



SUPER PHYSICS

Chapter 20 Notes

Magnetism

Laws of magnetism

Magnets attract magnetic materials

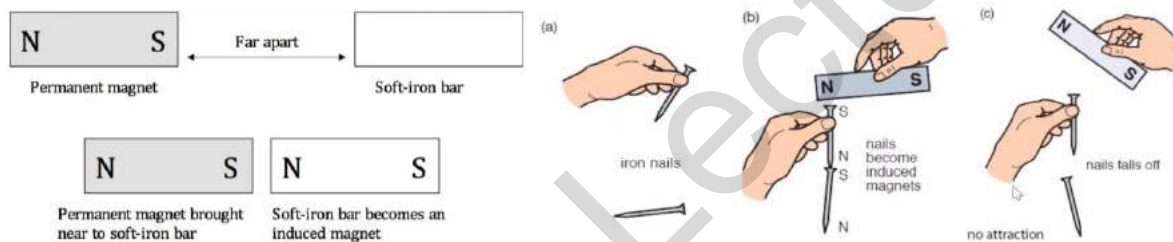
- Magnetic materials are materials that can be attracted to a magnet
- Non-magnetic materials are materials that cannot be attracted to a magnet
- Magnets have two poles
- Magnetic effects are strongest at the poles
- A freely suspended magnet comes to rest in the north-south direction
- The end of the bar magnet that points to the North Pole of the Earth is called the north-seeking pole / north pole / N pole
- The end of the bar magnet that points to the South Pole of the Earth is called the south-seeking pole / south pole / S pole
- This property allows magnetics to be used as compasses
- Like poles repel, unlike poles attract [Law of magnetic poles]
- South pole of one magnet will attract north pole of another magnet
- North pole of one magnet will repel north pole of another magnet

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Properties of magnets

Induced magnetism

- Magnetic induction is the process whereby an object made of a magnetic material becomes a magnet when it is near or in contact with a magnet.
- Magnetic induction can occur with or without physical contact.
- When a paper clip is brought near a permanent magnet, it is attracted to the magnet → paper clip becomes an induced magnet
- This induced magnet is able to attract other paper clips



Theory of Magnetism

- A bar magnet is made up of many 'tiny magnets' or magnetic domains.

Magnetic Domains

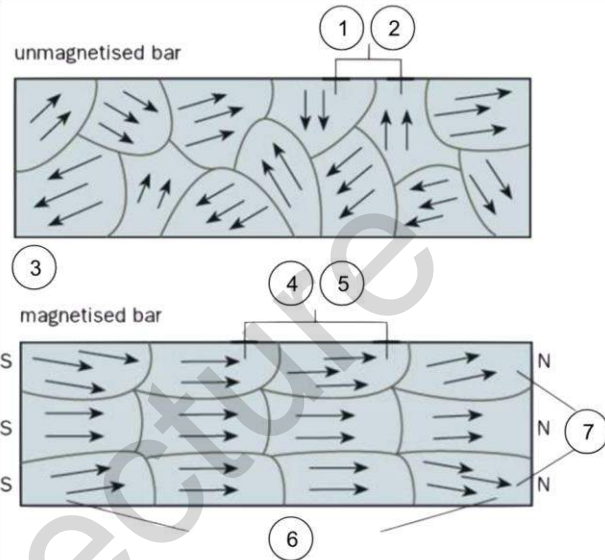
- Magnets are made of atoms. Physicists believe that the orbiting motion of electrons around the nucleus of an atom makes the atom an atomic magnet.
- A magnetic domain consists of a group of atomic magnets pointing in the same direction.

What happens during magnetisation

- In an unmagnetised material, the magnetic domains are randomly aligned.
- During magnetisation, the magnetic domains become aligned.

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1. The magnetic domains in an unmagnetised bar point in random directions
2. There is no net magnetisation because the domains cancel one another out.
3. Magnetisation: magnetism is induced by aligning the domains.
4. The magnetic domains point in the same direction, producing a net magnetisation.
5. Each arrow is arranged directly behind the arrow in front of it. Therefore, the N poles are cancelled out by the adjacent S poles.
6. The atomic magnets at the ends are 'free'. This produces the effect of N or S poles at the ends.
7. The atomic magnets at the ends tend to fan out due to repulsion between the like poles.

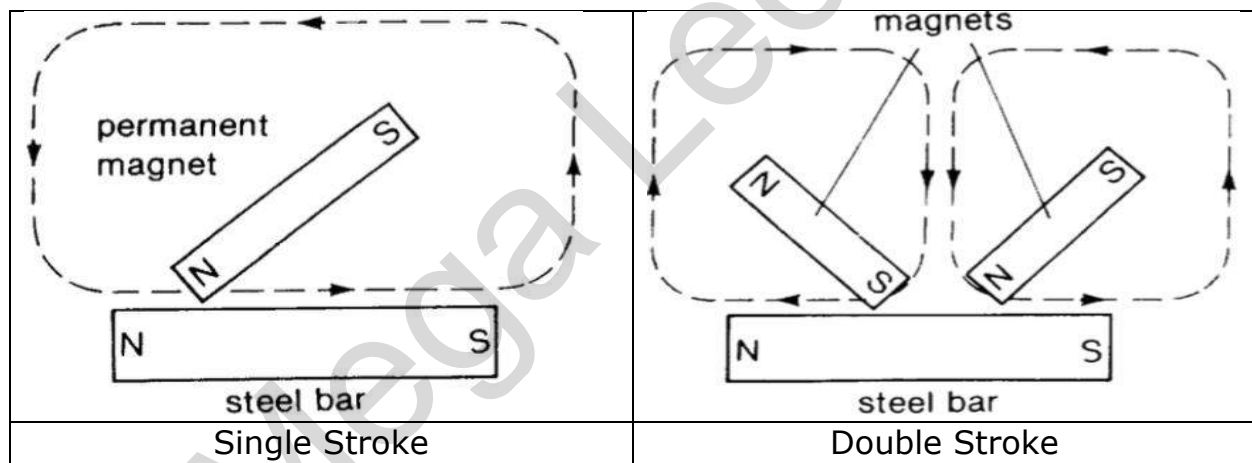


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Methods of magnetism and demagnetisation

Method 1: Stroking

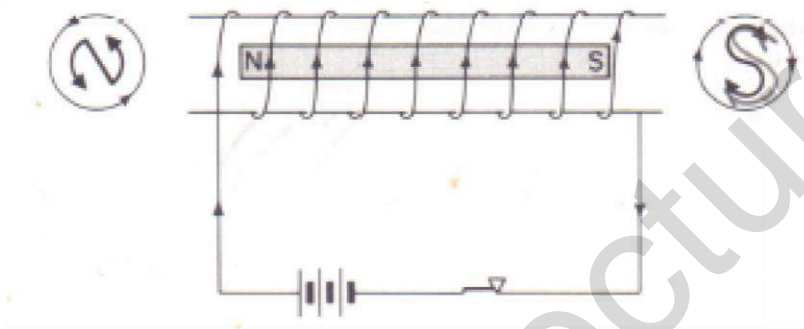
1. An unmagnetised steel bar is stroked several times from one end to the other, in one direction, with one of the poles of a permanent magnet
2. The stroking magnet should be lifted sufficiently high above the steel bar between successive strokes.
3. The pole produced at the end of the steel bar where the strokes finish is opposite to the stroking pole used.



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Method 2: Electrical method using a direct current

1. When a large current flows through coils of wire (a solenoid), a strong magnetic field is produced
2. The magnetic field aligns the magnetic domains in the steel bar
3. After a period of time, the steel bar will be magnetised.

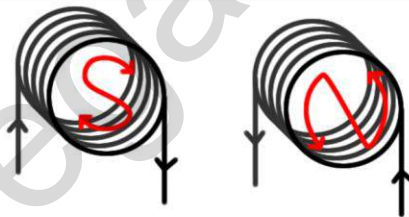


Determining the poles of the magnet

1. Direction of current flowing at the ends

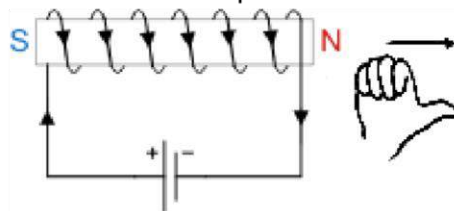
If the current at the end flows in

- A clockwise direction, that end will be the south pole
- An anticlockwise direction, that end will be the north pole



2. Right hand grip rule

- Grip the solenoid using the right hand
- Curl the fingers in the direction of the current flow in the solenoid
- The extended thumb will point in the direction of the north pole.



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Demagnetising Magnets

Method 1: Heating

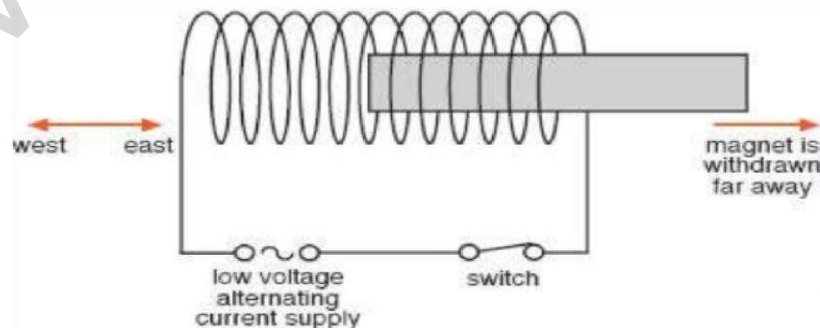
- Strongly heating a magnet and letting it cool in an east-west orientation will cause the magnet to lose its magnetism. The atoms of the magnet vibrate vigorously when heated, causing the magnetic domains to lose their alignment.

Method 2: Hammering

- Hammering a magnet placed in east-west direction alters the alignment of the magnetic domains, causing the magnet to lose its magnetism.

Method 3: Electrical method using an alternating current

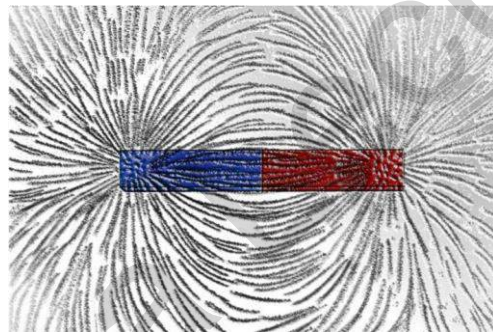
1. Place a magnet inside a solenoid in the east-west direction
2. Connect the solenoid to an alternating current (a.c.) current supply.
 - (an alternating current is an electric current that varies its direction many times per second)
3. Withdraw the magnet with the alternating current still flowing in the solenoid, until it is some distance away.



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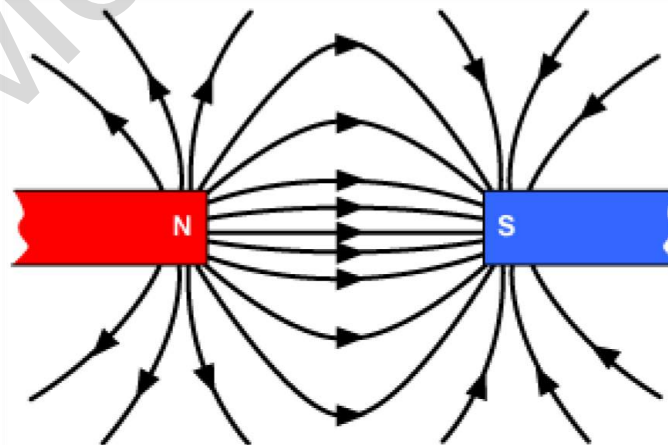
Magnetic field pattern

- A magnetic field is the region surrounding a magnet, in which a body of magnetic material experiences a magnetic force.
- A magnetic field is invisible, but can be visualized as imaginary magnetic lines of force surrounding the magnet.
- These lines give the direction and strength of the field.
- The arrangement of a group of magnetic lines of force is called a magnetic field pattern.
- The magnetic field pattern of a magnet can be revealed by
- Sprinkling iron filings around it



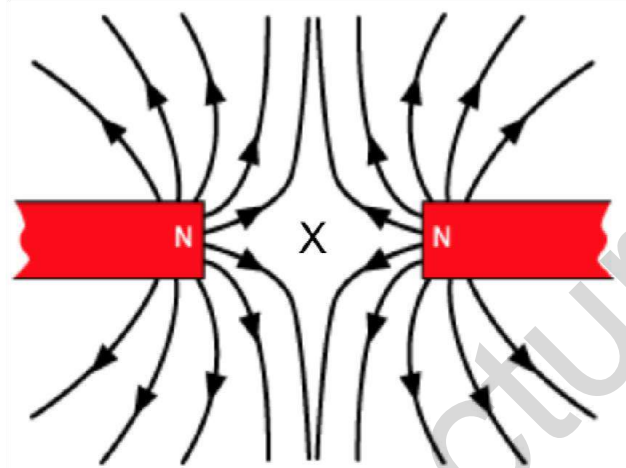
Magnetic field lines between magnets

Two unlike poles (N pole & S pole)



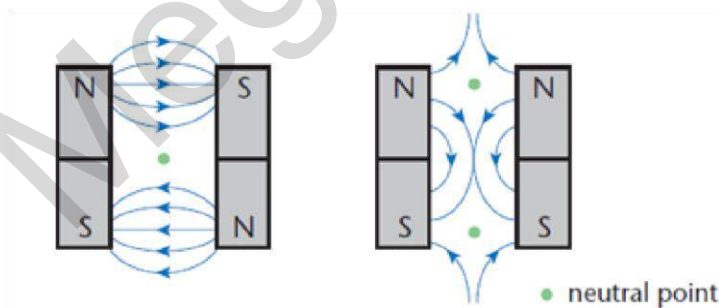
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Two like poles (2 N poles)



- Point X is a neutral point because fields from both magnets cancel each other out at that point.
- A neutral is a point where the resultant magnetic field is zero.
- Therefore, the magnets produce no magnetic effect at X, as indicated by the absence of magnetic field lines at that point.

Parallel bar magnets

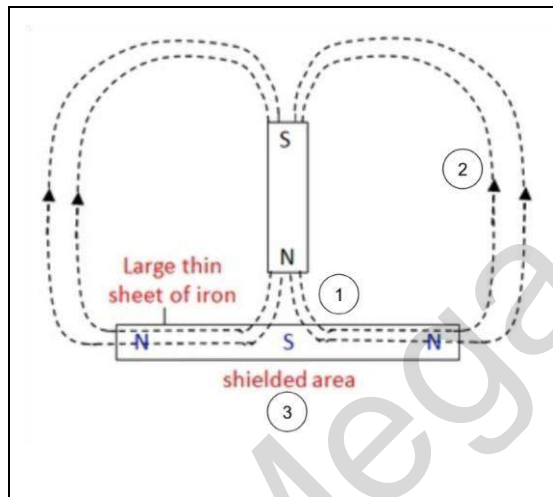


- Magnetic field lines can never intersect.
- By convention, the magnetic field line is the path along which an imaginary "free" North pole will move if placed along this line. If 2 magnetic field lines intersect, it would mean that 2 "free" North poles would have attracted, which is against the law of magnetism. Hence, magnetic field lines cannot intersect

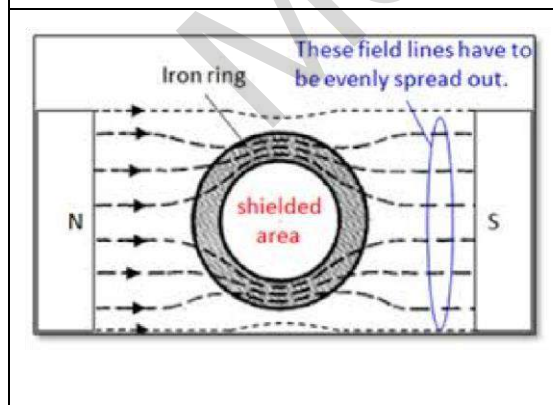
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Magnetic shielding

- Magnetic fields may affect the proper functioning of equipment like magnetic resonance imaging (MRI) equipment and computer hard drives.
- To prevent the surrounding magnetic fields from reaching the sensitive areas of these equipment, we use magnetic shielding
- In magnetic shielding, thick sheets of soft magnetic materials like iron are used to divert the magnetic fields that are present.
- They are able to do this because magnetic field lines tend to pass within them



1. Magnetic field lines coming out of the N pole 'prefer' to pass within the soft iron sheet rather than through air
2. The field lines, after passing through the soft iron, are 'forced' to come out and enter the S pole of the magnet to form closed loops
3. The region on this side of the soft iron sheet is free from the magnetic field

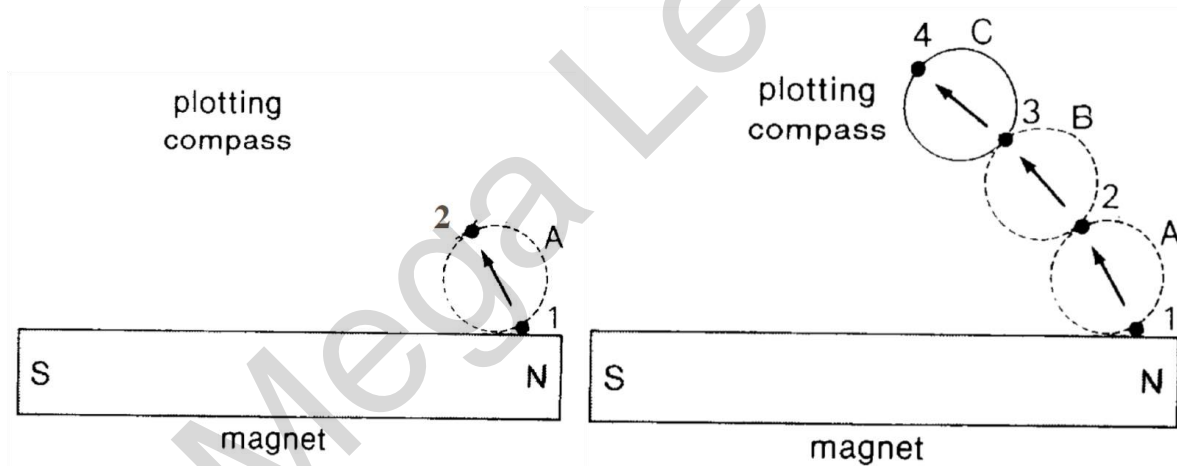


- Magnetic shielding using a hollow iron container.
- The region within the iron container has no magnetic field.

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Plotting of magnetic field lines with a compass

- The lines can be investigated to find their path and direction using a plotting compass.
 1. Place a plotting compass at point A.
 2. Note the direction it points at.
 3. Mark a 2nd point next to the N-pole of the plotting compass.
 4. These steps are repeated as shown.
 5. The points are all joined using a pencil.
 6. All these steps are repeated for other points next to the N-pole of the magnet.



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Temporary magnets and permanent magnets

Soft and Hard Magnetic Materials

Magnetic Material	Soft	Hard
Properties	Easily magnetised and demagnetised	Difficult to magnetise and demagnetise
Examples	Iron	Steel, alnico, neodymium
Used to make	Temporary magnets	Permanent magnets

Uses of permanent magnets

- Magnets are used in many devices
 - Permanent magnets are used when a constant magnetic field is needed
 - Temporary magnets are used when a changing magnetic field is needed
 - The function of some devices (eg loudspeaker, moving-coil ammeter) depend on the interaction of the magnetic fields of permanent and temporary magnets
- **Magnetic door catches**
 - Magnetic strips made of permanent magnets are fitted to the door of a refrigerator.
 - This ensures that the refrigerator is airtight when the door is shut against the steel frame

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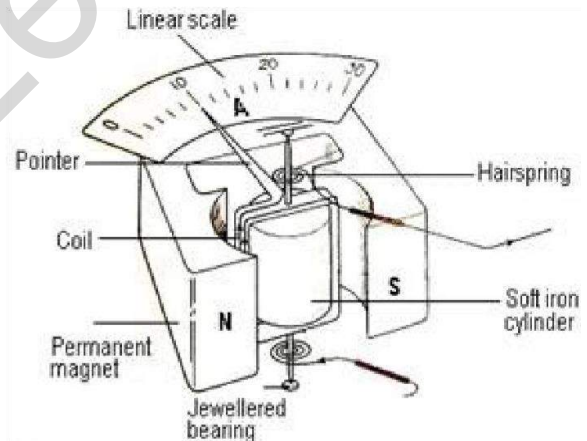
Uses of permanent and temporary magnets

- **Moving-coil loudspeakers**

1. A strong permanent magnet is used in the moving-coil loudspeaker to provide a constant magnetic field
2. A core made of soft magnetic material placed inside a current-carrying coil becomes a temporary magnet. The poles of the temporary magnet change when the direction of the current in the coils changes.
3. The loudspeaker diaphragm moves due to the alternating attraction and repulsion between the temporary and permanent magnets

- **Moving-coil ammeters**

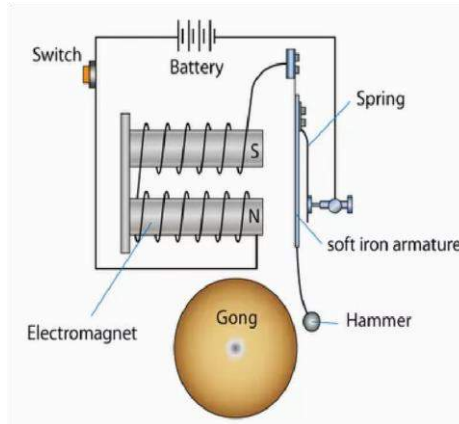
1. A strong permanent magnet is used in the moving-coil ammeter.
2. A core made of soft magnetic material is placed inside a current-carrying coil. When current flows through the coil, the core becomes a temporary magnet and a turning force is produced.
3. The pointer attached to the coil moves as the coil turns, and shows the amount of current flowing through the ammeter.



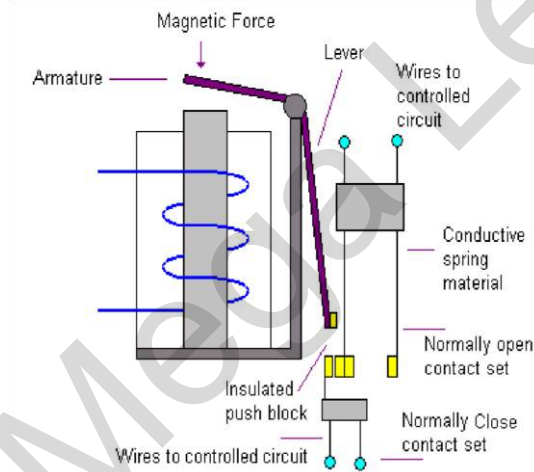
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Uses of temporary magnets (electromagnets)

- Electric-bell



Magnetic-relay



Cranes that help separate magnetic material and non-magnetic material

