JONAHS PHYSICS DEPARTMENT
S.2 NOTES FOR RECESS TERM
You are required to copy these notes before reporting date.
MAGNETISM
Magnets

- A magnet is a piece of metal/material which can attract other materials.
- A substance which is attracted by a magnet is known as a magnetic material or ***ferromagnetic*** material.
  Examples of magnetic material are iron, cobalt, Nickel and Steel.
- A substance which is not attracted by a magnet is known as a ***non-magnetic material.*** Examples include: wood, copper, brass, lead and so on.
- A form of iron ore called magnetite or loadstone which has a property of coming to rest while pointing in the North-south direction when freely suspended was the first naturally occurring magnet.
- All substances show some kind of magnetic effect even if it is very small. The apparently non-magnetic substances are classified as either **diamagnetic** or **paramagnetic** respectively.

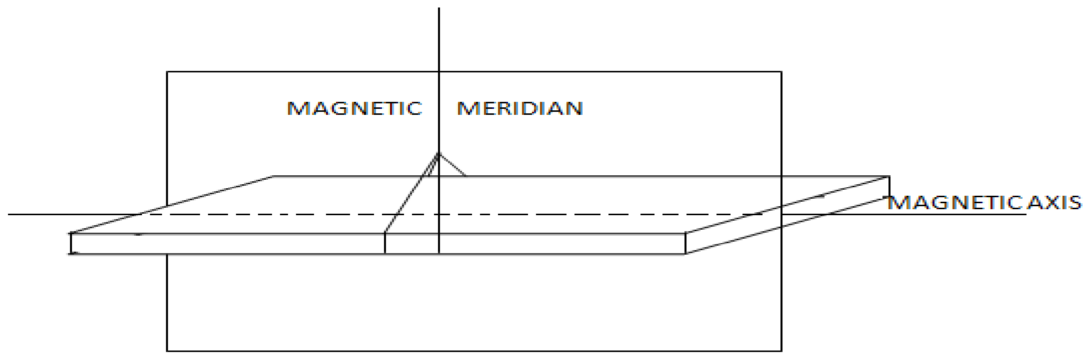
- Magnets are used in Electric motors, cycle dynamos, loud speakers and telephones.

Magnetic meridian and Magnetic axis

- When a magnet is freely suspended so that it can swing in a horizontal plane it oscillates to and fro for a short time and then comes to rest in N-S direction.
- The magnet may be regarded as having a *magnetic axis* about which its magnetism is symmetrical, and it comes to rest with this axis in a vertical plane called the *magnetic meridian*, as shown in fig below.

- ***Magnetic meridian*** is a vertical plane containing the magnetic axis of a freely suspended magnet at rest under the action of the earth`s magnetic field.

- The pole which points towards the north is called the north-seeking or N pole; the other is called the south-seeking or S pole.



Properties of magnets

1. **Magnetic materials**

Magnets can only attract strongly certain materials such as iron, steel, nickel, cobalt which are called ferromagnetic.

2. **Magnetic poles**

These are places in a magnet to which magnetic materials are attracted e.g. iron filings.

3. **North and south poles**

If a magnet is supported so that it can swing in a horizontal plane, it comes to rest so with one pole, the North-seeking or N pole, always pointing roughly towards the earth's north pole. A magnet can therefore be used as a compass.

4. **Law of magnetic poles**

Unlike poles of a magnet attract each other, that is a north pole and a south pole.
Like poles repel each other, that is north pole and north pole or south pole and south pole.
In summary: ***Like poles repel, unlike poles attract.***

Test for a magnet

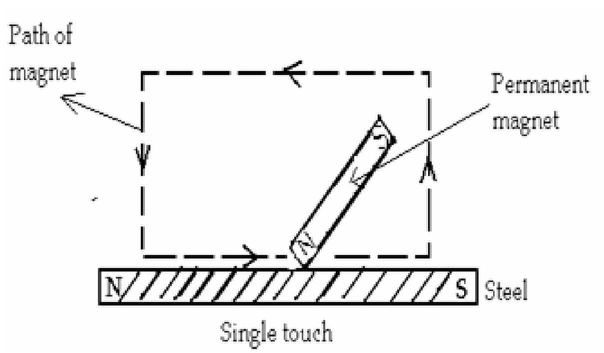
- A magnet causes repulsion with one pole when both poles are, in turn, brought near to a suspended magnet. An un-magnetised magnetic material would give attraction with both poles of the suspended magnet.

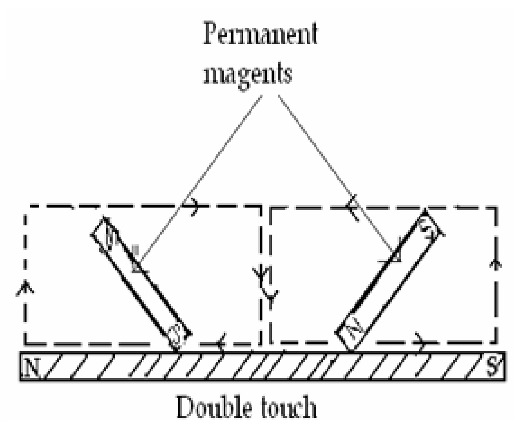
- Repulsion is therefore, the only sure test for a magnet.

Making a magnet

a) By stroking

i) **Single touch** **ii) Double (Divided) touch**





The methods of single and double touch are shown in figures a, b;
Steel knitting needles, hair grips or pieces of clock spring can be magnetized.
In single touch method, the steel is stroked from end to end about 20 times in the same direction by the same pole of a magnet.

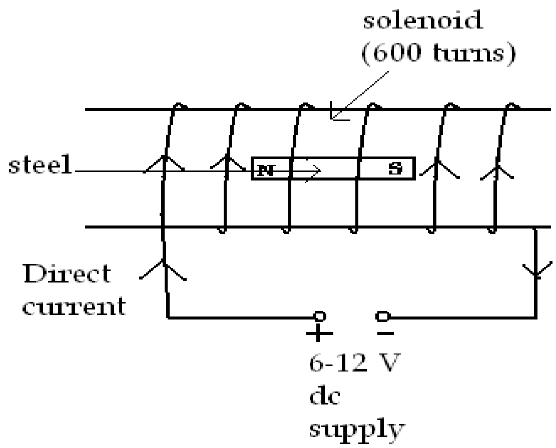
In the better method of double touch, stroking is done from the centre outwards with unlike poles of the magnet at the same time. The magnets must be lifted high above the steel at the end of each stroke in both methods. The pole produced at the end of the steel where the stroke ends is of the opposite kind to the striking pole.

b) Electrical method

The magnetic material is placed inside a cylindrical coil called a solenoid, having several hundred turns of insulated copper wire, which is connected to a 6-12V direct current (dc) supply, figure a. If the current is switched on for a second and then off, the material is found to be a magnet when removed from the solenoid.

The polarity of the magnet depends on the direction of the current and is given by the right-hand grip rule. It states that if the fingers of the right hand grip the solenoid in the direction of the current (i.e. from the positive of the supply), the thumb nails points to the North Pole, figure b

a)



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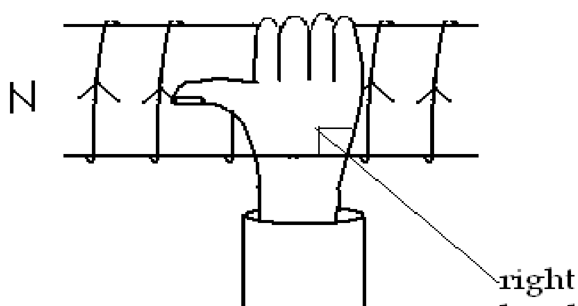
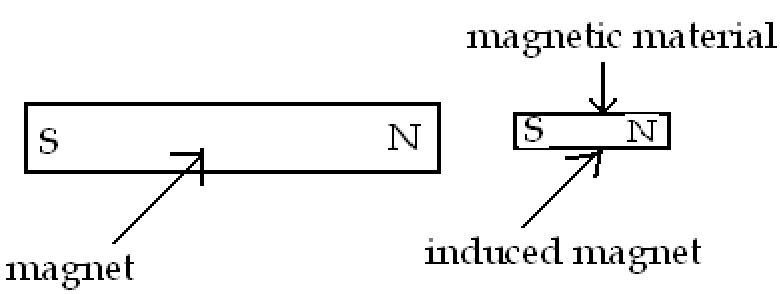
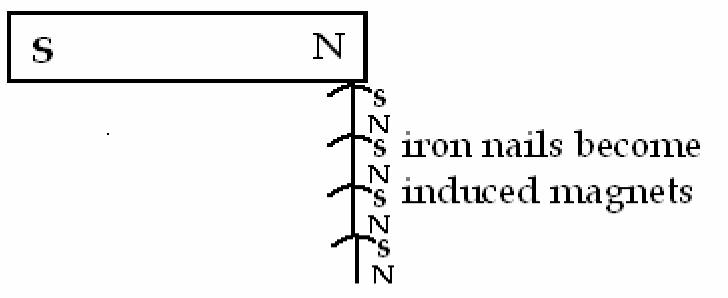


c)Induced magnetism

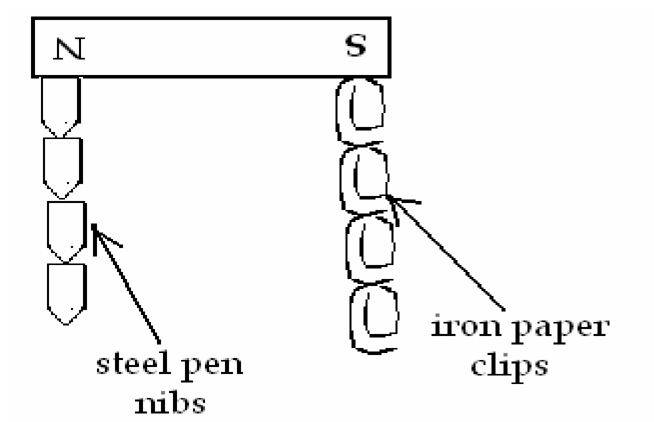
When a piece of un-magnetised magnetic material touches or is brought near to the pole of a magnet, it becomes a magnet itself. The figure below shows that a North pole induces a North pole in the far end.



Induced magnetism can be used to form a "magnetic chain" as shown in the figure below. Each nail added to the chain magnetizes the next one by induction and attraction occurs between their adjacent unlike poles.



Magnetic properties of iron and steel



- Chains of small iron paper clips and steel pen nibs can be hung from a magnet, figure above. Each clip or nib magnetises the one below it by induction and the unlike poles so formed attract.

- If the iron chain is removed by pulling the top clip away from the magnet, the chain collapses, showing that magnetism induced in iron is temporary. When the same is done with the steel chain, it does not collapse; magnetism induced in steel is permanent.

- Magnetic materials like iron which magnetise easily but do not keep their magnetism are said to be "soft". Those like steel which are harder to magnetise but stay magnetised, are "hard".

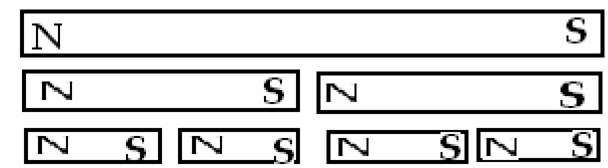
- Both types have their uses; very hard ones are used to make permanent magnets.

Domain Theory of magnetism

If a magnetised piece of steel rod is cut into smaller pieces, each piece is a magnet with a N and S pole, figure a. It is therefore reasonable to suppose that a magnet is made up of lots of 'tiny' magnets all lined up with their N poles pointing in the same direction, figure b.

At the ends, the free poles of 'tiny' magnets repel each other and fan out so that the poles of the magnet are round the ends.

a)



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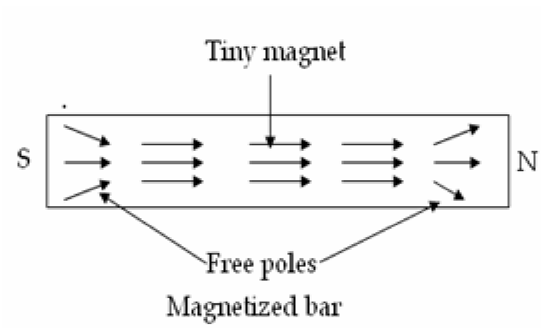
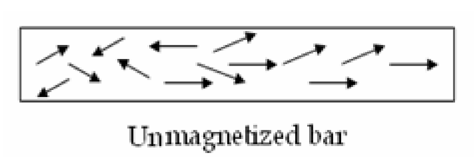


c)



In an un-magnetised bar we can imagine the 'tiny' magnets pointing in all directions, the N pole of one being neutralized by the S pole of another. Their magnetic effects cancel out and there are no 'free' poles near the ends, as shown in figure (c) above

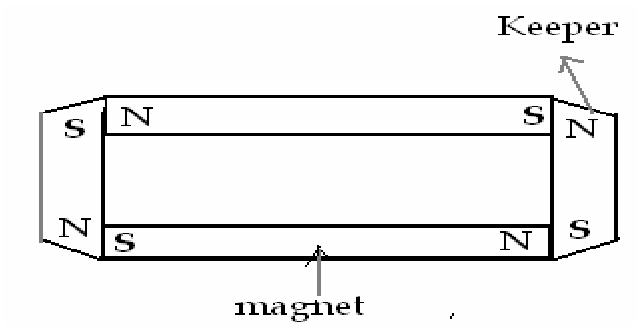
Breaking of a magnet

- **Magnetic saturation:** There is a hint to the strength of a magnet. It occurs when all the 'tiny' magnets are lined up
- **Demagnetization by heating or hammering**: Both processes cause the atoms in the magnet to vibrate more vigorously and disturb the alignment of the 'tiny' magnets.

- There is evidence to show that the 'tiny' magnets are groups of millions of atoms called **domains.** In a ferromagnetic material, each atom is a magnet and the magnetic effect of every atom in a particular domain acts in the same direction.

Storing magnets

A magnet tends to become weaker with time due to the 'free' poles near the ends repelling each other and upsetting the alignment of the domains. To prevent this, bar magnets are stored in pairs with unlike poles opposite and pieces of soft iron called keepers, across the ends, figure below.



The keepers become induced magnets and their poles neutralize the poles of the bar magnets. The domains in both magnets and keepers form closed chains with no "free" poles.

Magnetic Fields

The space surrounding a magnet where it produces magnetic force is called magnetic field.

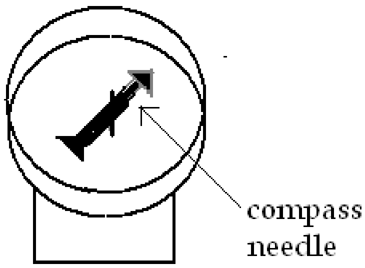
It is useful to consider that a magnetic field has a direction and to represent the field by lines of force. It has been decided that the direction of the field at any point should be the direction of the force on a north pole. To show the direction, arrows are put on the lines of force and point away from the north pole to the south pole.

Plotting the lines of force

a) Plotting compass method

A plotting compass is a small pivoted magnet in a glass case with brass walls, figure a.

a)



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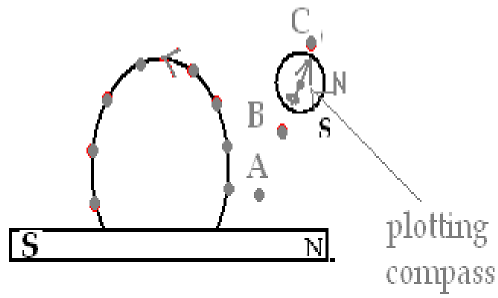
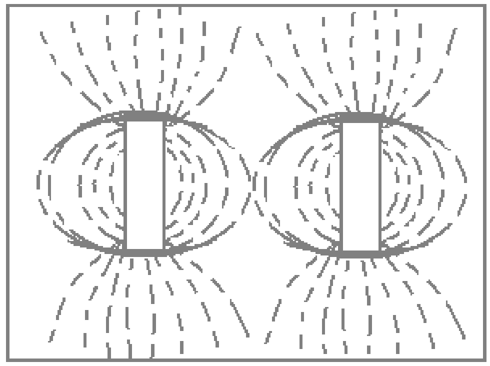


- Lay a bar magnet NS on a sheet of paper, figure b. Place the plotting compass at a point such as A near one pole of the magnet.
- Mark the position of the poles N,S of the compass by pencil dots A,B. Move the compass so that pole is exactly over B. Mark the new position of N by dot C.
- Continue this process until the south pole of the bar magnet is reached.
- Join the dots to give a line of force and show its direction by putting an arrow on it.
- Plot other lines by starting at difficult points around the magnet.
- This method is slow but suitable for weak fields.

b) Iron filings method

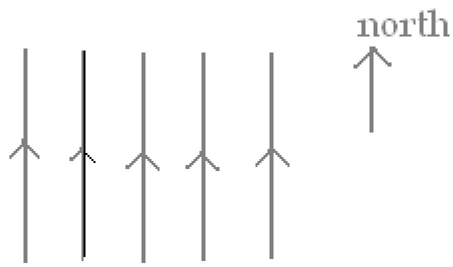
- Place a sheet of paper on top of a bar magnet and sprinkle iron filings thinly and evenly on to the paper from a “pepper pot”.
- Tap the paper gently with a pencil and the filings should form patterns of the lines of force. Each filing is magnetized by induction and turns in the direction of the field when the paper is tapped.
- The method is quick but no use to weak magnetic fields. Figure below shows typical patterns with two magnets.



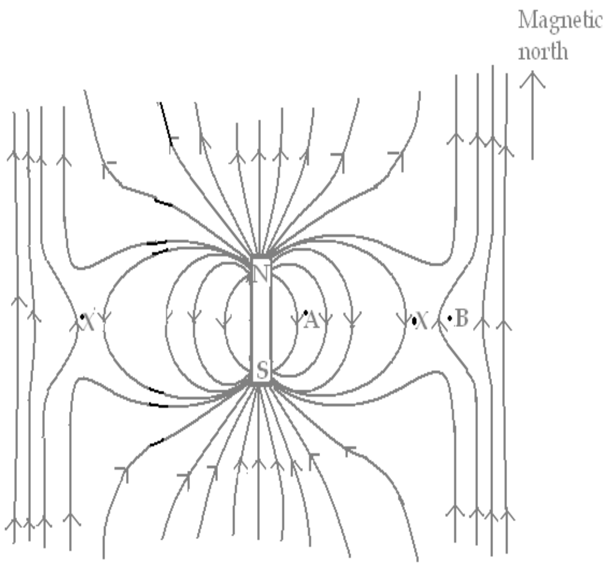
Earth's magnetic field

If lines of force are plotted on a sheet of paper with no magnet near, a set of parallel straight lines are obtained. They can run roughly from S to N geographically, figure below and represent a small part of the earth's magnetic field in a horizontal plane.

The combined field due to the earth and a bar magnet with its N pole pointing N is shown in figure a: it is obtained by the plotting compass method. At the points marked X,



the fields of the earth and the magnet are equal and opposite to the resultant force passing through them. At A, the magnet's field is stronger than the earth's field; at B it is weaker. When the north pole of the magnet points S, the neutral points Y are along the axis of the magnet, figure b a)



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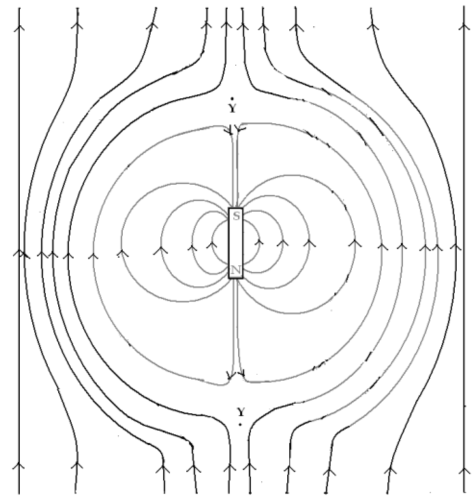
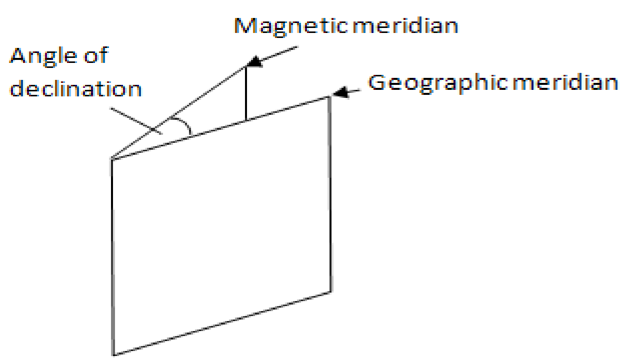


Neutral point:

This is the point in a magnetic field at which the resultant magnetic force/flux is zero.

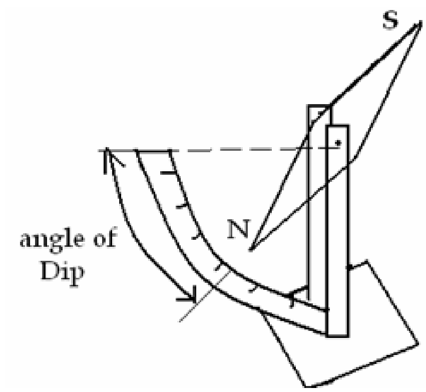
Magnetic Declination

The ***magnetic meridian*** at any place is a vertical plane containing the magnetic axis of a freely suspended magnet at rest under the action of the earth`s field.
The ***geographic meridian*** at a place is a plane containing the place and the earth`s axis of rotation.
The angle between the magnetic and geographic meridians is called the ***magnetic declination*** (Fig. below).

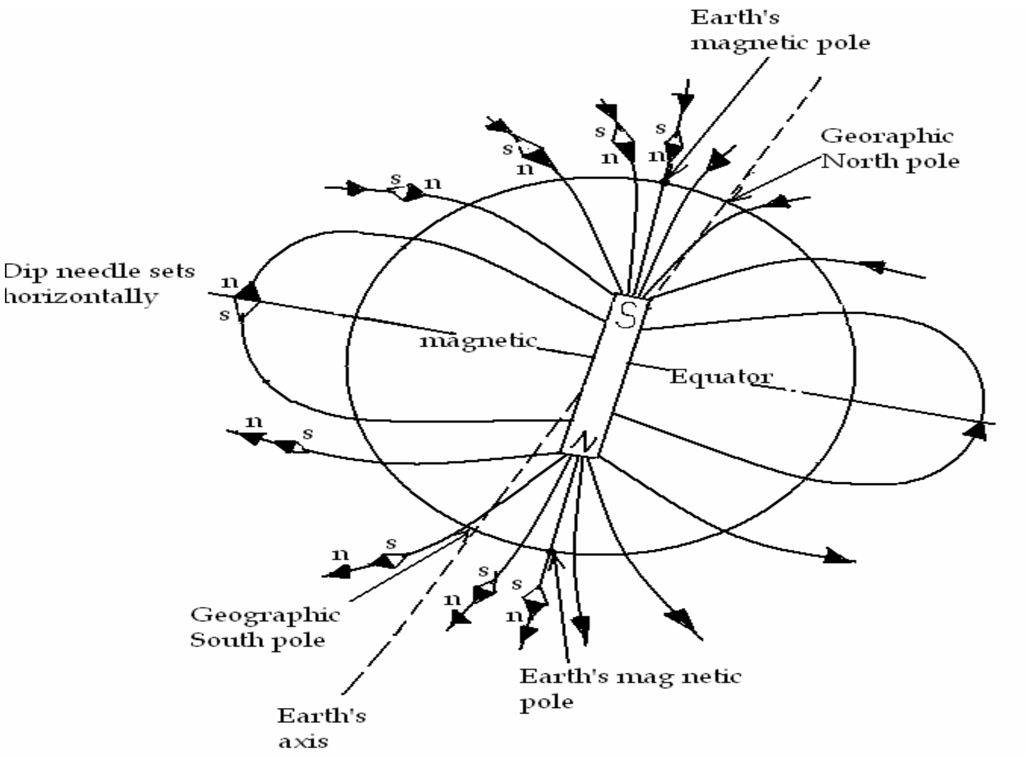


Dip or inclination

- A magnet pivoted at its centre of gravity so that it can rotate in a vertical plane is called a dip needle, figure below. When placed in the magnetic meridian, i.e. in the vertical plane containing magnetic N and S, it comes to rest with the North Pole pointing downwards at an angle.



- The angle a dip needle makes with the horizontal in the magnetic meridian is called the angle of dip or inclination***. Or Angle of dip*** is the angle between the direction of the setting compass and the horizontal axis.
- The angle of dip varies over the earth's surface from 0^o at the earth's magnetic equator to 90^o at its magnetic poles.
- This can be explained if we consider the earth behaves as though it had, at its centre, a strong bar magnet whose South Pole points to the magnetic N, figure below.
- The cause of the earth's magnetism may be electric currents in the liquid core at its centre but there is no generally acceptance for this theory.



TEST

SECTION A

1.

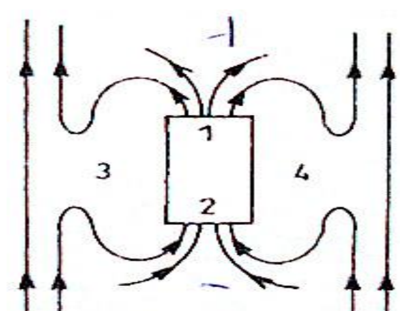


Fig. 2

Figure two shows the super position of the earth's magnetic field and the field due to a magnet. Identify point marked 1, 2, 3 and 4.

	1	2	3	4
A.	South pole	North pole	Neutral point	Neutral point
B	North pole	South pole	Neutral point	Neutral point
C.	Neutral point	Neutral point	North pole	South pole
D.	Neutral point	Neutral point	South pole	North pole

2. Which of these factors affect the magnitude of force on a current-carrying conductor in a magnetic field.

(i) The direction of current
(ii) the amount of current
(iii) the direction of the magnetic field
(iv) the strength of the magnetic field

a) (i) and (ii)
b) (ii) and (iii)
c) (i) and (iii)
d) (ii) and (iv)

3. A magnetic material can be magnetized by

(i) stroking with a permanent magnet
(ii) using a direct current
(iii) by induction

(a) (i) only
(b) (i) and (ii) only
(c) (ii) and (iii) only
(d) (i), (ii) and (iii)

4. Which of the following statements isn't true about a magnet?

A. Magnetic poles can't be separated
B. A paramagnetic material is a material from which strong magnets can be made
C. The neutral in a magnetic field is a point where there is no force experienced
D. Heating a magnet can reduce its magnetism

5. Four metals P, Q, R and S are tested for magnetism. Q attracts both P and R but not S. S does not attract P, Q or R. P and R sometimes attract one another and sometimes repel each other. Which of the following statements is correct about P, Q, R and S?

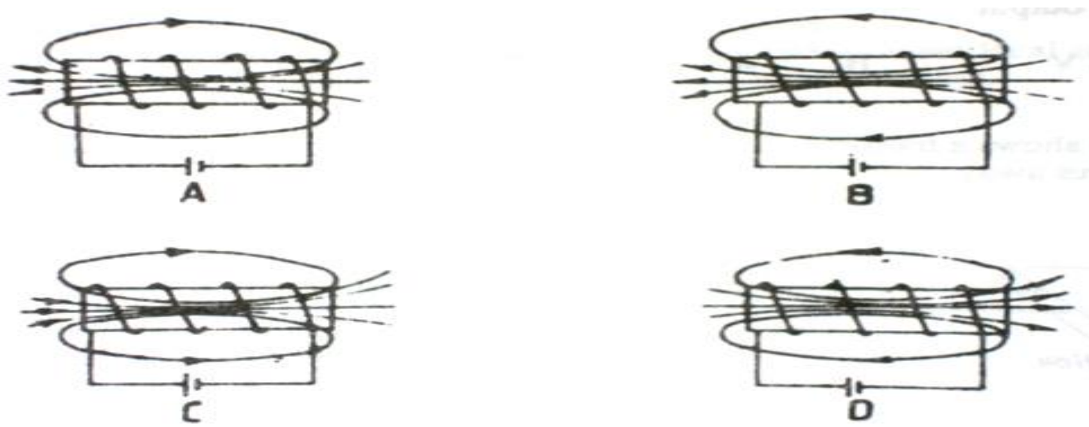
a) P, Q, R are magnets, S is magnetic
b) P and Q are magnets, S and R are magnetic.
c) P and R are magnets, Q is magnetic, S is non-magnetic.
d) P and R are magnets, Q and S are non-magnetic.

6. Which of the following statements are correct?

(i) the particles of magnetic materials are tiny magnets. (ii) the particles in un magnetised iron arrange themselves in closed chains
(iii) the particles in a magnet are arranged in open chains with N pole of one particle against the S pole of its neighbouring particle
(iv) groups of atoms form a magnetic domain

(a)	(i), (ii) and (iii)only	(b)	(i), (iii) and (iv) only
(c)	(ii) and (iv)only	(d)	(iv) only

7. Which one of the following diagrams shows a correct magnetic field due to a current flowing in a solenoid?



8. Which of the following statements are true about magnets

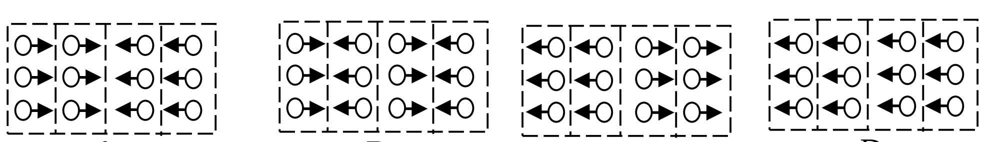
1. Magnets always have opposite polarities
2. A magnet can be used as a compass
3. Repulsion is the only sure test for a magnet
4. Magnets attract all metals

A.	1 only	B.	2 and 3 only
C.	1, 2 and 3 only	D.	All

9. Permanent magnets are made from

(a)	diamagnetic materials	(b)	Ferro magnetic materials
(c)	paramagnetic materials	(d)	dielectric materials

10. Which one of the following diagrams shows the correct arrangement of the magnetic domains in a magnetised material?



A B C D

11. Which of the following sentences is/are true about molecular theory of magnetism

1. Breaking a magnet into two results into the formation of two magnets
2. Heating and rough treatment destroys magnetism

3. The poles of a magnet are of equal strength
4. The lines of force travel from a north pole towards a south pole

A. 1 only B. 1 and 3 only
C. 2 only D. All

SECTION B

1. (a) What is a soft magnetic material?
(b) State two ways in which a bar magnet can be demagnetized.

2. a) (i) What is a magnetic field?
(ii) State the law of magnetism

3. What is a neutral point in a magnetic field?

4. **(a)** What happens when a magnet is
i) Dipped in iron filings
ii) Freely suspended in air

(b) A powerful magnet Q is placed on a soft board. Plastic pins are firmly stuck in the soft board around the magnet. An identical magnet P is held in the space surrounded by the pins above the magnet Q. When the magnet P is released, it floats above the magnet Q as shown in figure 3.

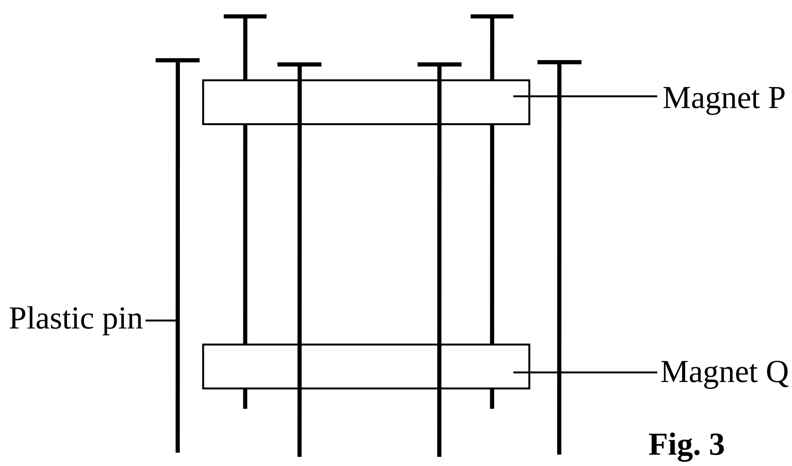


Fig. 3

(i) Explain why P floats above Q.

(ii) Why are plastic pins used instead of steel pins?

(iii) What would happen to magnet P if all the pins were removed at the same time?

5. (a) What is meant by the following;

(i) Magnetic meridian

(ii) Geographic meridian

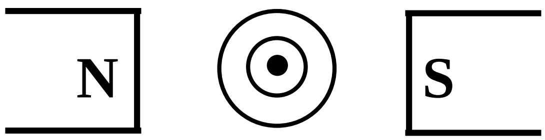
(b) Describe briefly how a steel bar may be magnetized.

6. (a) What is meant by

(i) Magnetic saturation

(ii) Demagnetisation by heating or hammering.

(b)



An iron ring is placed between two poles of two permanent magnets as shown in the figure above. Draw the magnetic field pattern set up between the two poles.

7. (a) (i) Describe an experiment to distinguish between soft and hard magnetic materials.

(ii) State one instance in which each of these materials is used.

(b)

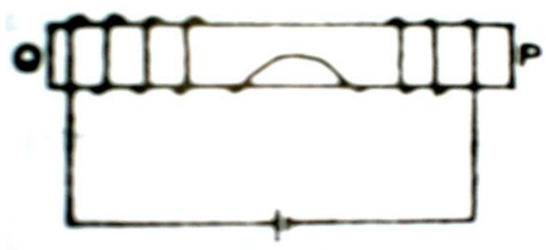


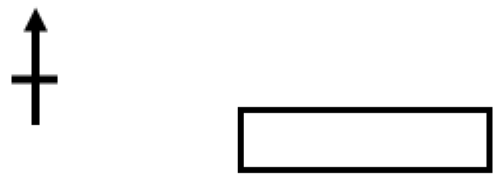
Fig. 3

The figure above shows how a magnetic material can be magnetised by electrical method

(i) Indicate the direction of current in the coil.

(ii) Name the polarities P and Q.

8. A bar magnet is placed in the earth's magnetic field with its north pole pointing to the geographical west as shown below.



(i) On the diagram, draw the lines of the resultant magnetic field around a magnet.

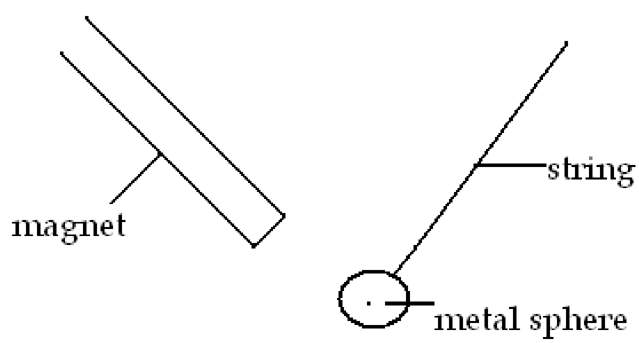
(ii) Mark the neutral point X

9. (a) Explain how a piece of iron can be magnetised by a single touch method illustrate your answer with a diagram

(b) How can you determine the polarity of a magnet?

10. With the aid of a diagram, explain the use of keepers to store magnets.

11. (a) The diagram in the figure shows a metal sphere of weight W in equilibrium. Complete the diagram to show the forces acting on the metal sphere.



(b) State two effects that a force can have on a body.

12. (a) Explain why a magnet loses its magnetism when placed in a coil of a wire carrying alternating current

(b) Describe the motion of a beam of electrons directed midway between the north and the south poles of a permanent magnet.

13. (a) Explain with the aid of diagrams how a steel bar can be magnetized by Double/divided touch method

(b) Sketch the magnetic field pattern of two bar magnets whose north poles face each other

14. **(**a) What is meant by

(i) Magnetic declination.

(ii) Angle of dip.

TEST FIVE

1.B 2.D 3. D 4.B 5.C 6.B 7.D 8.C 9.B 10.D
11.D