

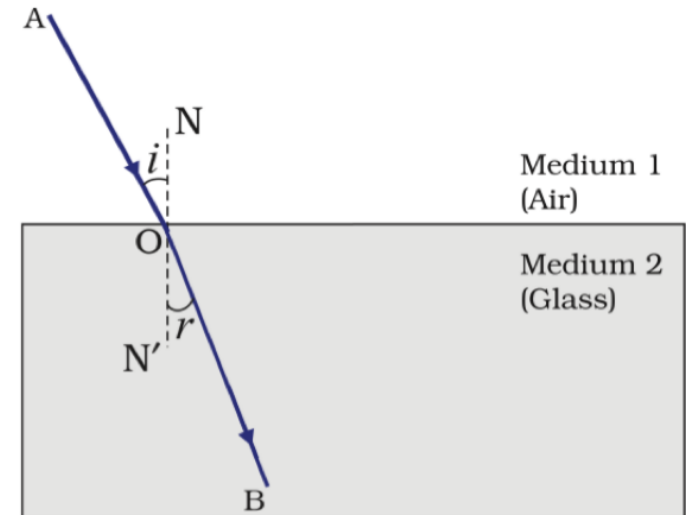
10.3.2 The Refractive Index

- When a ray of light travels obliquely from one medium to another it suffers a change in its direction in the second medium.
- This extent of change in direction that takes place is expressed in terms of the refractive index (n or μ)

$$\frac{\sin i}{\sin r} = \text{Refractive index}$$

- n_{21} → refers to refractive index of medium 2 with respect to medium 1.

n_{12} → refers to refractive index of medium 1 with respect to medium 2.



$$n_{21} = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}} = \frac{v_1}{v_2}$$

$$n_{12} = \frac{\text{Speed of light in medium 2}}{\text{Speed of light in medium 1}} = \frac{v_2}{v_1}$$

v_1 - speed of light in medium 1 ; v_2 - speed of light in medium 2 .

Absolute Refractive Index

If medium 1 is air or vacuum, then refractive index of medium 2 is called Absolute refractive index of the medium, represented by n_2 .

$$n_m = \frac{\text{Speed of light in air}}{\text{Speed of light in the medium}} = \frac{c}{v}$$

- Absolute refractive index of a medium is simply called refractive index.

- Refractive index of water $n_w = 1.33$ means light travels 1.33 times slower in water than in air or vacuum.
- $n_{\text{glass}} = 1.52$
- If $n_A > n_B$, it means light travels slower in A than in B
- A medium having higher refractive index is said to be optically denser
A medium having lower refractive index is said to be optically rarer

NOTE: Optically denser does not mean greater mass density.

- Speed of light is higher in a rarer medium than in a denser medium.

* As a ray of light travels from a
rarer to denser medium — It slows down & bends towards normal.
denser to rarer medium — It speeds up & bends away from the normal.

1. A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal? Why?

Ans 1. Bends towards normal since the speed of the light ray decreases. as it moves from a rarer medium (air) to a denser medium (water).

2. Light enters from air to glass having refractive index 1.50. What is the speed of light in the glass? The speed of light in vacuum is $3 \times 10^8 \text{ m s}^{-1}$.

Ans 2. $n_g = 1.50$ $c = 3 \times 10^8 \text{ m s}^{-1}$

$$n_g = \frac{c}{v_g} \Rightarrow 1.5 = \frac{3 \times 10^8}{v_g} \Rightarrow v_g = 2 \times 10^8 \text{ m s}^{-1}$$

3. Find out, from Table 10.3, the medium having highest optical density. Also find the medium with lowest optical density.

Medium having highest optical density is Diamond ($n_{\max}$)

Medium having lowest optical density is Air ($n_{\min}$)

Table 10.3 Absolute refractive index of some material media

Material medium	Refractive index	Material medium	Refractive index
Air	1.0003	Canada Balsam	1.53
Ice	1.31	Rock salt	1.54
Water	1.33	Carbon disulphide	1.63
Alcohol	1.36	Dense flint glass	1.65
Kerosene	1.44	Ruby	1.71
Fused quartz	1.46	Sapphire	1.77
Turpentine oil	1.47	Crown glass	1.52
Benzene	1.50	Diamond	2.42

4. You are given kerosene, turpentine and water. In which of these does the light travel fastest? Use the information given in Table 10.3.

Medium	Refractive index
1. Kerosene	1.44
2. turpentine	1.47
3. water	1.33

light travels fastest in medium
with less refractive index
 $\therefore$ In water

5. The refractive index of diamond is 2.42. What is the meaning of this statement?

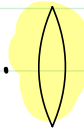
Ans. This statement means that the speed of light is 2.42 times slower in diamond than in air.

10.3.3 Refraction by Spherical Lenses

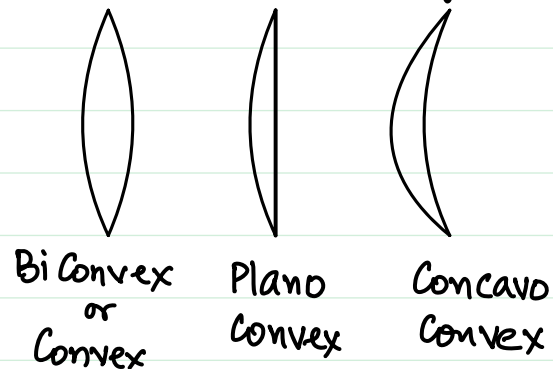
Lens - A transparent material bound by two surfaces, of which one or both surfaces are spherical forms a **lens**

- A lens is bound by at least one spherical surface, the other being plane.

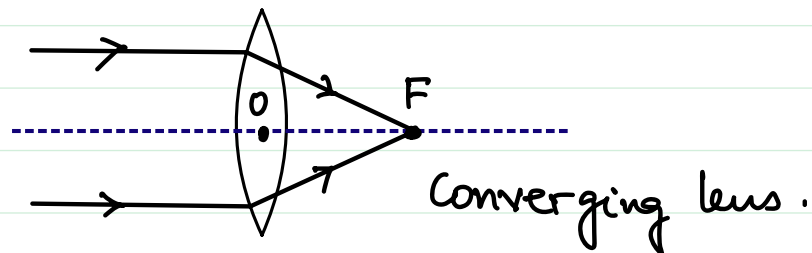
Lenses ——— Convex or Converging lens .
————— Concave or Diverging lens .



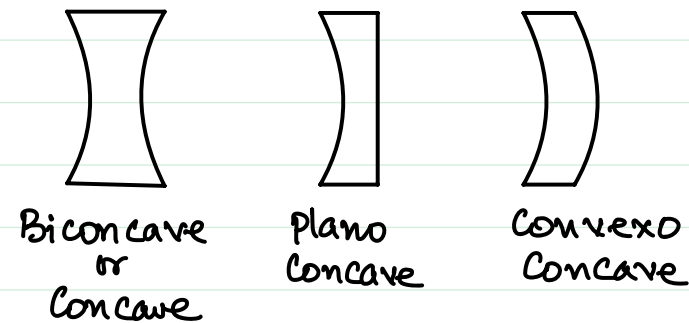
Convex or Converging lens



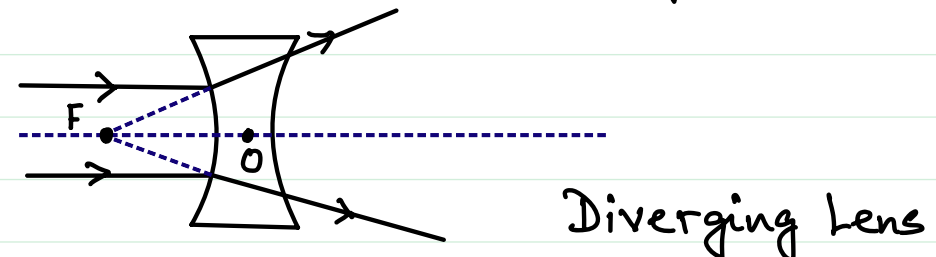
- Thick in middle, thin at edges



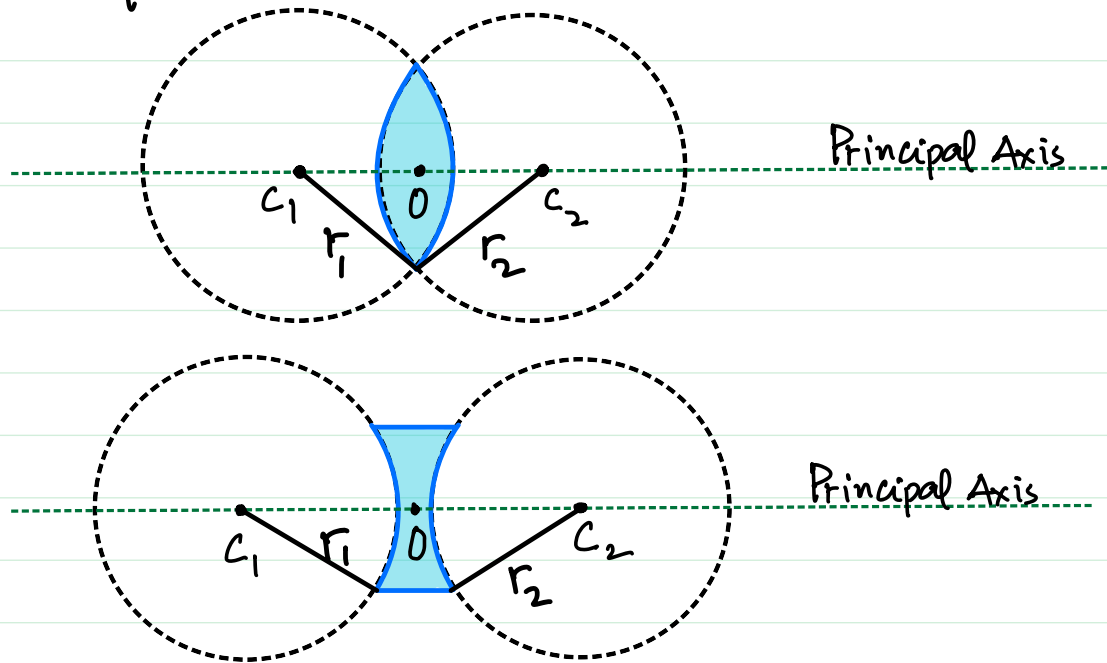
Concave or Diverging lens



- Thin in middle, thick at edges.



Important Terms



1. Centre of Curvature: Centres of the spheres of which the lens are a part are called Centres of curvature C_1 & C_2
2. Radii of Curvature: Radii of spheres of which the lens are a part are called radii of curvature r_1 & r_2
3. Principal Axis: An imaginary line passing through the two centres of curvatures of a lens is called Principal Axis.
4. Optical Centre: The central point of a lens is its optical centre 'O'.
* A ray of light through optical centre passes undeviated.

Electric Current and Circuit

- Current is defined as rate of flow of charge
- Current flowing through a conductor is charge flowing per second.
- Denoted by I

$$I = \frac{Q}{t} ; \quad Q \text{ is charge in coulomb} \\ t \text{ is time in seconds}$$

- Unit of current : $I = \frac{Q}{t} = \frac{\text{coulomb}}{\text{sec}} = \text{ampere}$ (After French physicist Andre Ampere)

$$1 \text{ A} = 1 \text{ C s}^{-1}$$

- Smaller units of current : milli ampere $\text{mA} = 10^{-3} \text{ A}$
micro ampere $\mu\text{A} = 10^{-6} \text{ A}$
- Current is measured using an ammeter connected in series.
- In metal conductors : moving charges are free electrons
- In electrolytes and ionised gases : cations $\oplus$ and anions $\ominus$ are moving charges

-  If n electrons pass a c/s in time t ,
total charge $I = \frac{ne}{t}$ $e = 1.6 \times 10^{-19} \text{ C}$

- For $I = 1 \text{ A}$, $t = 1 \text{ s}$ $n = \frac{It}{e} \Rightarrow n = \frac{1 \text{ A} \times 1 \text{ s}}{1.6 \times 10^{-19} \text{ C}} = \frac{1 \cancel{\text{C}}}{1.6 \times 10^{-19} \cancel{\text{C}}} \times \frac{1 \cancel{\text{s}}}{1.6 \times 10^{-19} \cancel{\text{s}}}$
 $n = 6.25 \times 10^{18} \text{ electrons}$

Electric Circuit

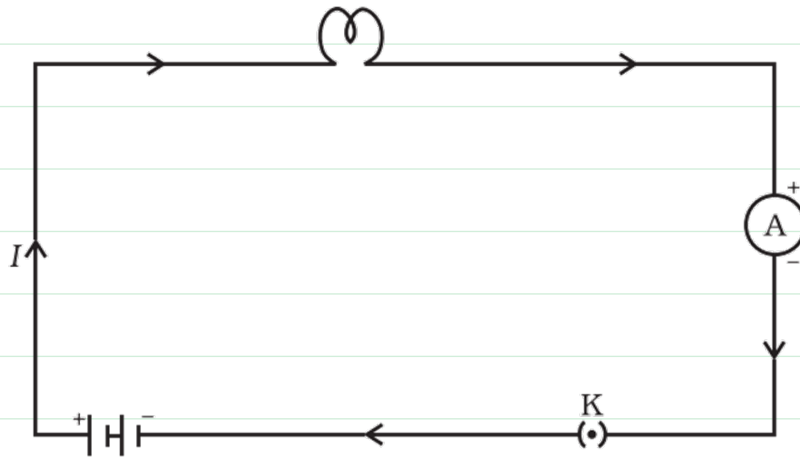


Figure 12.1

A schematic diagram of an electric circuit comprising – cell, electric bulb, ammeter and plug key

- A continuous and closed path of an electric current is called an **Electric Circuit**
- Components of a general circuit
 - Wire
 - Switch
 - Ammeter – measures current and is connected in series.
 - Load

Example 12.1

A current of 0.5 A is drawn by a filament of an electric bulb for 10 minutes. Find the amount of electric charge that flows through the circuit.

$$I = 0.5 \text{ A} , \quad t = 10 \text{ min} = 600 \text{ s}$$

$$I = \frac{Q}{t} \Rightarrow Q = It \Rightarrow Q = 0.5 \text{ A} \times 600 \text{ s}$$

$$Q = 300 \text{ C}$$

Definition - Electric potential at a point

Potential at a point is the work done per unit charge in bringing a unit positive test charge from infinity to that point.

- Denoted by V
- Potential is a scalar



Around a tve charge, the potential is positive



Around a -ve charge, the potential is negative.

Potential at a point refers to the ability of that point to cause flow of charge



If W joule of work is done to bring a test charge Q coulomb from infinity to point P , then electric potential V at the point P is given as

$$V = \frac{W}{Q}$$

- Unit of electric potential $V = \frac{\text{joules}}{\text{coulomb}} = \text{JC}^{-1} = \text{volts.}$



Alessandro Volta
(1745-1827)
Italian physicist

Definition of 1 volt : The electric potential at a point is said to be 1 volt, if 1 joule of work is done in bringing 1 coulomb charge from infinity to that point.

Concept of Potential Difference (p.d.)

- Potential difference between two points is equal to the work done per unit charge in moving a positive test charge from one point to the other.
- Potential difference is a scalar quantity.
- $V_A - V_B = \frac{W}{Q}$ P.d. b/w A & B if W joules is spent in moving a test positive charge Q from A to B.
- P.D. is measured by a voltmeter
- A voltmeter is connected in parallel with its +ve connected to the +ve of the battery.
- Unit of PD is also **volt**

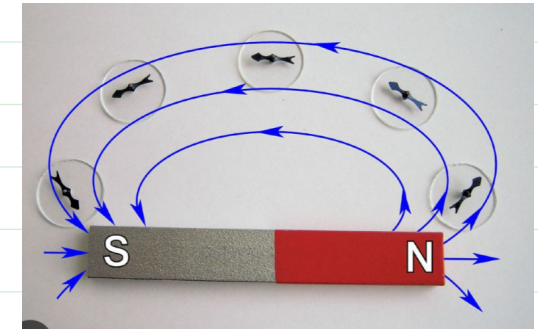
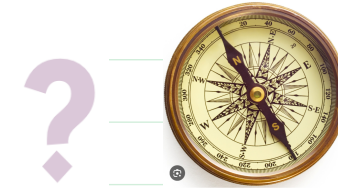
Alternate Definition of 1 volt

- The electric potential difference between two points is said to be 1 volt, if the work done in moving 1C charge from one point to the other is 1 joule.

13.1 MAGNETIC FIELD AND FIELD LINES

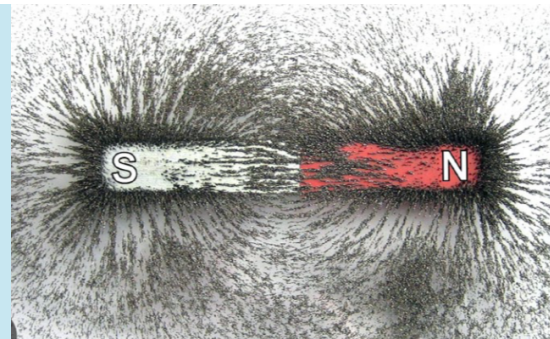
1. Why does a compass needle get deflected when brought near a bar magnet?

- A compass needle gets deflected when brought near a bar magnet, due to the field lines produced by the bar magnet which exert a force on the compass needle (itself a magnet).



Activity 13.2

- Fix a sheet of white paper on a drawing board using some adhesive material.
- Place a bar magnet in the centre of it.
- Sprinkle some iron filings uniformly around the bar magnet (Fig. 13.2). A salt-sprinkler may be used for this purpose.
- Now tap the board gently.
- What do you observe?



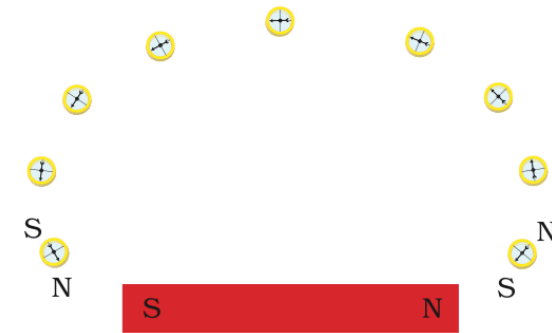
Q1. Why do iron filings arrange themselves in such a pattern?

Ans: • The magnetic field due to the bar magnet, exerts a force on the iron filings which arrange themselves in such a pattern.

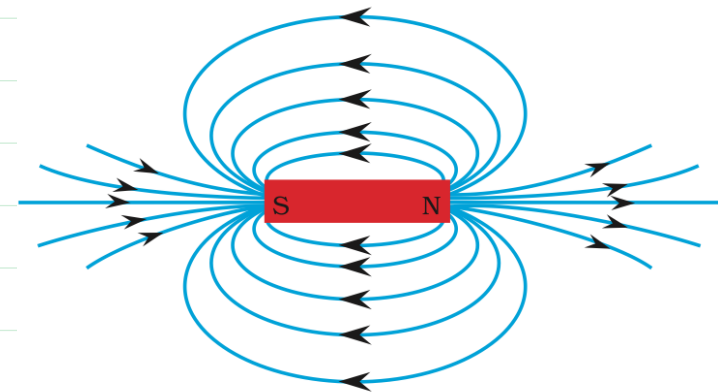
- The pattern represents the magnetic field lines.

Activity 13.3

- Take a small compass and a bar magnet.
- Place the magnet on a sheet of white paper fixed on a drawing board, using some adhesive material.
- Mark the boundary of the magnet.
- Place the compass near the north pole of the magnet. How does it behave? The south pole of the needle points towards the north pole of the magnet. The north pole of the compass is directed away from the north pole of the magnet.
- Mark the position of two ends of the needle.
- Now move the needle to a new position such that its south pole occupies the position previously occupied by its north pole.
- In this way, proceed step by step till you reach the south pole of the magnet as shown in Fig. 13.3.
- Join the points marked on the paper by a smooth curve. This curve represents a field line.
- Repeat the above procedure and draw as many lines as you can. You will get a pattern shown in Fig. 13.4. These lines represent the magnetic field around the magnet. These are known as magnetic field lines.
- Observe the deflection in the compass needle as you move it along a field line. The deflection increases as the needle is moved towards the poles.



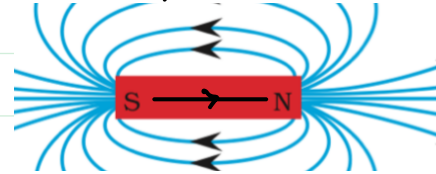
Drawing a magnetic field line with the help of a compass needle



Field lines around a bar magnet

Magnetic field Lines

- Magnetic field is a vector quantity ($\vec{B}$)
- Direction of a magnetic field line is the direction of the North pole of a compass needle placed near the bar magnet.
- Outside the magnet $N \rightarrow S$
Inside the magnet $S \rightarrow N$



- Magnetic field lines are closed curves
- No two field lines cross each other.
(Reason: Any point on a field line represents a unique direction of the magnetic field at that point. If two field lines intersect, it would indicate that at that point, the magnetic field has 2 different directions which is not possible.)