials in a Magnetic Field

On the other hand, if a magnetic material, such as soft iron, is introduced into a magnetic field, the field lines become more concentrated within the soft iron see below.



3.0 Electromagnetism

When a conductor carries a current, a magnetic field is produced around that conductor. This field is in the form of concentric circles along the whole length of the conductor.

3.1 Direction of Magnetic Fields and Currents

The direction of the field depends on the direction of the current - clockwise for a current flowing away from the observer, in the example illustrated in the figure below.



Direction of Current

Figure A below illustrates how a current flowing in a conductor in a direction which is away from the observer may be depicted by a "crossed line", and that the direction of the current flowing towards the observer may be depicted by a point or dot, see Figure B. The associated magnetic fields are also shown.



ALSO KNOWN AS DART NOTATION

3.2 Magnetic Field Strength between Current carrying Conductors

Figure A below illustrates the magnetic fields between two conductors through which current is flowing in opposite directions. There will be a force of repulsion exerted between the conductors.



Conversely, **Figure B** below illustrates the magnetic fields between two conductors in which current is flowing in the same direction. There will be a force of attraction exerted between the conductors.



3.3 Hand Rules

There is a definite relationship between the direction of current flow in a conductor and the direction of the magnetic field around that conductor. The direction can be determined by the use of either the Right Hand Grip Rule or the Corkscrew Rule.

1 Right Hand Grip Rule

In a current carrying conductor which is a straight wire, the direction of the magnetic field lines may be found quite simply by using the method shown below.



2 Corkscrew Rule

Refer to the figure below, visualise a screw being twisted into or out of the end of a conductor in the same direction as the current flow. The direction of rotation of the screw will indicate the direction of the magnetic field.

Direction of current flow



3.4 Magnetic Field of a Straight Conductor

The figure below illustrates how the magnetic field of a straight conductor is in the form of concentric circles along the whole length of the conductor.



3.5 Magnetic Field of a Coil

The figure below illustrates a current passing up through a sheet on the left hand side and down through the sheet on the right hand side.

The direction of the magnetic field on the left is anti-clockwise and the direction of the magnetic field on the right is clockwise.

Note that the resulting magnetic field is strongest between the two conductors.



Experiment

Refer to the figure below and assemble the circuit shown. Use a number of plotting compasses to view the direction of the magnetic field, the larger the current the more effective it will be.



Reverse the polarity and notice the difference in direction of the plotting compasses.



3.6 The Solenoid

If an insulated conductor is wound so that it forms many circular coils or turns it is called a solenoid. The strength of the magnetic field of a solenoid depends on the value of the current flowing through the conductor and on the number of turns used in forming the solenoid. The magnetic field will be more concentrated in the centre of the solenoid, see below.



The magnetic field of a solenoid extends outwards to give a complete flux pattern as shown in the figure shown below.



The solenoid is the electrical equivalent of the permanent magnet, but is often more versatile. For instance, the flux can be altered by a variation of solenoid current, or reduced to zero by switching off the current. Since a solenoid is simply a coil of conducting wire, its size and shape can be varied to suit almost any requirement.

3.7 Residual magnetism

When the permanent magnet is removed from the area of the soft iron core the core will loose most of its induced property, however some of the magnetism will remain and this is known as residual magnetism. This effect is used in dc motors.

3.8 Relays

Relays are electromagnetic switches that are turned on and off by a small electrical current.

Inside a relay is an electromagnet. When a small current energizes this electromagnet, it attracts an armature blade and closes contact points. This then allows current to flow across the heavy duty contacts to the consumer.



As long as the small switching current flows to the relay, the much larger current will flow through its contact points.

A relay is an electrical switch that opens and closes under control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of electrical amplifier.



4. Suggested Exercises

- 1. Identify magnetic materials
- 2. Confirm magnetic strength at poles by suspending nails
- 3. Identify the poles
- 4. Plot the lines of force
- 5. Find the neutral point
- 6. Magnetise old hacksaw blade by touch
- 7. Break the blade and check the polarity of pieces
- 8. Extend a magnet using a pole shoe
- 9. Magnetise a screwdriver by coiling wire around it and passing a current through it using a bulb as a resistor



An tSeirbhís Oideachais Leanúnaigh agus Scileanna Further Education and Training Authority

> 27-33 Upper Baggot Street Dublin 4