MAGNETISM

- A magnet is a piece of ferromagnetic material which has the property of attracting other metals like iron, nickel and cobalt.
- There are two main classes of magnets, namely;
- (i) Natural magnets e.g lodestone occurring naturally, (consists of Fe_3O_4)
- (ii) Artificial magnets – made artificially. These may be either permanent or temporary.

Permanent Magnets

- Permanent magnets are made of steel or cobalt and retain magnetism for a long time.
- They may be made in any shape and they are used in loud speakers, moving-coil instruments, microphones, etc.
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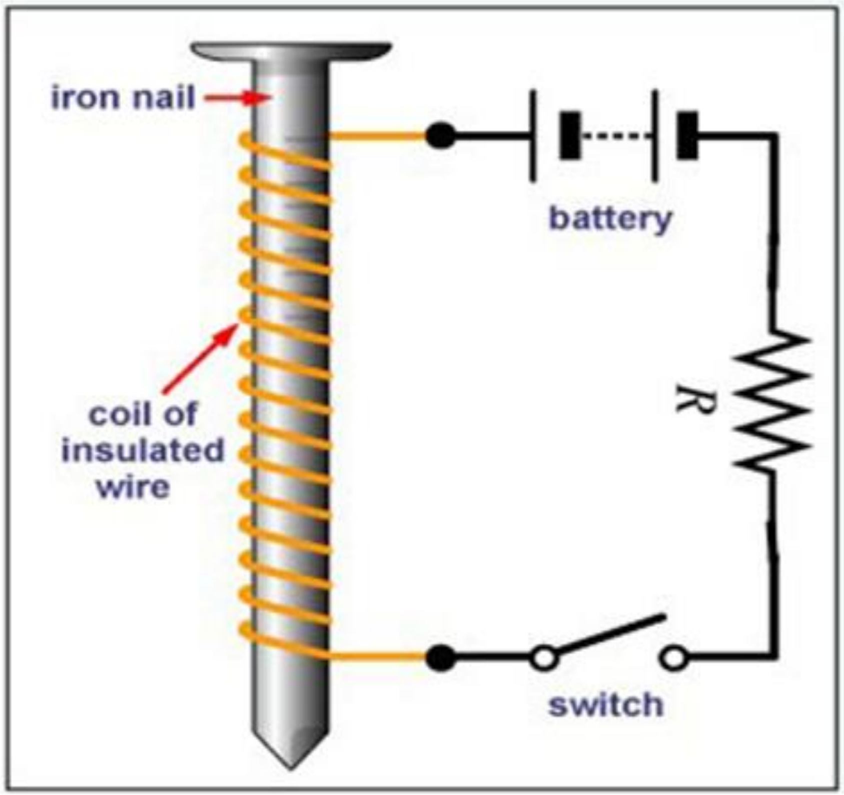
Temporary Magnets

- These are made by passing a current through a wire wound round a piece of soft iron.



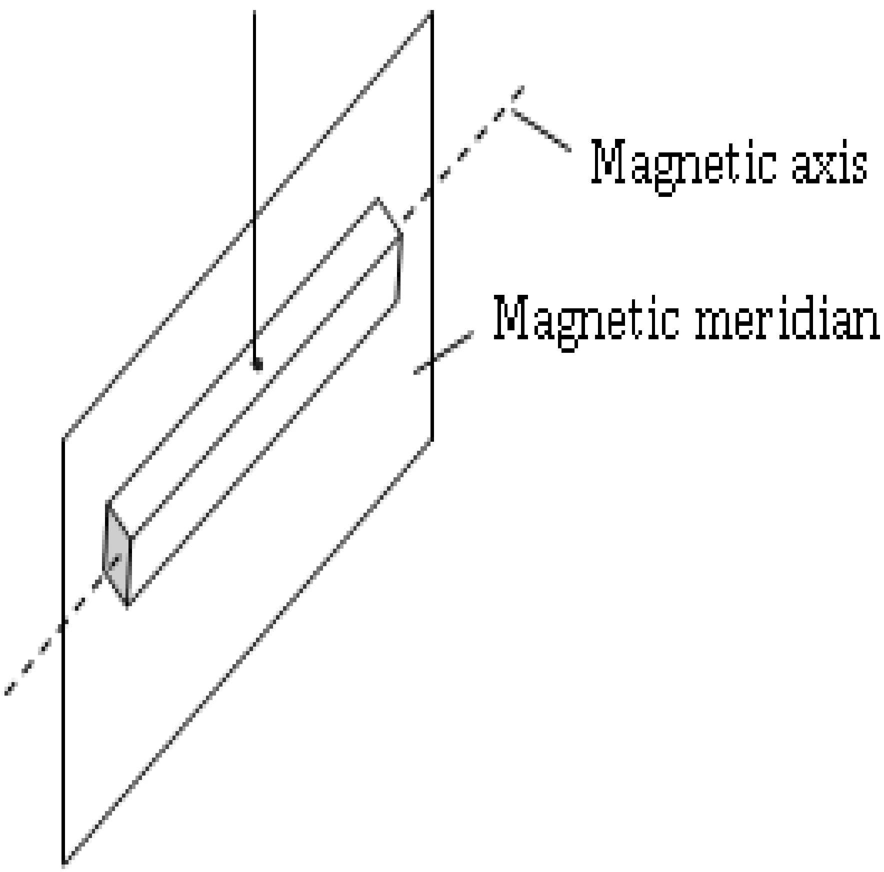
- These are known as ***electromagnets*** and remain magnetised only when the current is flowing in the coil.
- They are applied in: electric bells, relays, solenoid switches, contactors, etc.

Advantages of electromagnets

- The magnetism can be switched on and off when necessary.
- The strength of the magnet can be increased or decreased by adjusting the current passing through it.
- This is done by varying the rheostat, R, in the above figure.

Magnetic Poles and First Law of Magnetism

- Magnetic poles are points where the resultant attractive force appears to be concentrated.
- A freely suspended bar magnet rests in the north-south position. The end pointing north is the North pole while that pointing south the South pole



- The ***magnetic axis*** is the axis of a bar magnet about which its magnetism is symmetrical.

  The ***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.

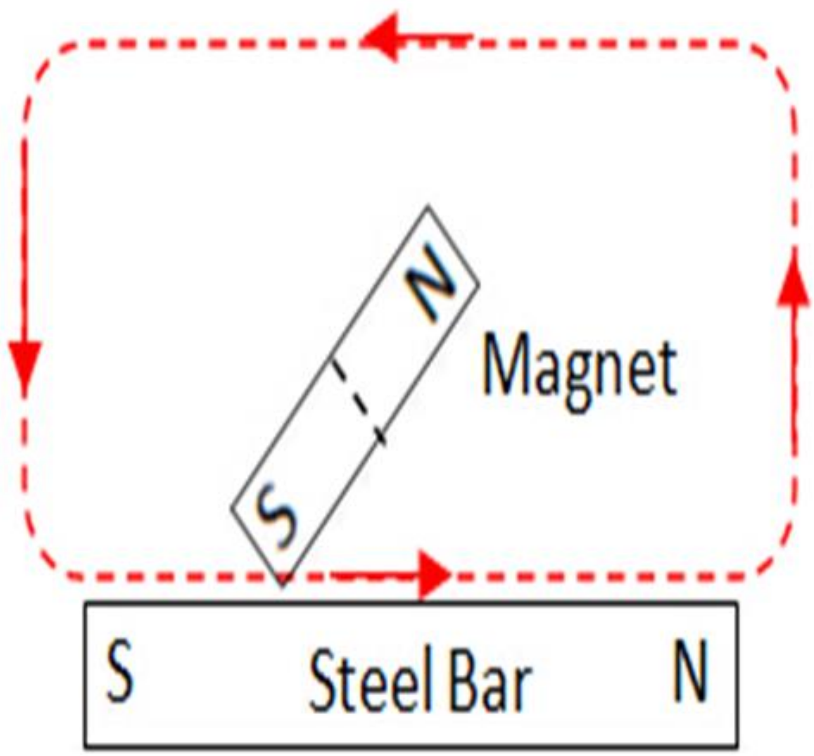
The First Law of Magnetism

- Like pole repel, unlike poles attract.

Testing the Polarity of a Magnet

- Both poles of the magnet are brought, in turn, near to the known poles of a suspended magnet.
- Repulsion confirms like poles. Attraction cannot be relied on for this test because any pole will attract even a mere ferromagnetic material.

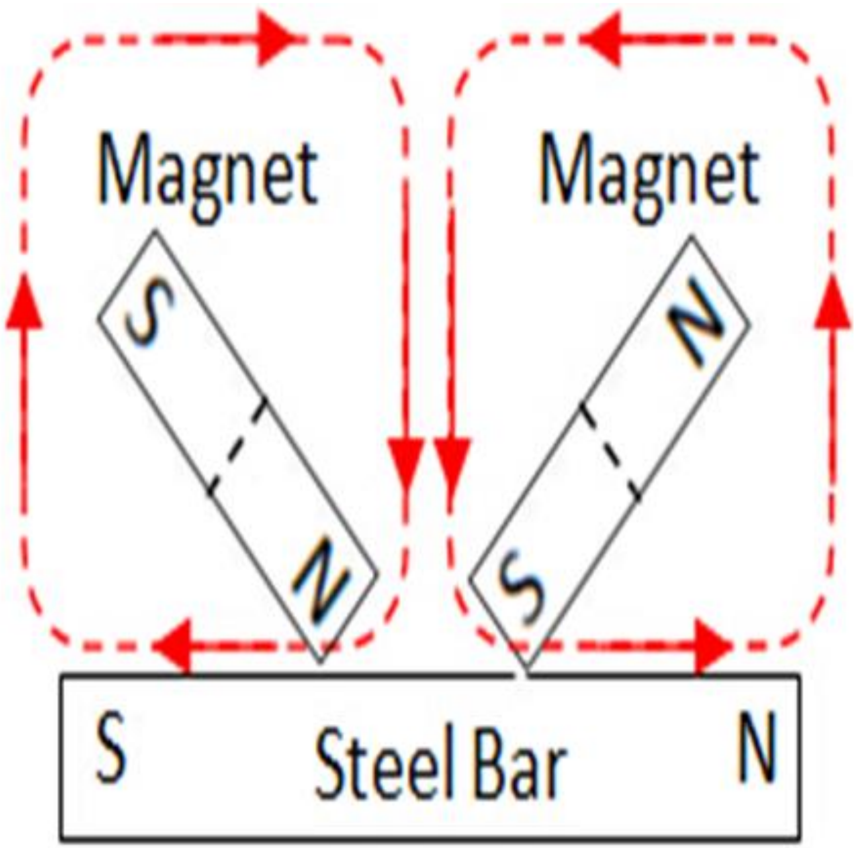
Methods of Magnetising a Steel Bar



(a) Using one Magnet

1. TOUCH METHODS

- **Single Touch Method: (or single stroke method)**
  The bar is stroked from one end to the other several times using one pole of a magnet, lifting high the pole at the end of each stroke. The end where the stroking pole descends acquires a like pole and where it leaves acquires an unlike pole.

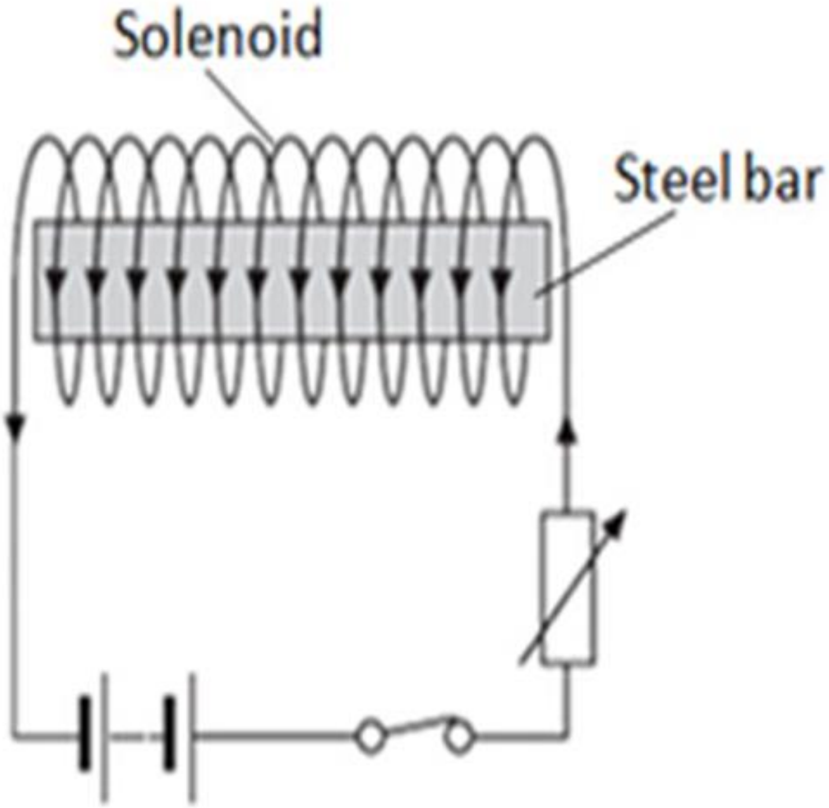


(b) Using two Magnets

- **<u>Divided Touch Method(Double stroke)</u>** Two unlike poles are used to stroke the bar simultaneously from the centre (or from the ends).

  If like poles are used for stroking, ***consequent*** poles are obtained as shown in the diagram below.

2. Using Electricity

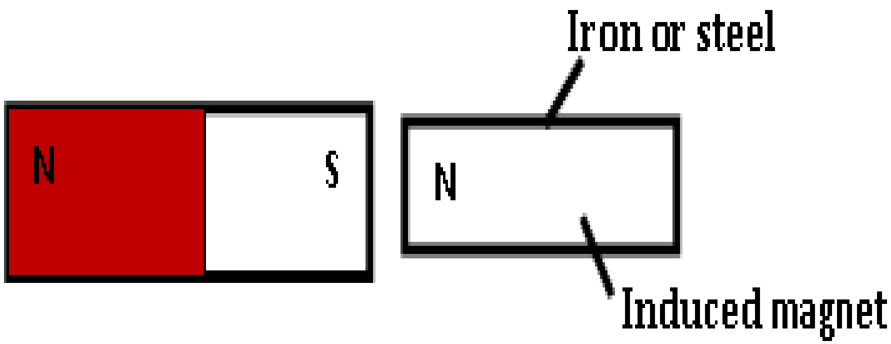


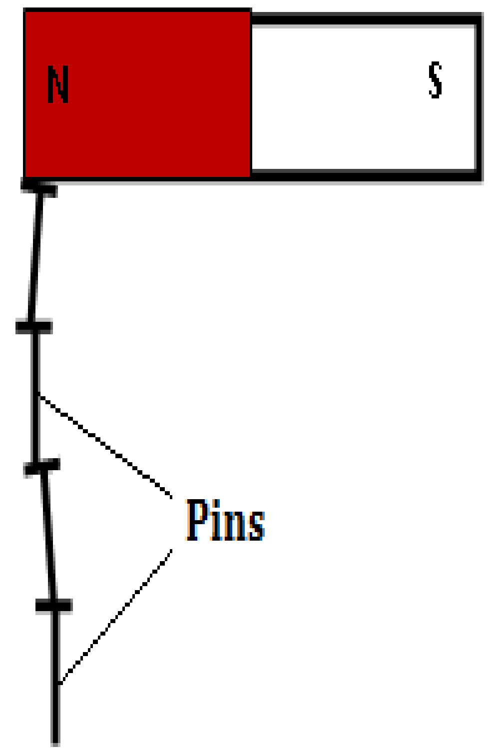
- The steel bar is placed inside the solenoid.
- The current is switched on and then off.
- The polarity of the magnet formed depends on the direction of the current round the solenoid.

Polarity

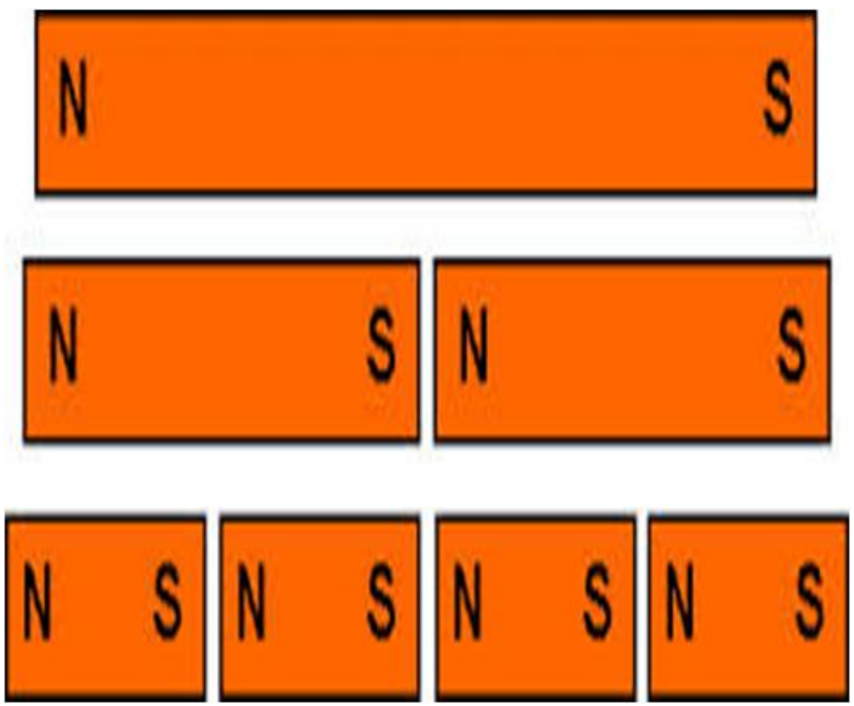
- If, on looking at the end of the bar, the current is flowing in a clockwise direction, that end is a S-pole; if anticlockwise, then it is a N-pole.

- **Induced Magnetism**
- A piece of ferromagnetic material, placed near or in contact with a magnetic pole, gets magnetised due to induction.
- For the same reason, a series of steel pins or nails form a "magnetic chain" hanging from a magnet.


Iron or steel
N
S
N
Induced magnet

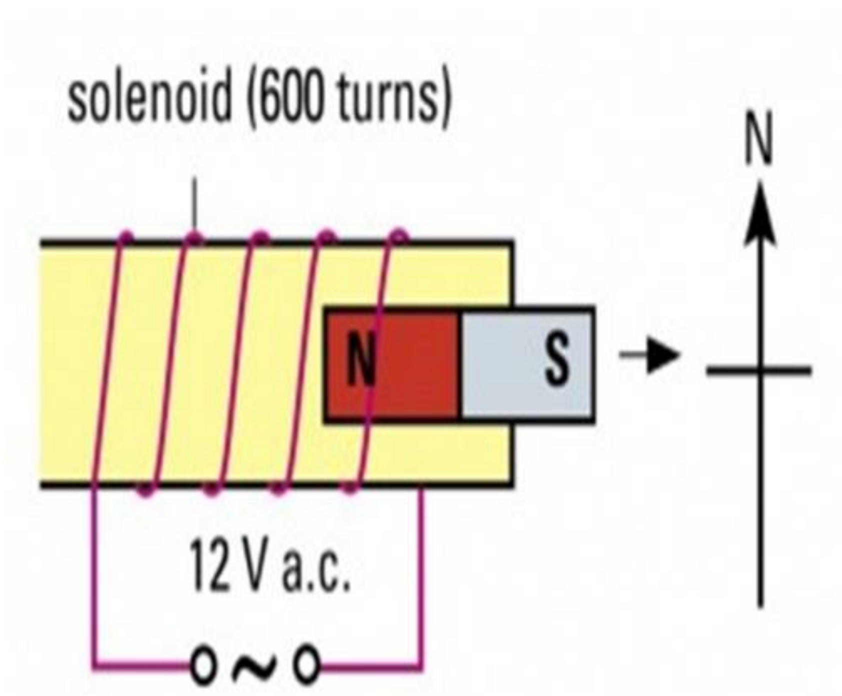

N
S
Pins

What happens when a magnet is broken?



When a bar magnet is broken, each piece becomes a magnet with the same polarity as the parent magnet.

Demagnetisation



1. Electrical Method:

- The magnet is placed in a solenoid lying in the E – W direction and an alternating current through the solenoid is switched on.
- While the current is still on, the specimen is withdrawn to a distant place.

2. By Heating

- The magnet is heated to redness and then allowed to cool while lying in an E – W direction .
- This method is not recommended because heat would spoil the steel.

3. By hitting

- This is done by hitting the magnet repeatedly while facing the east – west direction


Hammering
S
N
Heating
S
N
Dropping
S
N

Uses of magnets

They have the following uses, e.g.

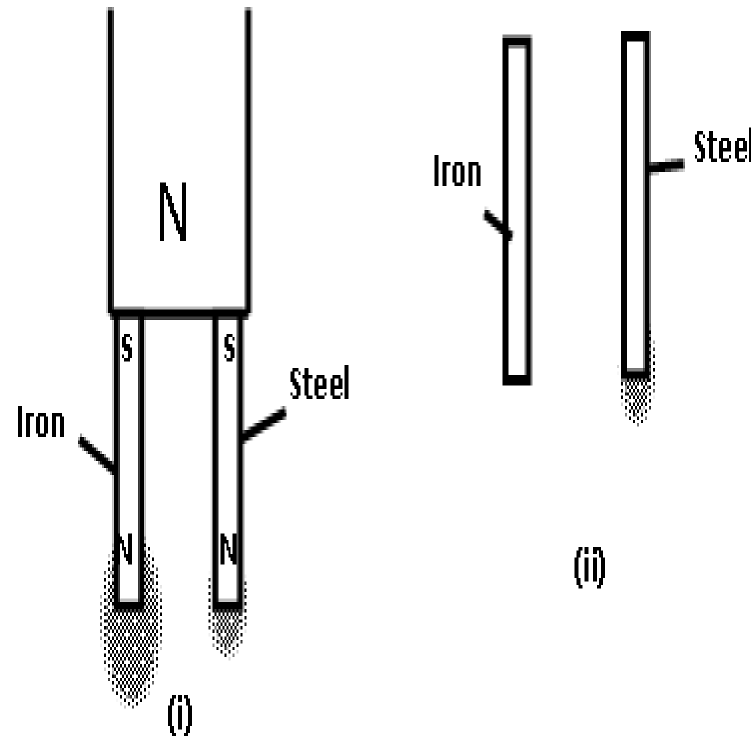
- Used to separate magnetic substances from non magnetic substances.
- Used in cycle dynamos.
- Used in loud speakers.
- In refrigerators and freezer doors to keep the door closed.
- Used in transformers.
- Used in radio receivers.
- Used in electric motors
- Used in telephone

- **Used in computers as magnetic memory.**
- **To remove iron objects from peoples eyes, ears or nose.**
- **Used in banks, magnetic ink is used on cheques so that machines can read the cheque number, account number and the amount of money paid, and automatically feed this information in the bank's computer.**
- **Used in transport e.g. modern trains (maglev trains)**
- **Used in the compass for showing direction.**

Magnetic properties of iron and steel

- ***Experiment: To compare Magnetic Properties of Iron and Steel***
- A strip of soft iron and another of steel of identical dimensions, both initially unmagnetised, are placed side by side in contact with a magnetic pole as shown in (i) above. The free ends are dipped into iron filings.

- ***Observation***
- More iron filings cling to the soft iron. However, when the magnetic pole is removed soft iron loses almost all the iron filings while steel retains almost all.



Conclusion:-

(i) Soft iron acquires greater induced magnetism than steel.

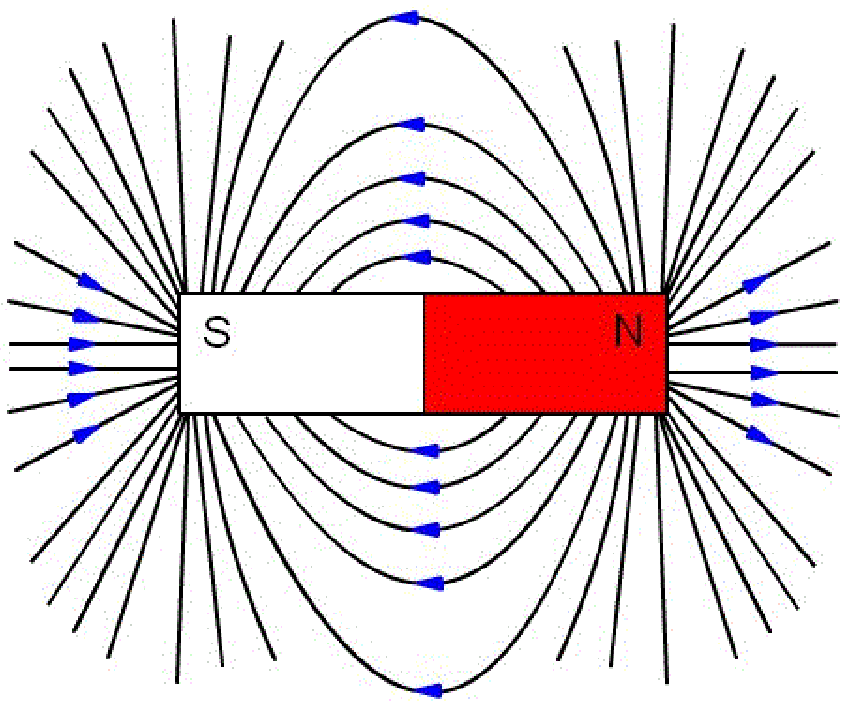
(ii) The magnetism in the soft iron is temporary while that in steel is permanent.

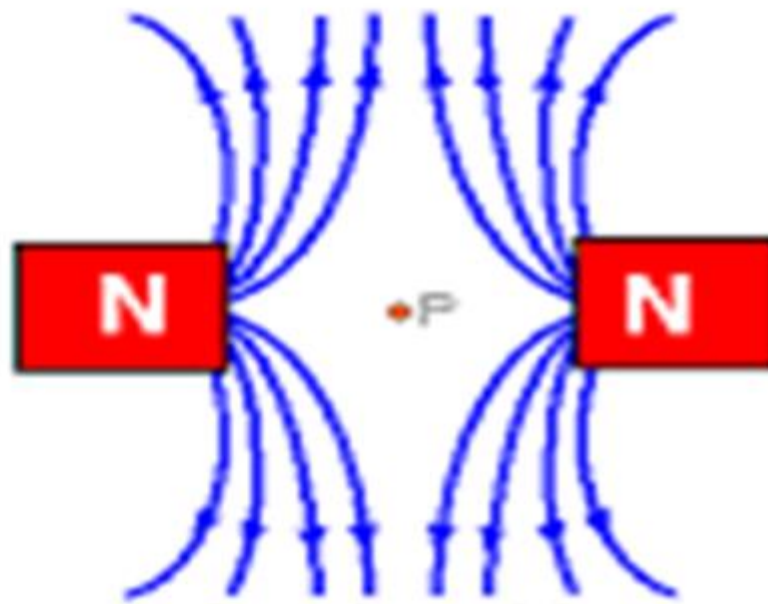
Applications of Iron and Steel

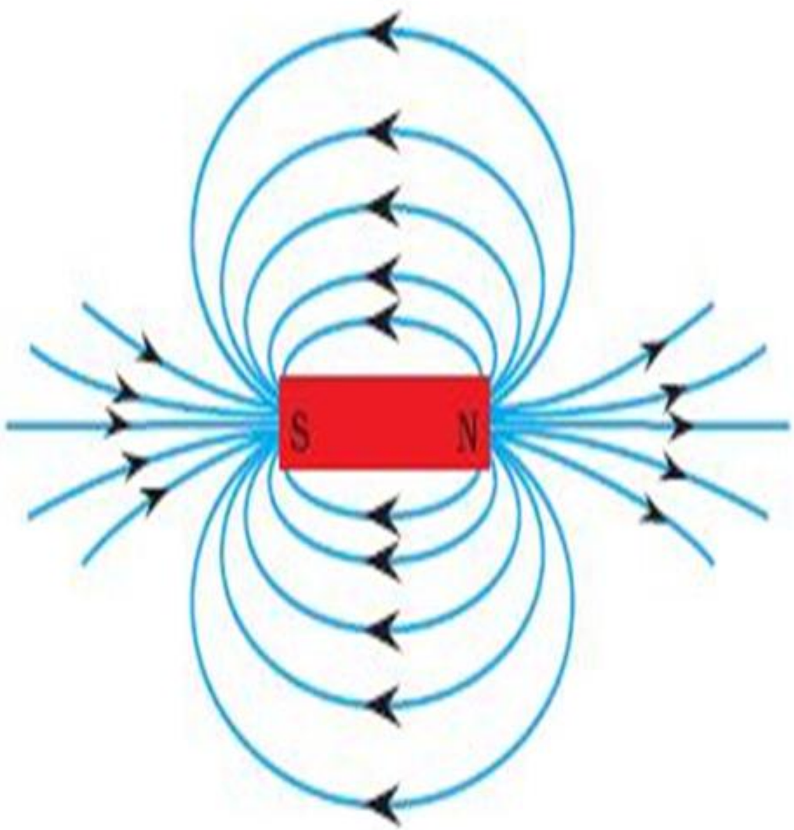
- Steel is used for making permanent magnets.
- Soft iron is used for temporary magnets e.g. in electric bells, electromagnets, transformer cores, relays, motor and dynamo armatures.

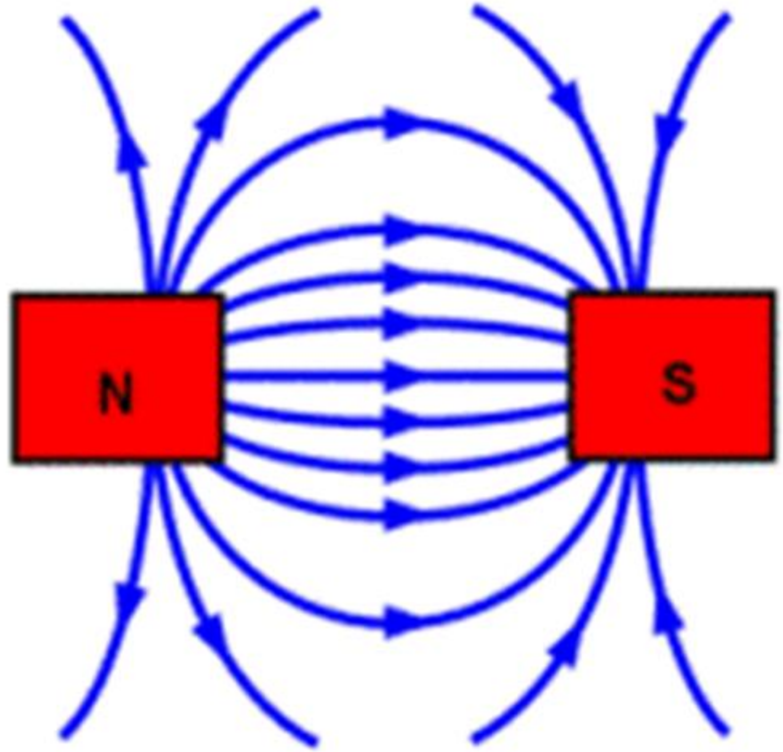
Magnetic Fields

- **A magnetic field is a region where a magnetic force can be detected. It is represented by magnetic field lines.**
- **A magnetic field line of force shows the path and direction a north pole would take if freely placed on it.**
- **Thus, field lines run from N-pole to S-pole outside the magnet. They DO NOT cross each other.**


S
N


N
P
N

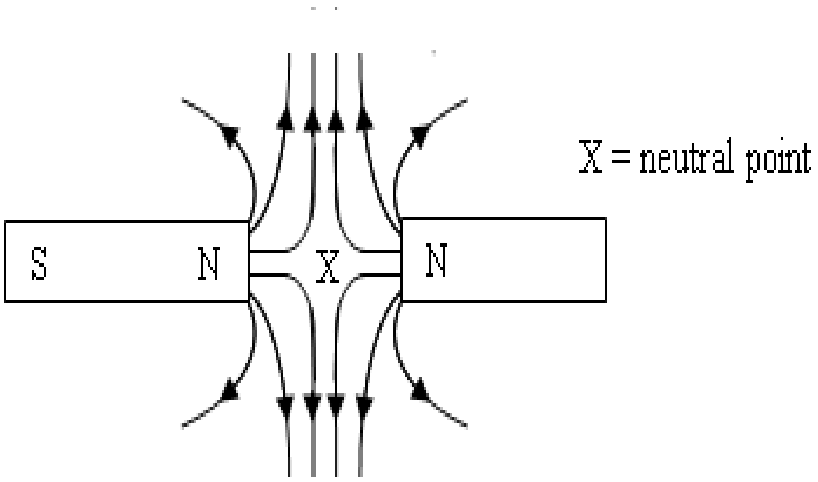


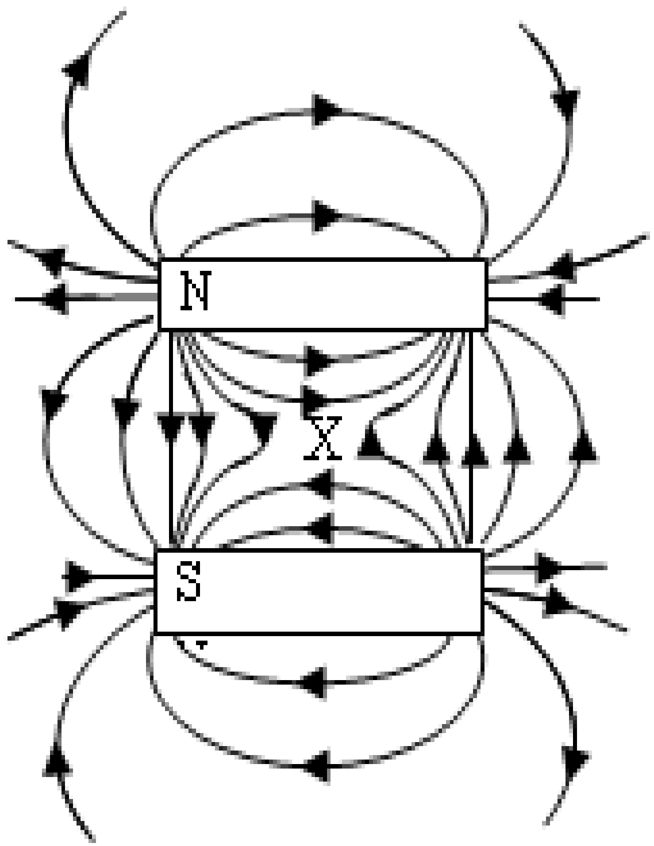


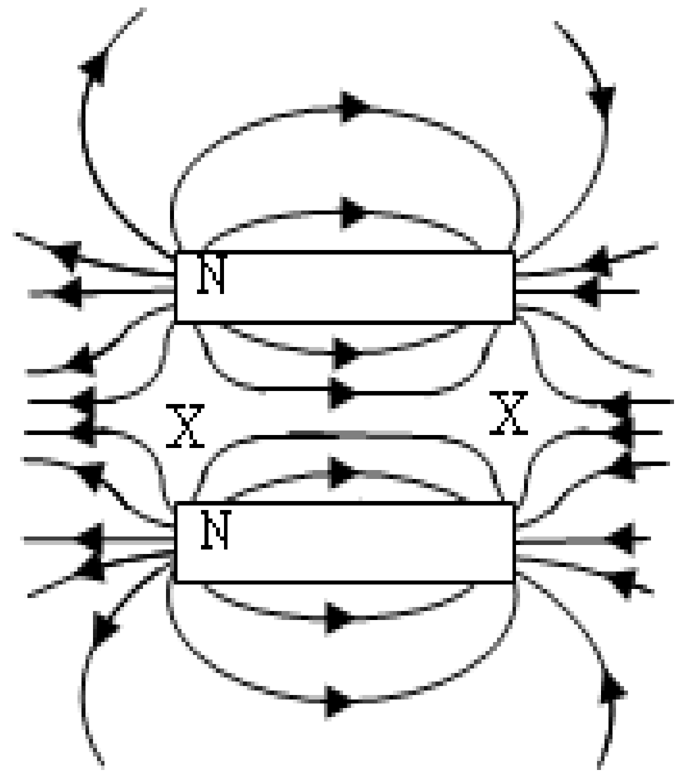
(resourcefulphysics.org)

A neutral point

- A neutral point is a point at which the resultant magnetic flux density is zero. At the neutral point the magnetic force is zero.




N
X
S


N
X
X
N

The Earth's magnetism

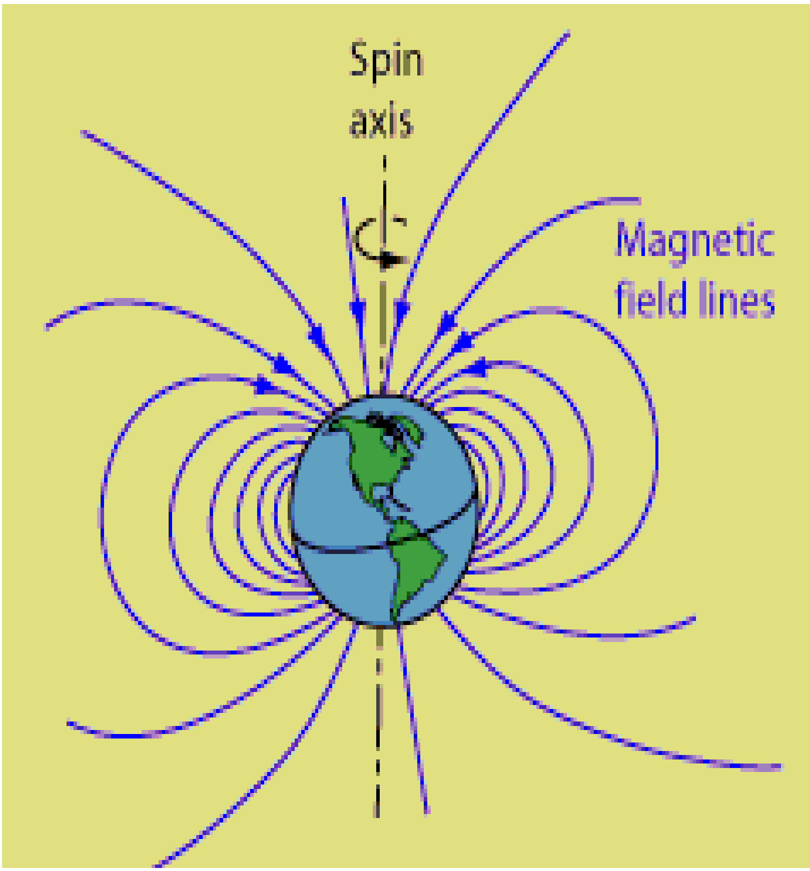
- The earth behaves as though it contains a strong bar magnet at its centre, with its north pole in the southern hemisphere and the south pole in the northern hemisphere.
- So above the earth's surface the earth's magnetic lines of force run from South to North.

- ✓ When a bar magnet is freely suspended, it rests with its axis along the Earth's magnetic field. So it rests in the N – S direction and at the equator it is horizontal.
- ✓ Near the north and south poles of the earth, a freely suspended magnet dips at an angle to the horizontal.

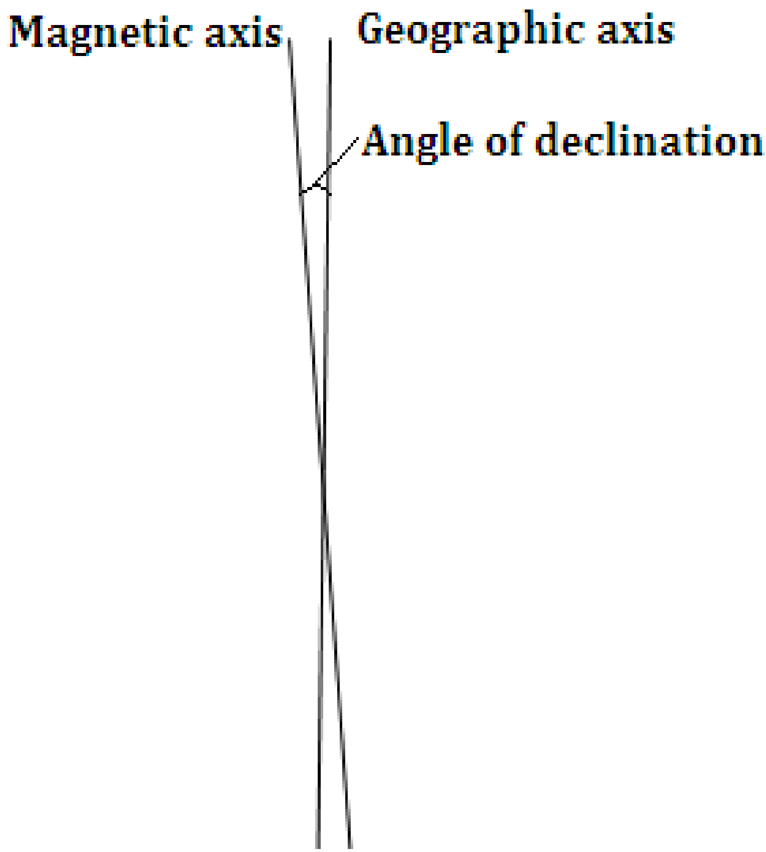
- ✓ **TERMS**

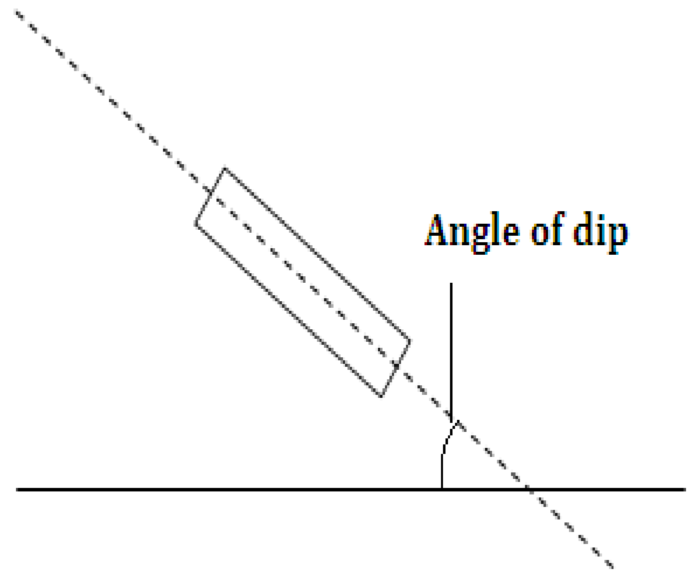
(a) Magnetic meridian

- ✓ **This is a vertical plane in which a freely suspended magnet comes to rest. The magnetic axis lies along this plane.**



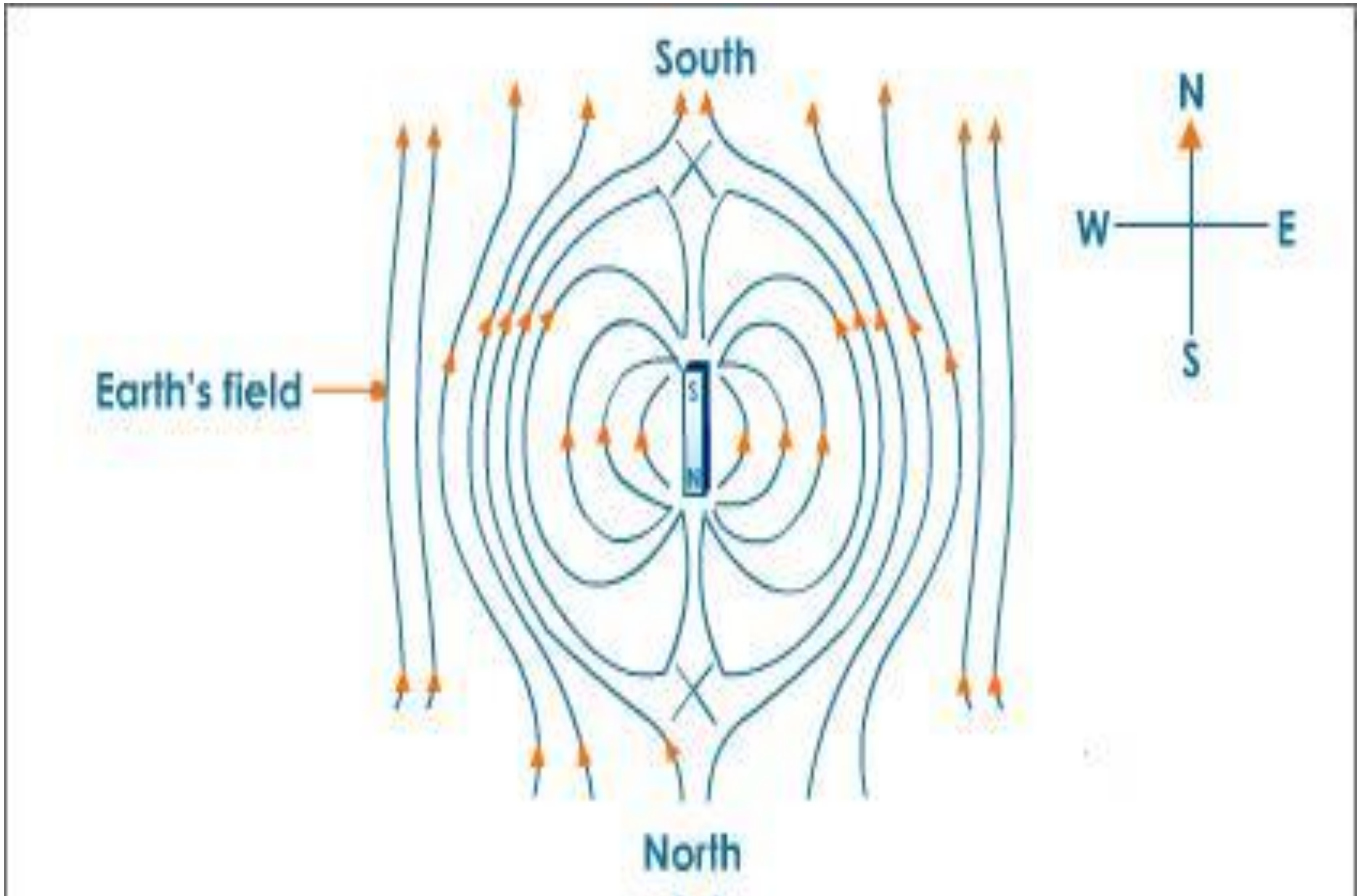
- **(b) Angle of declination**
- This is the angle between the magnetic meridian and the geographic meridian.
- **(c) Angle of dip (Inclination)**
- This is the angle between the direction of the earth's magnetic flux and the horizontal.


Magnetic axis
Geographic axis
Angle of declination

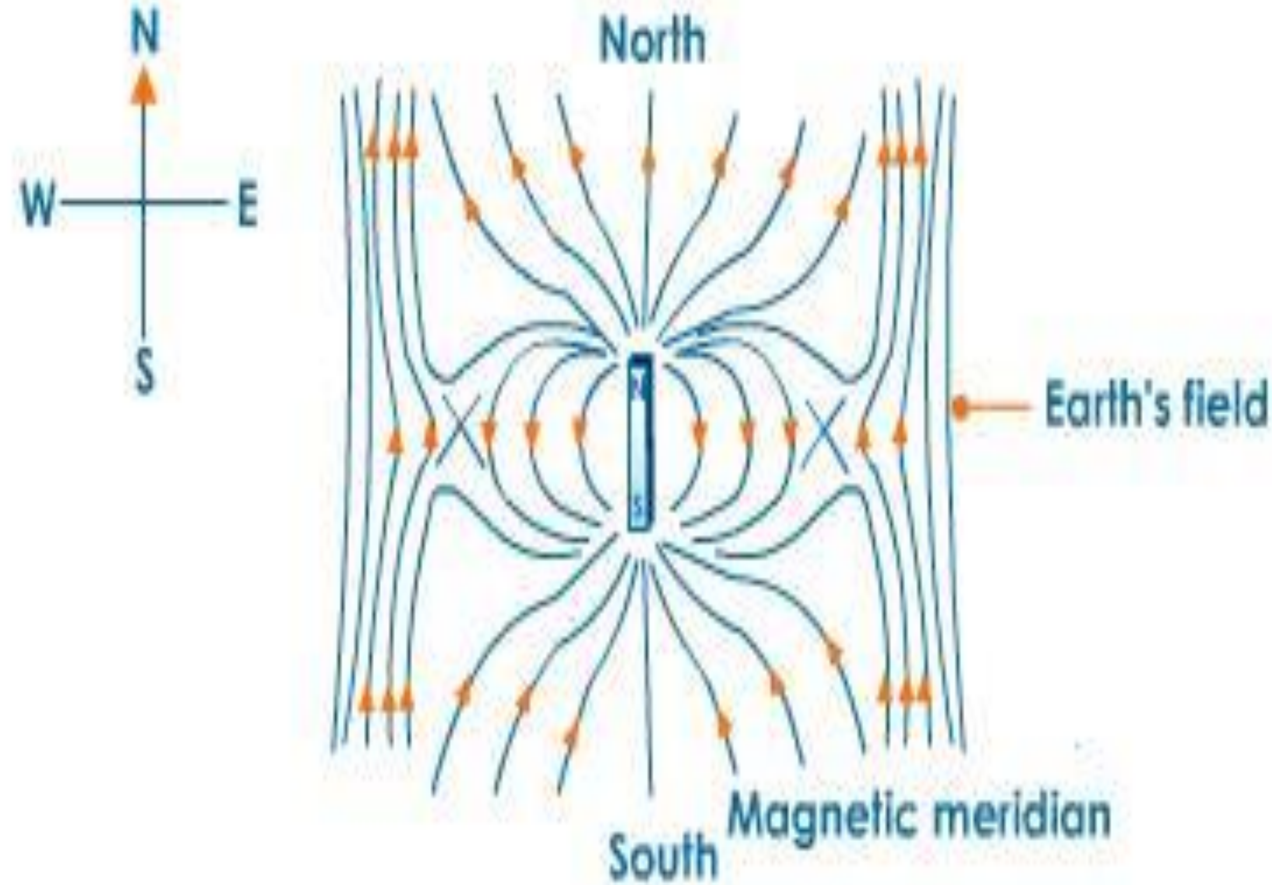

Angle of dip

Interaction between earth's field and that of bar magnet

- In practice two magnetic fields are present around most bar magnets. i.e.
  - ✓ One due to the magnet its self.
  - ✓ One due to the earth.
- The diagram (a) below shows field lines when a magnet is placed with its north pole pointing towards the south of the earth, and (b) shows field lines when north of bar magnet is pointing towards the north.



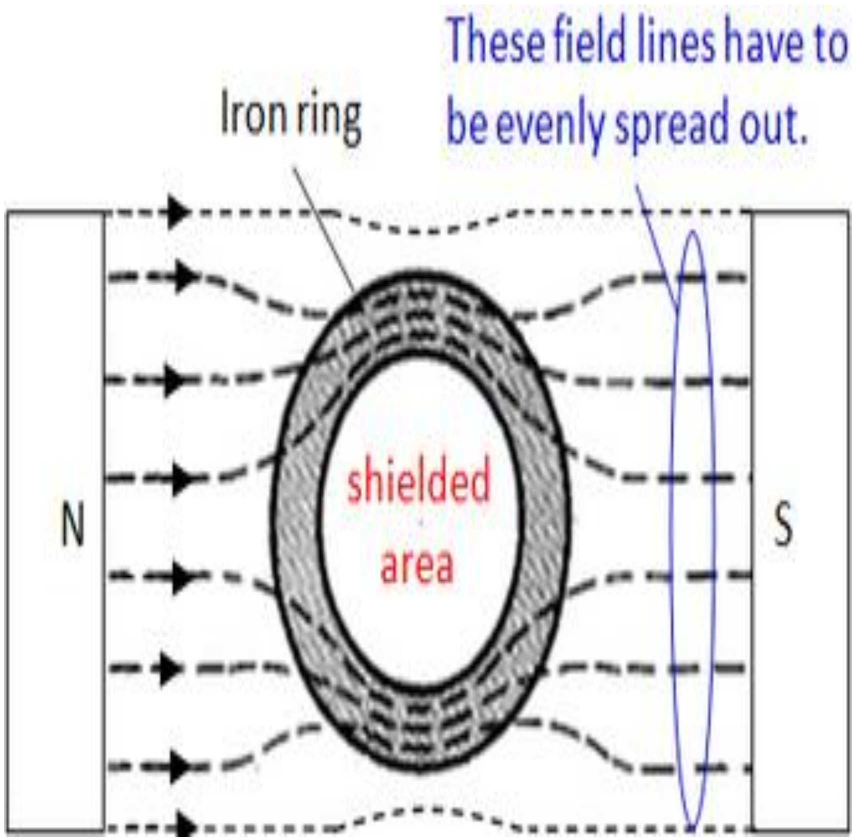
(a)

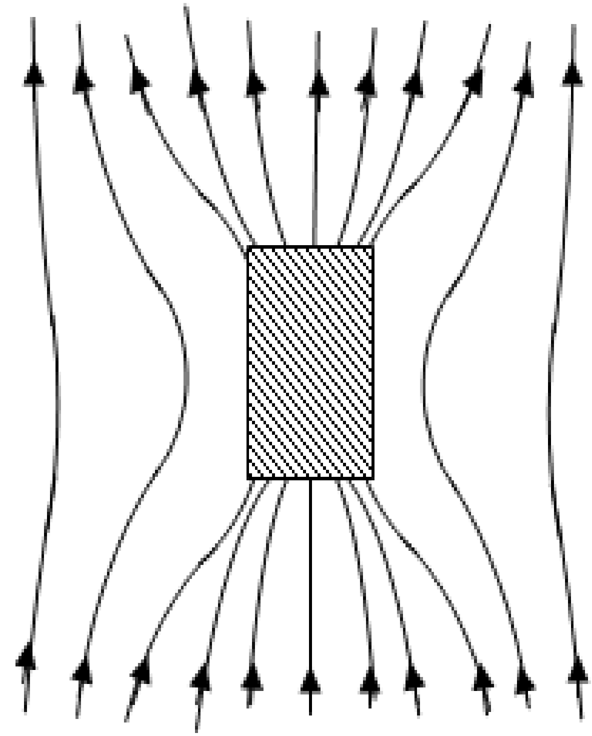


(b)

Soft Iron in a magnetic field

- It is easier for the magnetic lines of force to go through soft iron than air. So the field lines squeeze within the piece of soft iron.



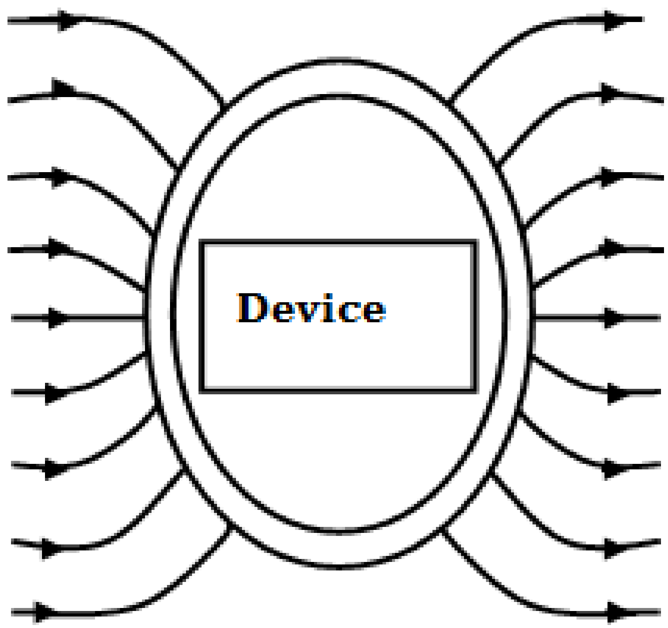


Soft iron in earth's field

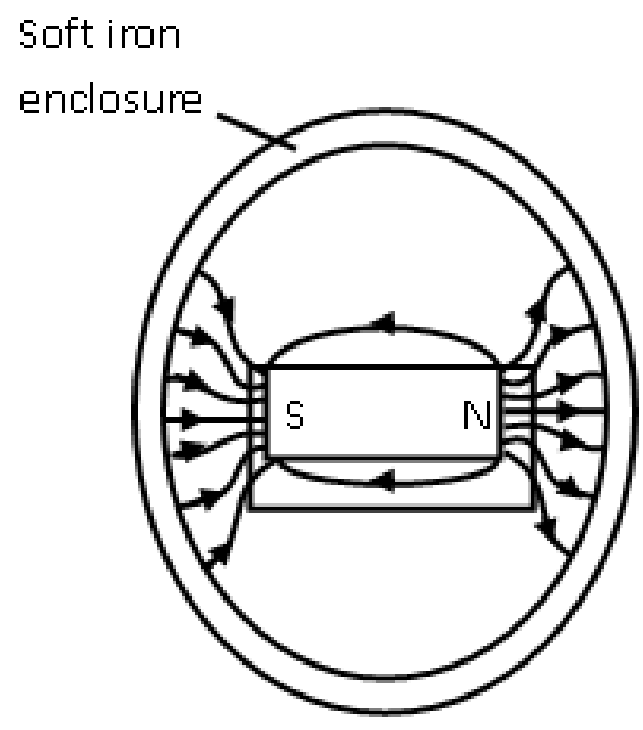
Magnetic Shielding

- This may be applied in order to:
- protect a device from a magnetic field in the surroundings. This is done by placing the device in a soft iron enclosure.
- The magnetic lines of force circulate through the soft iron ring without reaching the inside
- prevent the magnetic field in one place from spreading to the surroundings. In this case the magnetic field is enclosed by soft iron.

The magnetic field lines pass through the soft iron and do not reach inside

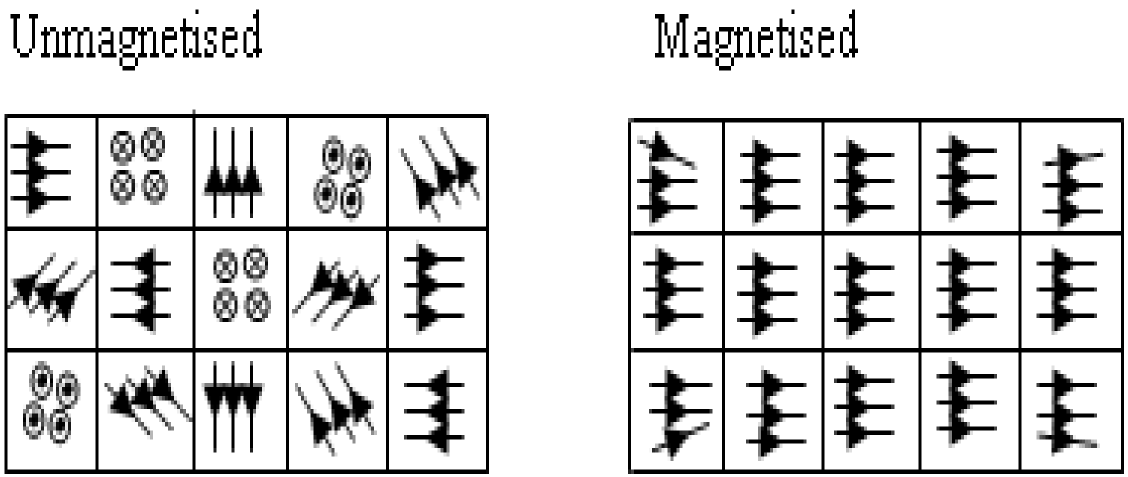


The magnetic field lines circulate around the iron ring without reaching outside.



The Domain theory of magnetism

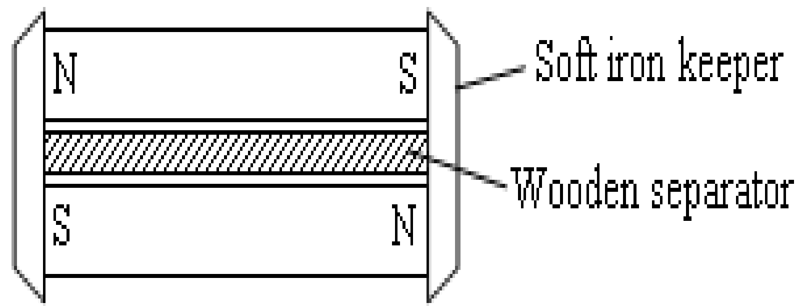
- In ferromagnetic materials the atomic magnets group themselves and in single groups, known as ***magnetic domains***, all the atomic magnets in a single domain align in one direction.
- If the material is unmagnetised, the domains face different directions.
- When magnetised, the domains turn round and align in the same direction as shown in the illustrations below.

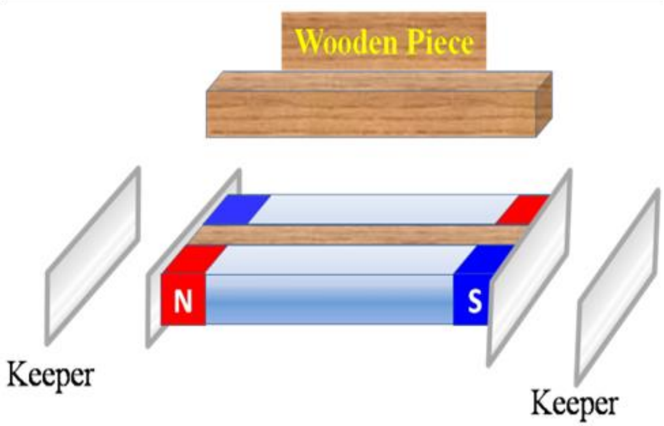

Unmagnetised
Magnetised

Care for magnets

- 1. Bar magnets should be kept in pairs side by side with their ends facing opposite polarity and soft iron keepers are placed at their ends.
- 2. Magnets should NOT be banged or heated.


e-magnets UK


N
S
S
N
Soft iron keeper
Wooden separator


Wooden Piece
N
S
Keeper
Keeper