FORM 4 REVISION PHYSICS

Magnetism

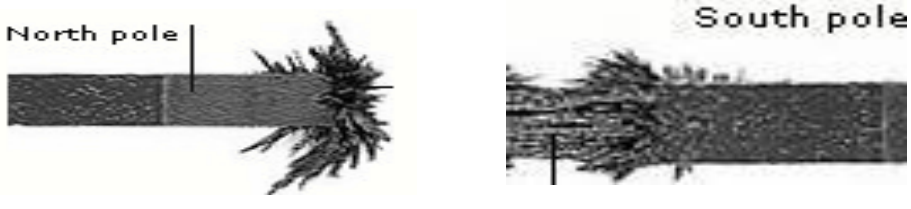
- ***Magnets*** *are pieces of metals which are able to attract or repel other pieces of materials.*
- *Magnets was first found as* ***lodestone*** *(leading stone) which is* ***magnetite*** *or* ***iron(II) or iron(III)oxide****.*

Technical terms of magnets:

- ***Magnetism****: this mysterious force which appear between magnets or between magnets and magnetic materials k-like iron and steel.*
- ***Magnetic materials****: materials that are attracted by the magnets. Magnetic materials may be ferromagnetic materials or ferri magnetic* ***(ferrites).***
- *Ferromagnetic materials are elements which react strongly to magnets. E.g. cobalt, gadolinium, iron and nickel. Ferrites are metal oxides that have strong magnetic properties. E.g. copper, cobalt, manganese, nickel and zinc.*
- ***Magnetically soft materials****: materials those are easily magnetized and easily demagnetized. E.g. soft iron (****pure iron****).*
- ***Magnetically hard materials:*** *materials those are not easily magnetized and not easily demagnetized. E.g. steel.*
- ***Diamagnetic materials:*** *these are* ***non- magnetic materials*** *.They are materials that magnets cannot attract or materials that cannot be magnetized.*
- ***Diamagnetic materials*** *are composed of atoms that have no net magnetic moments. However, when exposed to a field, a weak negative magnetization is produced which causes repulsion instead of attraction. E.g. carbon, nitrogen and sulphur.*
- ***Paramagnetic materials*** *: these are materials that show a weak magnetic attraction when placed near a magnet. E.g. liquid oxygen and aluminum.*

Properties of magnets:

- *When a bar magnet is suspended so that it can freely swing around, it comes to rest with one end pointing south pole of the earth (this pole is called south seeking pole or simply* ***south pole*** *) and the other end pointing the north pole of the earth (this pole is called north seeking pole or simply* ***north pole*** *).*
- *The magnetic force of magnets is strongest to its poles and weakest to its centre.*

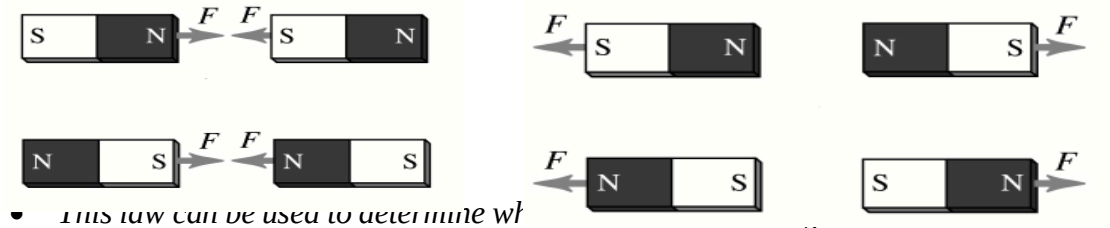


- *There is no isolated pole. This means if a magnet is snapped into two pieces, each piece has its North Pole and South Pole, so there is no magnetic bar that has only one pole.*



- *Like poles repel and unlike poles attract . This is also called the law of magnetism.*

Attraction of unlike poles Repulsion of like poles

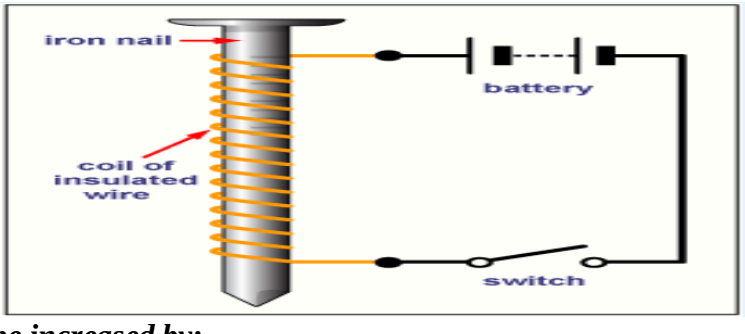


- *This law can be used to determine wh pole of a magnet will attract either the unlike pole of another magnet or a piece of un-magnetized material, we cannot use attraction to find out if a bar is a magnet or not. The only test is repulsion.*

Permanent Magnets and Temporary magnets (Electromagnets)

- *Some magnets keep its magnetism for long time they are called* ***permanent*** *while others which can't hold their magnetism are called* ***magnets,***
- ***Electromagnet*** *.Magnets can also be made by winding a coil around a nail and passing an electric current through it*





The strength of electromagnets can be increased by:

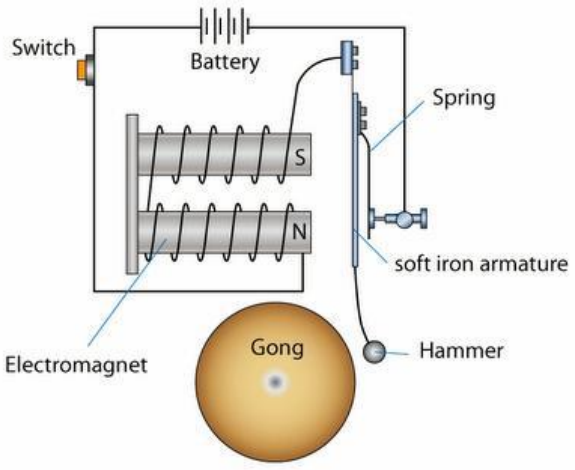
- *Increasing the current*
- *Increasing the number of turns of the wire or the solenoid.*
- *Using soft iron*

Magnetic material

Hard	***Soft***
these are hard to magnetize and demagnetize, and used for permanent magnets i.e steel	*they are easily magnetize and demagnetize, they are used for temporary magnets i.e iron*

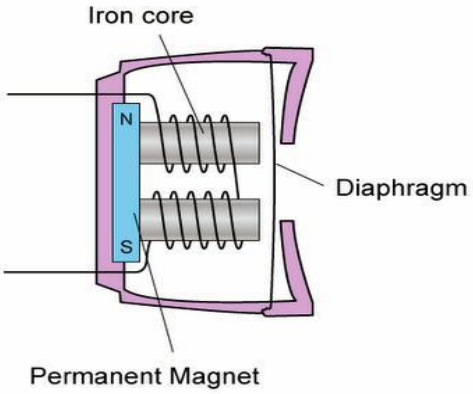
Uses of Electromagnets:

1- The Electric Bell:



- *A simple electric bell is shown in figure opposite when someone pushes the button, current flows and the armature is attracted to the electromagnet. The moving armature causes the hammer to strike the bell.*
- *At the same time, the circuit breaker opens and the current are cut off. The armature returns to its original position and so closes the circuit again.*

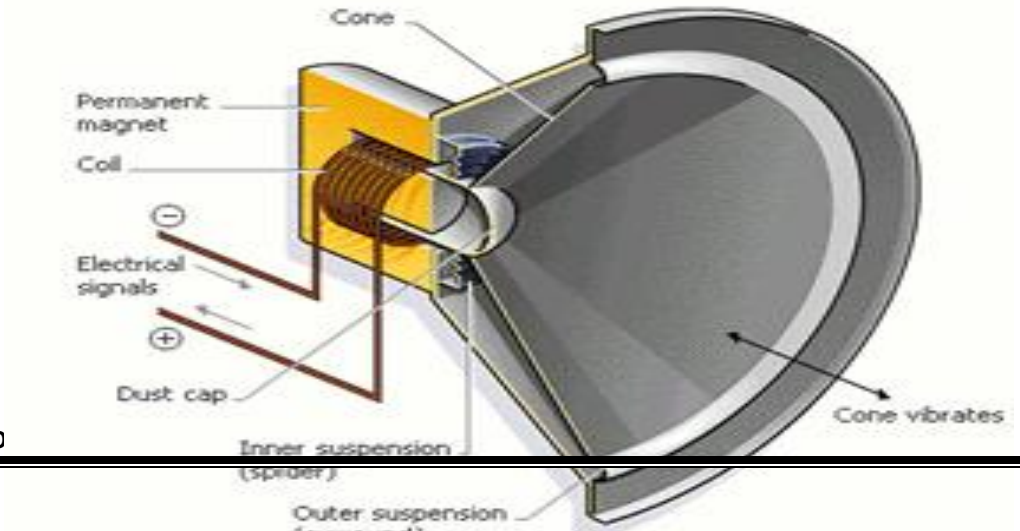
2- The Telephone:



- *The earpiece of a telephone contains an electromagnet see the figure opposite the diaphragm is attracted by a permanent magnet. The current varies according to the sound producing it.*
- *When the varying current passes through the coil, the magnetic force on the diaphragm also varies. Thus the diaphragm moves to and fro in step with the current. It sets the air nearby into vibration and sound waves are set up.*

3- The moving coil loudspeaker:

- *The figure shows the inside of a loudspeaker. At the centre of the paper come is a wire coil The coil has flexible leads connected to terminals outside. When a varying electric current passes through the coil, it moves to and fro in the radial magnetic field of the tubular magnet.*
- *The cone thus sets the surrounding air in vibration and sound is transmitted. The varying current could come from a microphone, radio, a television and so on different variations in the current produce different sounds.*



4- Recovering scrap iron:



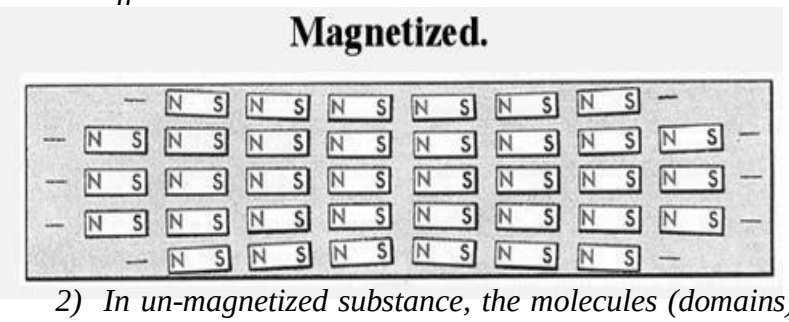
- *Cans are made from aluminum or iron Cans for recycling are passed on a belt below an electromagnet.*
- *The iron cans are removed and the aluminum cans pass on.*
- *Steel scrap can be lifted in a scrap-yard by a powerful electromagnet the crane moves the scrap to its new place and when the current is turned off, the scrap falls from the electromagnet*

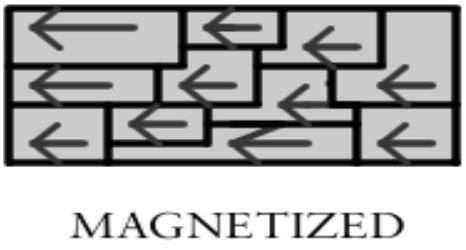
Domain theory:

Magnetic Domains:

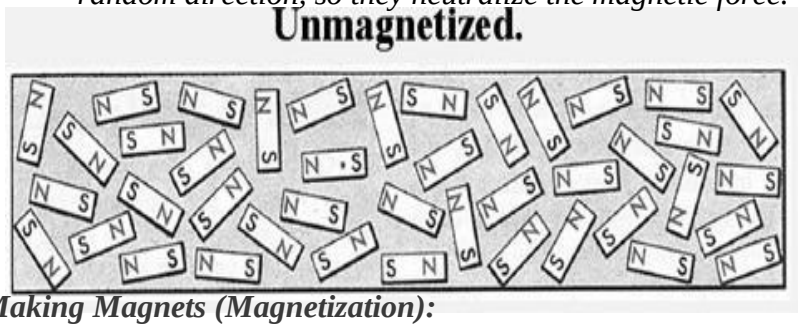
- *Magnetic materials consist of smaller called magnetic domains. Each domain consists of two poles called North Pole and South Pole. The domains vary in size and shape.*

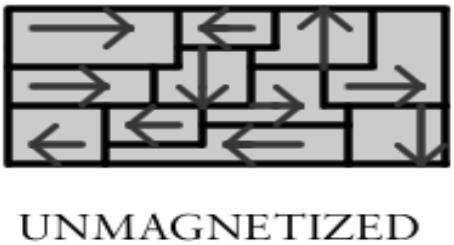
1) *In magnetized substance, the molecules (domains) are arranged in order so as to produce internal effect and directed in one direction.*





2) *In un-magnetized substance, the molecules (domains) are not arranged in order and directed to random direction, so they neutralize the magnetic force.*





Making Magnets (Magnetization):

i) ***Mechanical Methods:***

a) ***Hammering:*** *if an iron bar is heated and placed so it points to N – S direction and hammered vigorously as it cools it becomes magnet.*

b) ***Stroking:*** *it is kind of rubbing a magnet to an iron bar in one direction repeating it and lifting the magnet well a part from the iron the action makes the iron rod a magnet.*

ii) ***Electrical Methods:*** *see electromagnetic in* ***page 3.***

Demagnetization:

- *Demagnetization is the process of destroying the magnetic property of a magnet. It can be done by one of the following ways:*

1. ***Heating:***

- *When a magnet is heated until red hot, then placed pointing in E – W direction until it cools, it loses its magnetism.*

2. ***Hammering:***

- *Vigorously hammering of a magnet when it is placed pointing in E – W direction demagnetizes the magnet. Dropping the magnet several times can also demagnetize it.*

3. ***Electrical method:***

- *A magnet can be demagnetizes by placing it inside a solenoid while pointing E – W direction and passing alternating current (AC) through the solenoid.*

4. ***Self-demagnetization:***

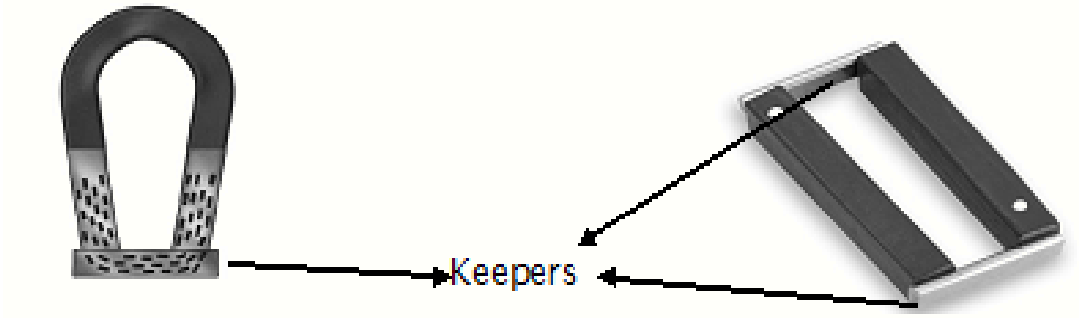
- *Most magnets lose their magnetism over a period of time.*

Storing Magnets:

- *Even the strongest magnets lose their magnetism with time to avoid this magnets should be stored.*

a) ***Horse shoe:*** *this can be stored by putting soft iron across the poles.*

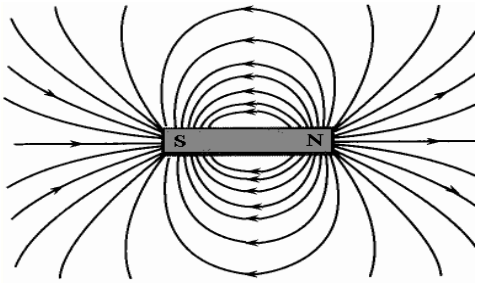
b) ***Bar magnet:*** *this can be stored in pairs of opposite poles face each other and putting a soft iron across U. the small soft iron is called* ***keepers.***



Magnetic fields:

- *The space around a magnetic field where it produces a magnetic force or it can attract or repel other materials is called magnetic field. This region is represented by a magnetic field lines or lines of a force.*

- *Magnetic field lines are sometimes called* ***lines of magnetic flux****. Magnetic flux is a vector quantity which has both magnitude and direction. The strength of the field is defined in terms of flux density. A high flux density means that the lines of force are close together.*

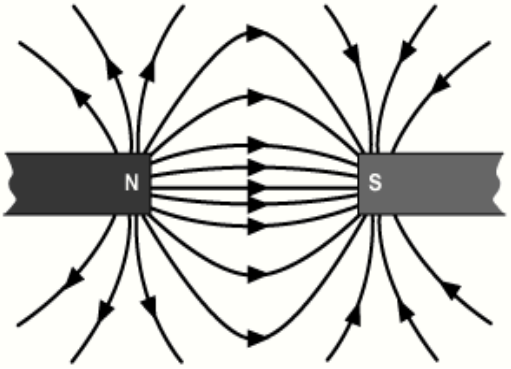


Magnetic field lines have the following characteristics:

- *They start from the North Pole to the South Pole.*
- *Magnetic field lines are strongest where the lines are closest together.*
- *No two field lines can ever cross. When two placed together, their magnetic fields interact as shown below.*

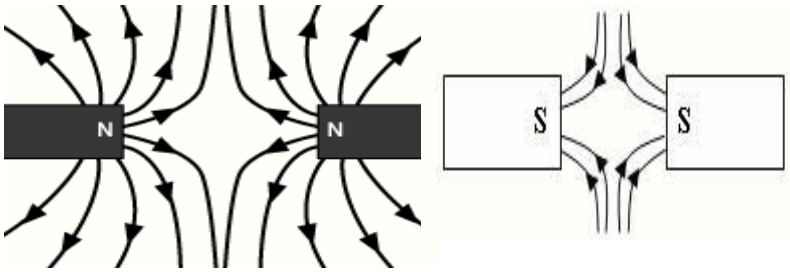
Magnetic field between unlike poles

(South pole and north pole)



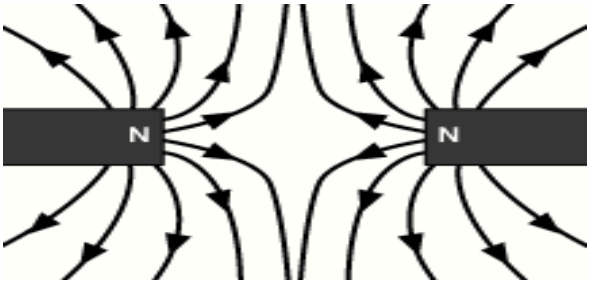
Magnetic field between like poles

(North & North pole) and (south &south)

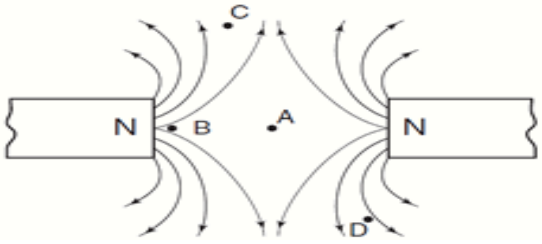


Neutral Points:

- *When like poles are brought near each other, there is a point between them that there is no magnetic effect. This point is called neutral point and is marked "X" in the figure.*



- *Magnetic field lines are strongest near magnetic poles. In the figure below point "* ***B*** *" is the strongest and point "* ***A*** *" is the neutral point.*

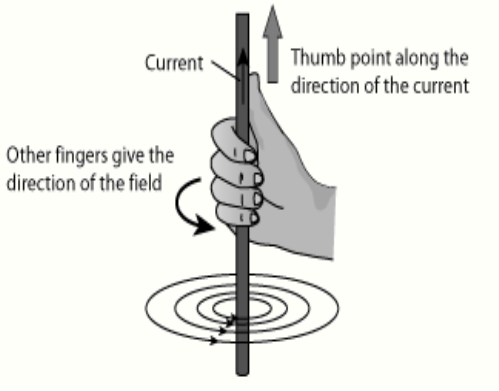


Earth's Magnetic Field:

- *The earth has a magnetic field it's magnetic field lines runs from south pole to north pole.*
- *A most places on earth's surface a magnetic compass points slightly to E – W of the true north the angle between magnetic north and the true north is called* ***declination.***

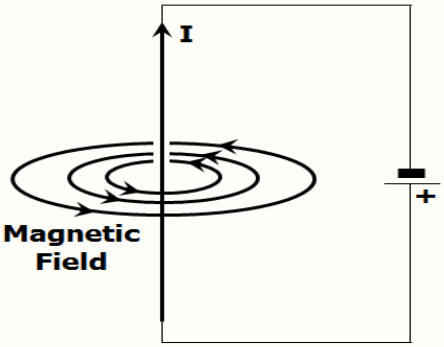
Magnetic effect of the electric current:

1) Magnetic field due to single wire:



In a current carrying conductor there is a magnetic field around the wire the field has the following features.

- *The field lines are circles with the conductor at the centre.*
- *Field lines are circles and strongest close to the wire.*
- *Reversing the current reverses the direction of the field.*
- *The direction of the field is given by* ***right hand grip rule (RHGR).***
- *Any conductor carrying a current has a magnetic field even if the wire itself is not made of magnetic material. This is one of the effects of the electric current (Magnetic effect of the electric current) and was discovered by Danish scientist Hans Christian Oerestred.*



Right-hand grip rule*:*

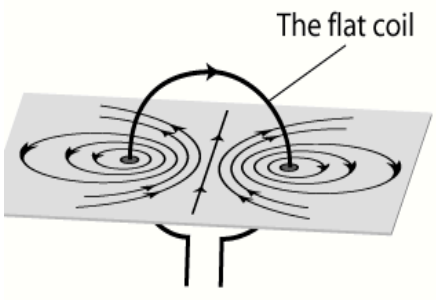
- *This rule states "while holding the conductor with right hand and the thumb pointing the direction of the current, then with the fingers curled around the wire as if to grip it, the fingers indicate the direction of the field lines around the wire."*

The strength of the magnetic field form by a current carrying conductor depends on:

- *The magnitude of the current. A stronger current will produce a stronger magnetic field around the wire.*
- *The distance from the wire. The strength of the field decreases as you move further out.*

Magnetic field pattern due to the circular coil:

- *the circular coil consists and behaves like two single wires so it will has two independent magnetic field find each side of the coil independently using right hand grip rule.*

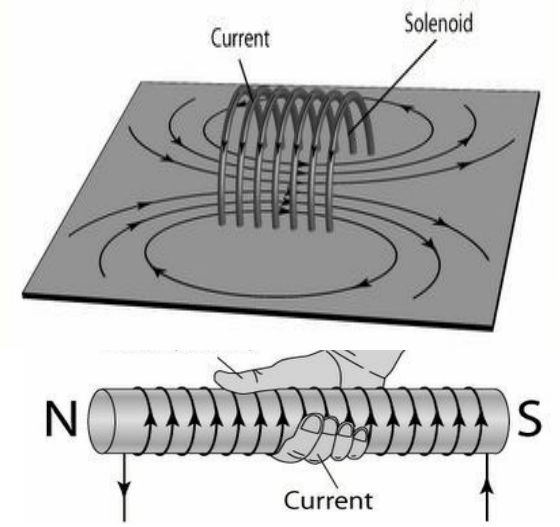


Magnetic field pattern generated by a flat coil

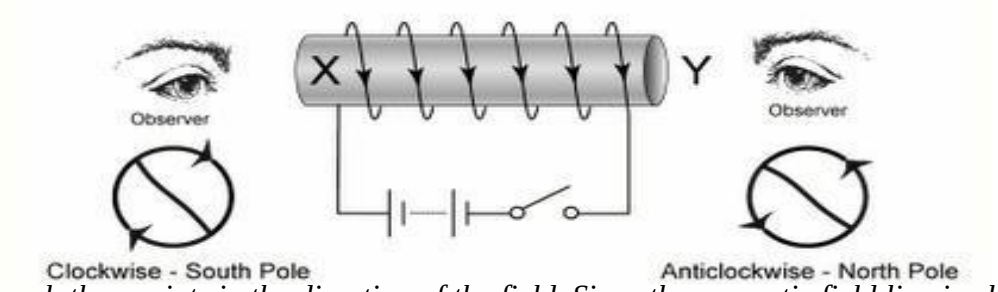
There are two ways to increase the strength of the magnetic field:

- *increase the current and*
- *Increase the number of turns of the coil.*

Magnetic field of a solenoid:



- *A solenoid is a long coil made up of a numbers of turns of wire.*
- *The magnetic field of a solenoid resembles that of the long bar magnet, and it behaves as if it has a North Pole at one end and a South Pole at the other.*
- *The right hand grip rule can be used to determine the magnetic field pattern as shown in the figure below.*
- *Imagine your right-hand gripping the coil of the solenoid such that your fingers point the same way as the current.*
- ***Alternatively the rule for polarity (clock rule) can be used:***
- *This rule states:* ***"when the solenoid viewed from one end, if the current seems to flow in the clockwise direction that end is the south pole. If it seems to flow in the anticlockwise direction, then that end is a north pole."***



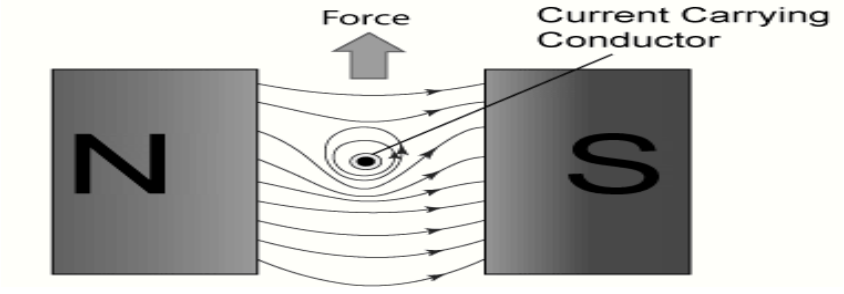
- *Your thumb then points in the direction of the field. Since the magnetic field line is always coming out from the North Pole, therefore the thumb points towards the North Pole.*

The strength of the magnetic field of solenoid can be increased by:

- *Increasing the current.*
- *Increasing the number of turns per unit length of the solenoid.*
- *Using a soft-iron core within the solenoid.*

Force on a current carrying conductor:

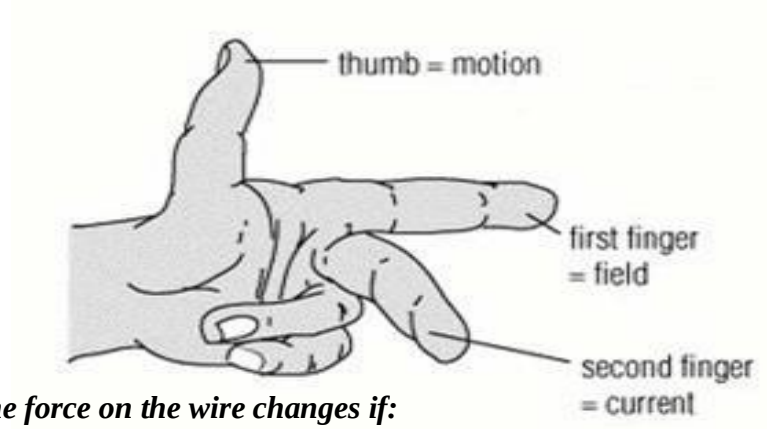
- *When a current-carrying conductor is placed in a magnetic field, the interaction between the two magnetic fields (the magnetic field of the conductor and the magnetic field of the magnets) will produce a force on the conductor.*



- *The figure above shows two magnetic fields from the wire and the permanent magnet.*
- *On one side of the wire the fields have the same direction and repel the wire, on the other side of the wire the fields have opposite directions and attract the wire. This is called the catapult effect (or motor effect because it is the basic principle of the motors).*

The direction of the force can be determined by Fleming's left hand rule (motor rule):

- *The fore finger, middle finger and the thumb are perpendicularly to each other. The forefinger points along the direction of the magnetic field, middle finger points in the current direction and the thumb points along the direction of the force.*



The direction of the force on the wire changes if:

- *The direction of the current changes.*
- *The magnetic poles are reversed over each other.*

The size of the force on the conductor can be increased by:

- *Increasing the strength of the magnetic field it experiences.*
- *Increasing the size of the current flowing through it.*
- *Increasing the number of turns of wire experiencing the magnetic field.*
-
  - *The effect is called motor effect it is the interaction of two field which produce of force and hence motion*
  - *Energy transformation = flied + current = mechanical*

Magnetic Flux Density:

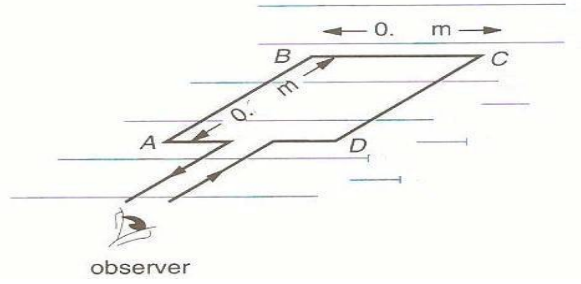
- *Magnetic flux density or magnetic field strength is defined as the force per unit length its symbol is (B) and has unit of* ***Tesla*** *(T).* $B = \frac{F}{IL}$ $F=BIL$

Example #1: *For the figure shown rectangular coil carrying a current of 0.5A to a magnetic field strength of 0.8T find*

a) Will the wire rotate clock wise or anti clock wise?

b) Work out the magnitude of the force?

c) Find the torque?



SOLUTION

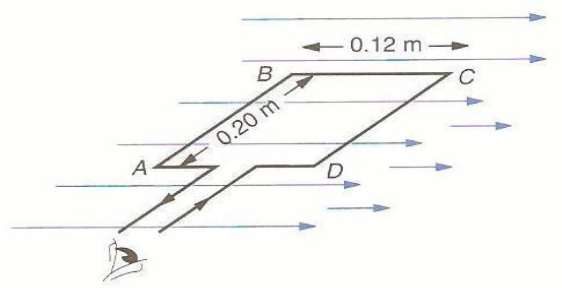
a) Using FLHR side AB will move downward. So side CD will move upward therefore the coil will rotate anticlockwise

b) F = BIL = 0.8T X 0.5 A X 0.3m = 0.2N

c) Torque = force X distance = 0.12 X 0.2 = 0.24 Nm

***Example #2:** The figure below shows a rectangle coil wire carrying a current of 0.26A. That has 150 turns the coil is parallel to a magnetic field of flux density 0.36Y*

a) using FLHR side AB moves upward so side CD moves down ward therefore the coil waves clock wise



b) F = BIL = 0.36X 0.26X0.20 = 0.0187N

Force on 150 turns = 150 X 0.0187 = 2.80N

c) Torque = f x d = 2.80 X 0.12 = 0.34N

Application of Motor Effect

- *Electric motors, fans, refrigerators, air conditioners and some toys make use of motor effect.*
- ***Dc motor:** A simple dc motor contains a rectangular coil of wire of many turns mounted between two permanent magnets current passes to the wire via brushes which are pushed against split ring commentator reverses the current flow every half cycle to ensure the coil to rotate in one direction.*

