MAGNETS AND MAGNETIC FIELDS (8 periods)

COMPETENCY: The learner should investigate and understand the properties of magnets and explain how the Earth behaves as a magnet.

LEARNING OUTCOMES

The leaner should be able to:

- know that a small number of materials are magnetic, but most are not. (K)
- know how magnets can be made and destroyed. (K, S)
- understand the behaviour of magnets and magnetic fields (u)
- know that the Earth is a magnet and how a compass is used to determine direction, (k, s)

LEARNING ACTIVITIES

1. In pairs, learners use prior learning to discuss and classify materials in a table into magnetic or non- magnetic: [copper, nickel, iron, steel, cobalt, aluminium, steel, zinc, wood, rubber], then confirm their results with a magnet, and identify any pattern in the results.
2. In pairs, learners plan and carry out investigations using magnets and research to discover and report:
   - ❖ which poles attract and repel.
   - ❖ the law of magnetism, and
   - ❖ which pole of a bar magnet is south and which is north.
3. In groups, learners use iron filings and paper to plot magnetic fields around a bar magnet and individually draw diagrams to show the lines of force.
4. In pairs, learners do as follow, and produce a report:
   - ✓ investigate the strength of available magnets using a chain of small nails or pins as a measure.
   - ✓ investigate what happens when a magnetised needle is suspended freely by a thread.
   - ✓ research how the Earth behaves as a magnet and how a magnet can be used to navigate.

MAGNETS

A magnet is a piece of material which can attract certain materials. Metals which are strongly attracted by the magnet are called ferromagnetic materials. E.g., iron, cobalt, nickel.

LEARNING ACTIVITY ONE

Some materials are magnetic while others are non-magnetic materials. A scrap seller buys magnetic materials at UGX 800 a kilogram while non-magnetic materials are bought at UGX 400 a kilogram. you have been provided with the following materials in order to help him identify the magnetic materials from non-magnetic materials.

A bar magnet	A plastic bottle top
Iron nail	A piece of wood
A pen and pencil	A piece of aluminium
An optical pin	A piece of rubber
coin	A piece of glass
Steel masses	Copper wire

a) Which materials are **magnetic**? and explain why?
   Iron Nail, optical pin, and steel masses
   They are magnetic because they can be attracted by a magnet.
b) Which materials are **non-magnetic**? and explain why?
   Pen, pencil, plastic bottle top, wood, aluminium, rubber, glass, copper wire. They are non-magnetic because they are not attracted by a magnet.
c) Name any other **magnetic** materials besides those above.
   Cobalt, nickel, iron, steel
d) Name any other **non-magnetic** materials besides those above.
   Silver, gold. Brass, copper, aluminium, plastic, wood, paper, rubber
e) List down the **uses** of magnets
   - Used in fridge doors,
   - used in necklaces,bangles and earrings for opening and closing.
   - Used in magnetic compass for navigation.

- Used in MRI (Magnetic Resonance Imaging) scans in the hospital. This MRI scan produces exact images of human body organs, bones and tissues which can then be treated.
- In industries there are special vehicles that have strong magnets on them, for picking up cars and scrap metal and relocating them.
- Used in electronic devices such as computers and mobile phones, TVs, speakers, radios etc.
- It is also used in food processing industries for separating small metallic pieces from grains etc.
- Used in electric bells.

f) Explain it is important to distinguish magnetic substance from non-magnetic materials in the above scrap business.
Used in recycling process since they separate different metals. This is because some of the metals will stick to the magnet, and some won't. This eases the recycling process.

LEARNING ACTIVITY TWO

You have been provided with the following materials.

2 sheets of papers	1 bar magnet	Iron fillings

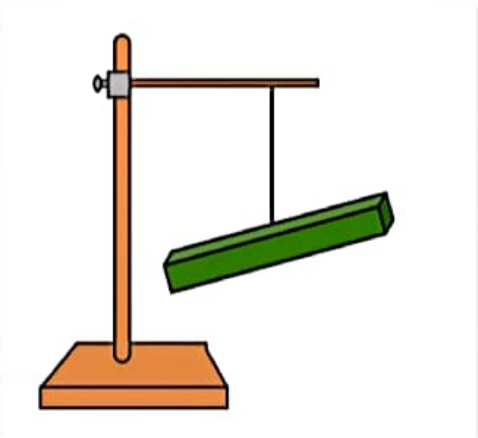
a) Where is the attractive force of the magnet concentrated/strongest? hence define the pole of a magnet.
The attractive force is strongest at the poles hence pole of a magnet is the end of a magnet where the attractive force is strongest.

b) Write down the procedures you followed to come up with that conclusion.

- One sheet of paper is placed on the table.
- Iron fillings are uniformly spread on the 1st sheet of paper.
- 2nd sheet of paper is then placed on top of the 1st sheet of paper to cover the iron fillings gently.
- The bar magnet is then placed on top of the 2nd sheet of paper.
- 2nd sheet of paper is then lifted together with the bar magnet and observations are made.

LEARNING ACRIVITY THREE

Joseph is a worker in a factory which makes bar magnets, one day the worker in charge of painting the magnets wasn't around. The bar magnets are always painted differently basing on the poles. The north pole is painted red while the south pole is painted blue.



Support material

- Unpainted bar magnets
- A wooden retort stand with a clamp.
- A piece of cotton thread

Task

a) What advice would you give joseph to paint the magnets correctly? Include a well labelled illustration.

- Joseph needs to first identify the poles of the unpainted magnets and then later paint them correctly and to do so I advise him to follow these procedures below.
- Tie the unpainted bar magnet in the middle with a piece of thread.
- Suspend the unpainted bar magnet from the retort stand and allow the magnet to come to rest.
- Note the pole and direction in which the magnet comes to rest.

b) Discuss your observations.

It is observed that the magnet comes to rest in the North-South direction.

The end pointing in the earth's geographical North is the North pole

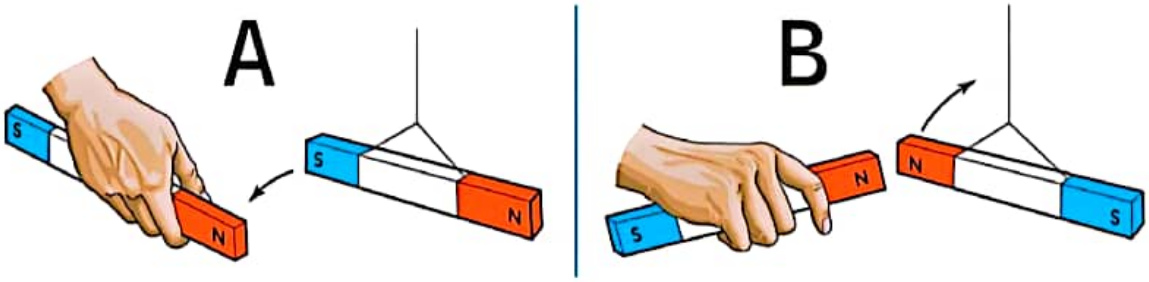
The end pointing in the earth's geographical South is the South pole

c) Explain your observations.

The bar magnets rest in the North-South direction because the earth itself is a magnet. The earth's magnetic North pole is in the Southern hemisphere and the earth's magnetic South pole is in the Northen hemisphere.

ACTIVITY FOUR

you are provided with two labelled bar magnets shown below in diagram A and B. Use them to deduce the law of magnetism.



KEY QUESTION

a) Explain how you can use the above two set ups to deduce the laws of magnetism.

In A above the north pole of one bar magnet is brought close to the south pole of another bar magnet and repulsion occurs hence Opposite poles attract

In B above the north pole of one magnet is brought close to the north pole another bar magnet and attraction occurs hence like poles attract

The law of magnetism states that opposite poles attract while like poles repel.

b) Which of the two laws in figure A and B above is the best way of testing the polarity of a magnet?

Repulsion is the only sure way of testing the polarity.

c) Why is it the best way of testing polarity of a magnet?

Repulsion is the only sure way to test for the polarity of a magnet since attraction can occur either between magnets or between a magnet and un-magnetized material.

d) Describe how you can test the polarity of a magnet.

To be answered by each student

MAKING MAGNETS (MAGNETIZATION)

Many electronic devices rely on magnets to function, and this has created a strong demand in man-made (artificial) magnets. There are different categories of magnets such as

- permanent magnets
- temporary magnets

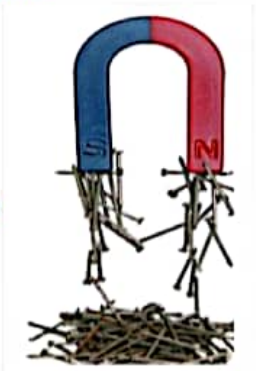
The question that puzzles most scientists however today is how to make a magnet since the naturally occurring magnets are very few and yet we need to use them in daily life.

LEARNING ACTIVITY FIVE

You have a brother in primary who has challenges on understanding temporary magnetism are provided with a magnet and nails or optical pins.

a) Describe a simple activity you can carry out to help him understand this topic very easily using the above materials and hence deduce the meaning of the word temporary magnet? (Include an illustration)

- Place the nails on a flat surface.
- Bring the magnet close to the nails.
- It is observed that the nails are attracted to the magnet and other nails are attracted to each other as well. This means that those nails attracting each other have acquired some magnetism called temporary magnetism.
- The magnet is then gently separated from the nails.
- It is observed that the nails that were attached to each other also separated meaning they lost their magnetism. And because the magnetism did not last long, we call it temporary magnetism.



b) What is the meaning of the word temporary magnet.

Temporary magnets are made of soft metals that are magnetised for a short period of time only when exposed to a permanent magnetic field or an electric current. When they come into contact with a magnetic field, they become magnetized. When the magnetic field is removed, they gradually lose their magnetism.

c) How is it any different from permanent magnet?

Permanent magnets are types of magnets that can retain their magnetism for a long period of time even after removing the external magnetic field.

d) How useful is this magnetism to a:

(i) a grain farmer to separate the grains from the metal pieces.

(ii) scrap dealer to lift metals and to separate different metals i.e., the magnetic metals from non-magnetic metals.

(iii) medical doctor during MRI scans to show images of internal organs, tissues, and bones of the patient.

(iv) Tourists and explorers, to show direction in the compass needles for navigation purposes.

NOTE. The above method of magnetisation is also called magnetisation by **induction**.

Definition. **Magnetic Induction** is the process by which a magnetic material becomes magnetized by bringing near or in contact with the pole of a permanent magnet.

Magnetisation is the process of making a magnet.

Methods of magnetisation

- Single touch method /single stroke method
- Electrical method
- Induction method and others

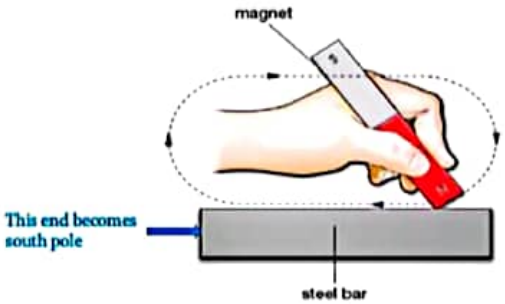
LEARNING ACTIVITY SIX

A student is provided with a steel bar, a magnet and office pins. The diagram below shows the set up used by the student.

a) Describe the activity that this student is carrying out.

b) Discuss your observations.

c) What name is used to represent the method of magnetisation above.



Solution a)

- ✓ The student placed the steel bar on a flat surface.
- ✓ He then stroked the steel bar several times with the north pole of the bar magnet. (Around 20 strokes)
- ✓ After every stroke, he lifts the magnet up as shown in the figure above before the next stroke.

Solution b)

The end of the steel bar A becomes north pole and end B becomes south pole. Explanation. Steel bar in its natural state has dipoles facing in different directions and so it is un-magnetised. Stroking helps to align these dipoles to face in the same direction and so making steel bar to become magnetized.

Solution c)

The student is magnetizing steel bar by single stroke method.

DOMAIN THEORY OF MAGNETISM

The domain theory of magnetism states that all magnetic materials are made up of tiny magnets called dipoles which are divided into regions called domains.

In a **magnetized** magnetic material, the dipoles face in the same direction whereas in an **un-magnetized** magnetic material, the dipoles face in different directions

Question Between materials in **figure A** and **Figure B** below, which one is **magnetized** material, and which one is **un -magnetized** material. explain why you think so.

Figure A

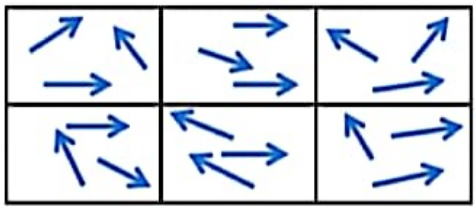
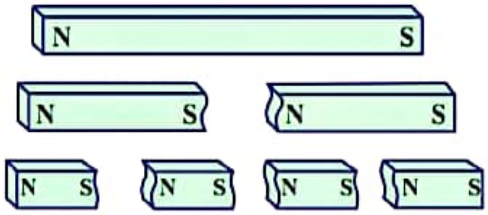


Figure B

Solution. Figure A is magnetized because its dipoles are all facing in one direction while figure B is un-magnetized because its dipoles are facing in different directions

QUESTION

John broke a magnet into very small pieces as shown below but to his surprise even the smallest pieces still managed to attract small office pins.how can you explain this?



When a magnet is broken into many pieces, the smallest possible piece of a magnetic material called a dipole has a North and South pole.each broken piece has a North pole and South pole. Therefore, each piece is a complete magnet that expalins why it can still attract small office pins

LEARNING ACTIVITY SEVEN

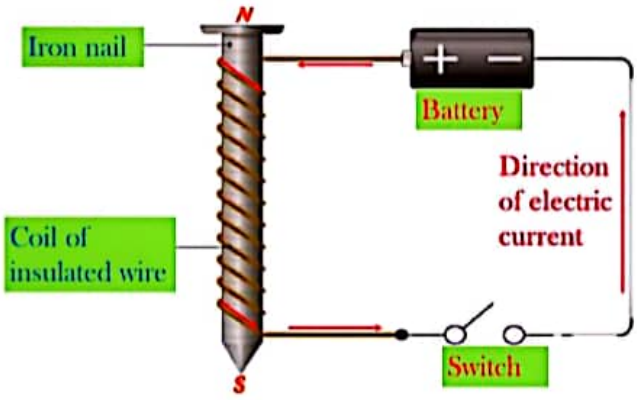
A company that makes transformers advertised are looking for an expert in supplying them with magnets. You have been hired by a company in order to help them produce powerful strong magnets such that they reduce on buying expensive ones.

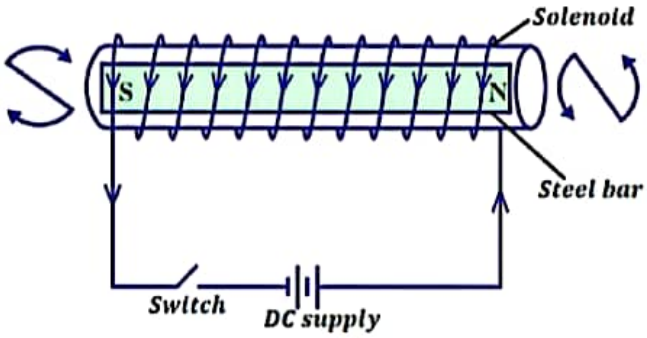
Support materials (include a switch)

Copper wire **iron nail** **connecting wires** **paper clips / pins.**

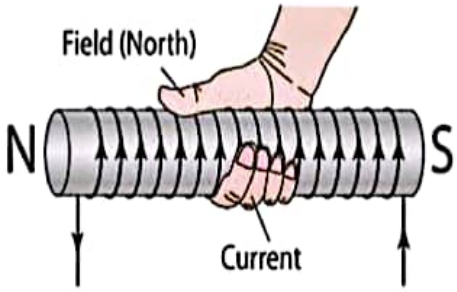
Task

With the aid of a well labelled diagram, describe how you can help the company solve the problem of scarcity in magnets using the above and discuss your observations.





- Assemble the circuit as shown above.
- Switch on for about three minutes and later switch off.
- It is observed that the iron nail is magnetized when is closed (ON). It attracts paper clips/ small office pins.
- One end of the nail becomes the North and the other the South pole. To determine the polarity of the electromagnet made we can use the **solenoid right hand grip rule** which states that when gripping a solenoid such that the figures point/curl in the direction of current then the thumb will point in the direction of the North pole.
- It is also observed that when the switch is opened (OFF), the iron nail is un magnetized and the paper clips/ small office pins fall off.
- NOTE. The magnet made in this set up is called an electromagnet. The figure below is the Right-hand grip rule for solenoids.



•Wrap the fingers around the coil in the direction of current.

•The thump will indicate the North pole.

NOTE:

➢ Since **direct current** flows in one direction, the dipoles of the steel bar/iron nail are arranged so as to face in the same direction. This explains why it becomes magnetised in presence of direct current.

➢ If **Alternating current** was used, the arrangement of the dipoles of the steel bar/ iron nails would be disorganized so that they face in different directions. This makes it to loose magnetism and the pins fall off.

LESSON ACTIVITY EIGHT (Types of magnets)

There are mainly two types of magnets, i.e., temporary magnets (made using soft magnetic materials like iron) and permanent magnets (made using hard magnetic materials like steel)

Soft magnetic materials are easy to magnetize but lose their magnetism easily whereas hard magnetic materials are hard to magnetize but retain their magnetism for long period of time.

Question. Distinguish between hard and soft magnetic materials giving example of each.

Question. Distinguish between temporary and permanent magnets.

Research work. Where are these magnets commonly applied.

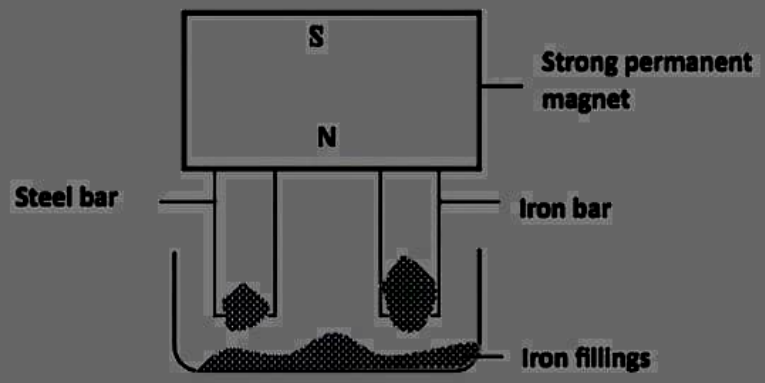
(a) Hard magnets (b) soft magnets

ACTIVITY

In an attempt to distinguish between hard and soft magnetic materials, a student was provided with the following materials.

Permanent magnet, steel nail, iron nail, iron fillings.

Task With the aid of a well labelled diagram describe an activity that you can carry out to understand the difference between the above types of magnetic materials.



- ✓ Un-magnetized strips of Iron and Steel are placed side by side in contact with the pole of a magnet.
- ✓ Both strips are then dipped in iron fillings as shown above

Observations and conclusions

- ✓ More iron fillings are attracted to the iron strip than the steel strip indicating that iron is easily magnetized than steel.
- ✓ On removing the permanent magnet, almost all iron fillings on iron fall off and very few fall from steel indicating that iron is easily demagnetized than steel.
- ✓ Therefore, iron is soft magnetic material while steel is hard magnetic.

NOTE. Hard magnetic materials are used in making permanent magnets used in voltmeters, ammeters, loudspeakers, telephone receivers

STORAGE OF MAGNETS

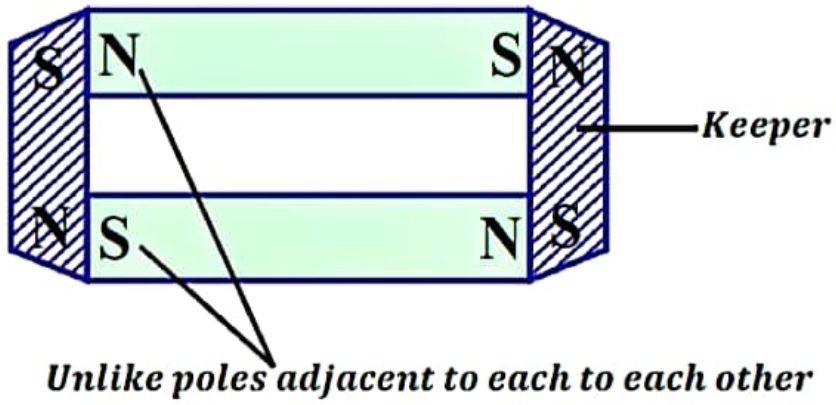
Magnets need to be carefully kept in order for them to be able to keep the strength of their magnetism for a long time. Moisture, heat, shock and position of the magnets matter most while keeping a magnet. If kept wrongly, a magnet can loose its magnetic properties easily.

QUESTION (research)

Magnets tend to become weaker with time due to self-demagnetization due to repulsion between free like poles near the ends. This disorganizes the arrangement of the dipoles in magnets. To prevent self-demagnetization explain using a well labelled diagram how you would solve this problem.

To prevent self-demagnetization, magnets are stored in pairs with their **unlike** poles adjacent to each other with small pieces of soft iron called **keepers** placed across their ends.

The keepers are magnetized by induction thus forming a closed loop of magnets with no free exposed poles. This eliminates self-demagnetization.



DEMAGNETISATION OF MAGNETS

When magnets lose their ability to attract metals like iron, we say they have been demagnetised.

Magnetisation is a process by which a magnet loses its magnetism. During this process, the order of the tiny magnets (dipoles) is so disorganized such that the dipoles face in different directions.

Question. Discuss the meaning of the term demagnetisation and explain any three possible ways of demagnetising a magnet.

Heating:

The magnet is heated until it becomes red-hot and then cooled while resting in the East-West direction. Hence making dipoles disorganised.

Hammering:

The magnet is hammered several times while resting in the East-West direction. This disorganises the dipoles (dipoles face different directions

Using alternating current:

A magnet is placed in a solenoid connected to an alternating current supply while resting in the East-West direction.

It is then switched on and then off and on removing the magnet,

The magnet loses its magnetism since A.C current disorganizes the arrangement of the dipoles.

NOTE: solenoid is a cylindrical coil of wires

Note: During demagnetization, the magnet is rested in the East – West direction so that it doesn't retain some magnetism due to the earth's magnetic field.

Note soft magnetic materials are used in making temporary magnets used in electric bells, transformers, relays, magnetic keepers etc.

MAGNETIC FIELDS

A magnetic field is the region around a magnet where a magnetic force is experienced. Magnetic field is stronger near the poles but weaker further away from the poles.

Magnetic fields are represented by magnetic field lines.

Magnetic field patterns can be determined using two methods.

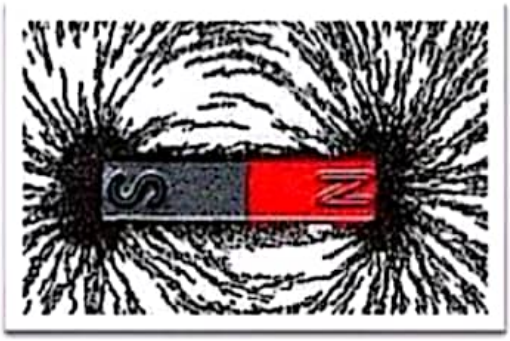
- Using a plotting compass
- Using iron fillings

ACTIVITY (research work)

You are provided with a bar magnet, a sheet of paper and a plotting compass. With the aid of a well labelled diagram, carry out an activity to identify the magnetic field lines and describe all the steps followed.

ACTIVITY

You are provided with a bar magnet, a sheet of paper and iron fillings. With the aid of a well labelled diagram, carry out an activity to identify the magnetic field lines and describe all the steps followed.



- A bar magnet is placed on a table and then covered with a smooth paper.
- Iron fillings are sprinkled all over the paper.
- The paper is gently tapped.
- The iron fillings arrange themselves as shown above.

Question what are the Properties of magnetic field lines?

They move from North pole to South pole.

They do not cross each other.

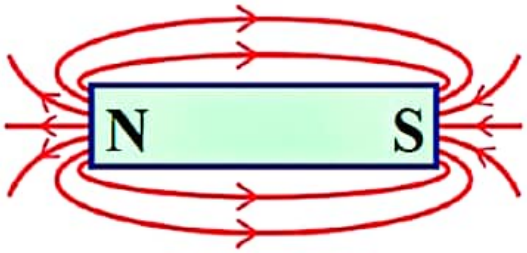
They are closer at the poles.

The number of magnetic field lines show the strength of a magnet.

They can pass through non-magnetic substances.

They all have the same strength.

Question *From the below picture draw a clear illustration of field lines of an isolated bar magnet.*



ACTVITY (DRAWING MAGNETIC FIELD LINES)

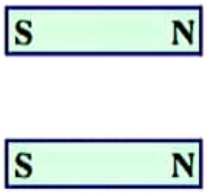
With the help of iron fillings, a sheet of paper and the magnets provided, investigate the magnetic field patterns formed when the magnets are placed as shown below. Copy and draw the filed lines of each of the following magnets as arranged below and where necessary indicate the neutral point.

a) Two bar magnets with unlike poles facing each other:

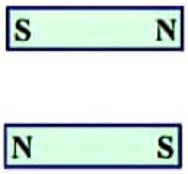
b) Two magnets with like poles facing each other: (south facing south)

c) Two magnets with like poles facing each other: (North facing North)

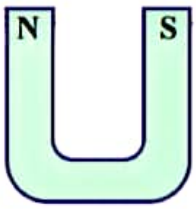
d) Two bar magnets placed parallel with same poles facing each other.



e) Two bar magnets placed parallel with opposite poles facing each other:



f) Horse shoe (U shaped magnet)



Did you know?

Magnets are used in refrigerators to keep the doors closed and used in hospitals to remove the iron pieces from the patients' eyes.

Magnets are used to lift heavy containers at the large ports.

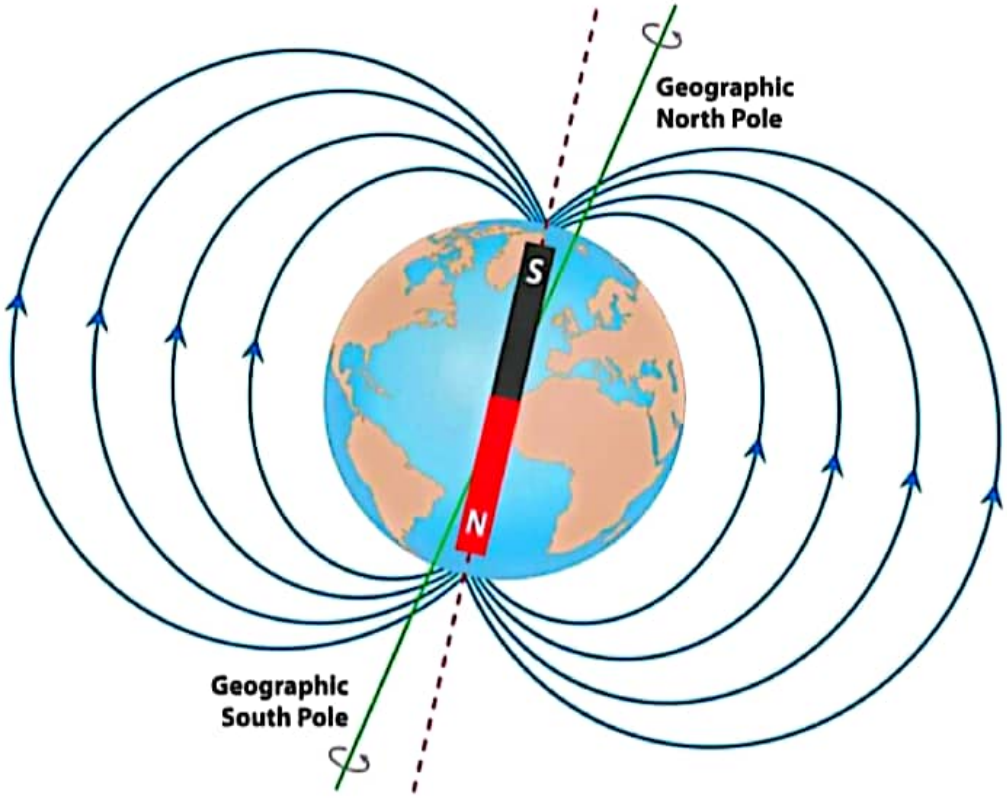
Neutral point: This is a point in a magnetic field where the resultant magnetic force is zero.

THE EARTH AS A MAGNET

The earth behaves as though it contains a bar magnet inclined at an angle to its axis of rotation. This magnetic field is very important to man. It is the reason why the earth is safe and protected from sun's harmful radiations since it shields earth.

The earth's magnetic field lines are made up of parallel lines running from the geographical south (magnetic North pole) to the geographical north (magnetic South pole).

The **earth's magnetic South Pole** is within the northern hemisphere (geographic north) and the **earth's magnetic North Pole** is in the southern hemisphere (geographic south).



The magnetic field of the earth is due to electric currents in the core of the earth.

Explain what happens when you freely suspend a bar magnet.

When a bar magnet is freely suspended, it always come to rest in a north-south direction.

This is because the earth is a magnet having its north pole in the southern hemisphere and South Pole in the northern hemisphere and these poles attract the poles of the freely suspended magnet.

The compass needle:

The compass needle points approximately **north** because it is **attracted** to the poles of the earth's magnetic field. The compass has a small magnetic needle which freely rotates and comes to rest with its north facing earth's **geographical North**. The north of the compass needle points earth's **geographical North** because it is attracted by the earth's **magnetic south** which is in the **geographical North.**

QUESTION one of your friends got lost when you went to tour the Mabira forest and with you is only a magnetic compass. Explain how that navigation tool will help you locate your friend.

Inside the compass box there is a freely rotating compass needle is made of a special naturally occurring magnetic material called magnetite. It always aligns itself with the earth's magnetic field and for that reason it always points towards the north to indicate direction.

This is because the earth itself is like a giant magnet with its own north (in the geographic South) and south poles (in the geographic North). The magnet in the compass needle aligns with the earth's magnetic field pointing towards the geographical North.

By using a compass, you can tell which direction you are facing and which way to go to get where you want to go. It is very useful to hikers, campers and anyone who wants to explore and navigate outdoor.

Did you know that some birds like pigeons and robins have some magnetic particles (magnetite) in their brains. These particles act as internal an internal compass to help them navigate.

ACTIVITY OF INTEGRATION

Grain millers in a certain community faced a problem of impure grains which spoilt their grinding machine. It was discovered by one of their workers that some community members bring grains mixed with some metal pieces such as iron.

You may use these support materials.

Connecting wires, switch, 6-inch-long nail, battery (power source), iron fillings, masking tape, insulated copper wire

Task

a) Design a prototype of a **simple device** which the millers can use to sort the impurities from grains and **explain** how it works stating any **precautions** which must be taken while designing and using it. (Ensure to **test** if the device you have designed works). **Conclude** by suggesting other **applications** of the device you have designed.

ACTIVITY OF INTEGRATION

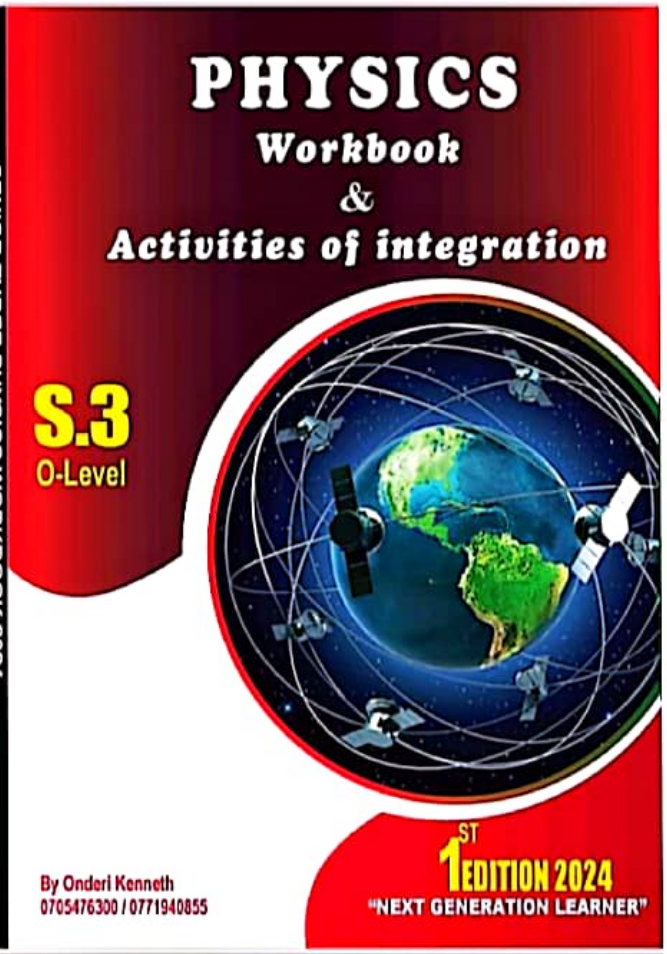
On one vacation, you met a group of youths who had also gone to enjoy the beautiful scenery in the forest unfortunately they had lost their way and were not sure of the right direction to follow to get out of the forest. All the smart devices they had carried had run out of power. So left with no other choice you checked inside your travel bag and found a **pen**, a **notebook**, a **map** of the forest, a **bar magnet** and a **string**.

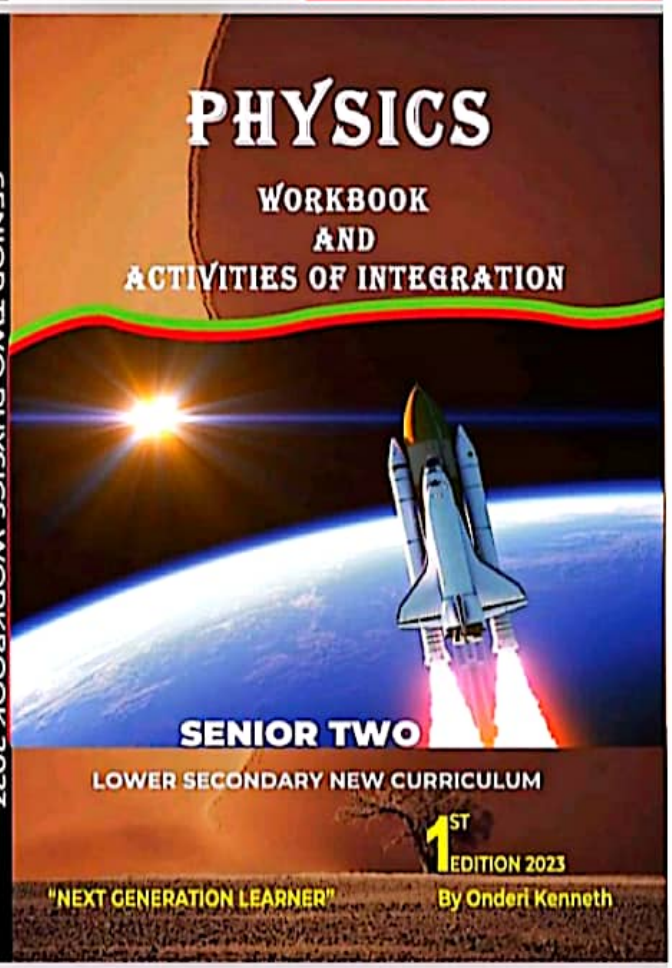
Hint: Assuming they want to head west and are not sure where west is

How will you use the above materials to help them find their way out of the forest?

THE END >>>>>>>ELCTROSTATICS UPNEXT

MAGNETISM BY ONDERI KENNETH @2024 @COMPETENCE BASED





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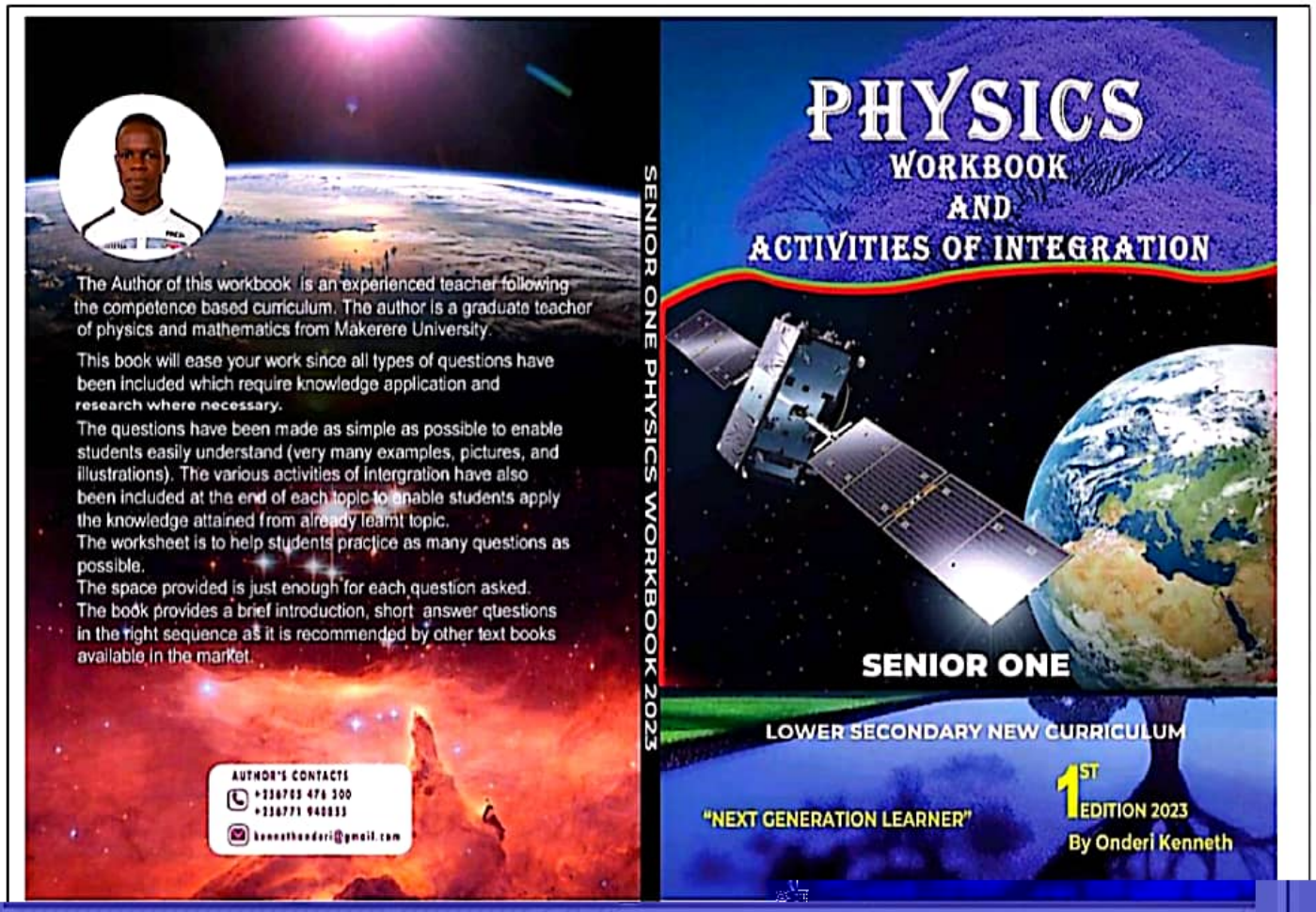

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- Positive criticism is well received to help improve our service delivery to the nation in terms of physics as a subject and how the books should be like in order to make the subject better.
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