

PHYSICS • CLASS 12

CHAPTER 5

Magnetism and Matter

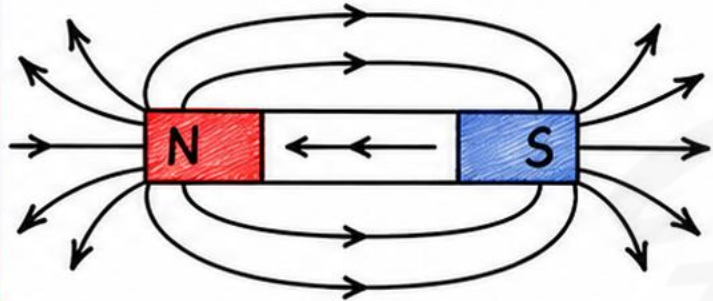
CHAPTER NOTES



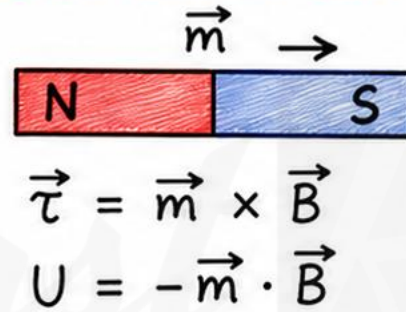
MAGNETISM AND MATTER

Magnetism links current loops and atomic moments to fields, torque, energy and material response.

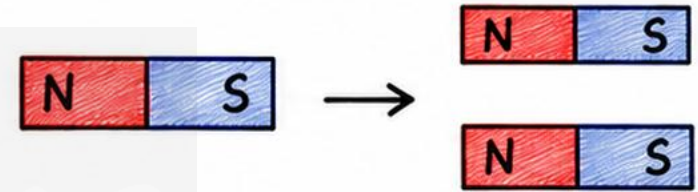
1. BAR MAGNET



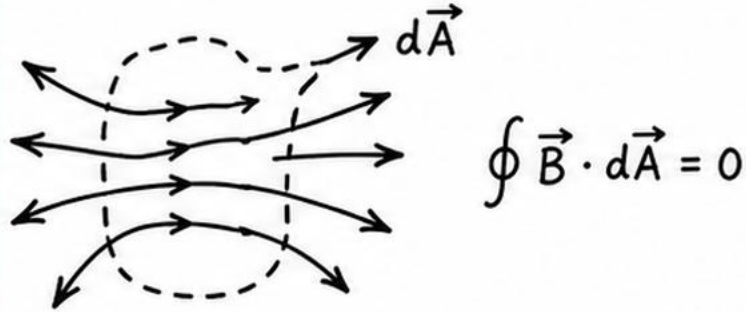
2. MAGNETIC DIPOLE



3. NO MONOPOLES



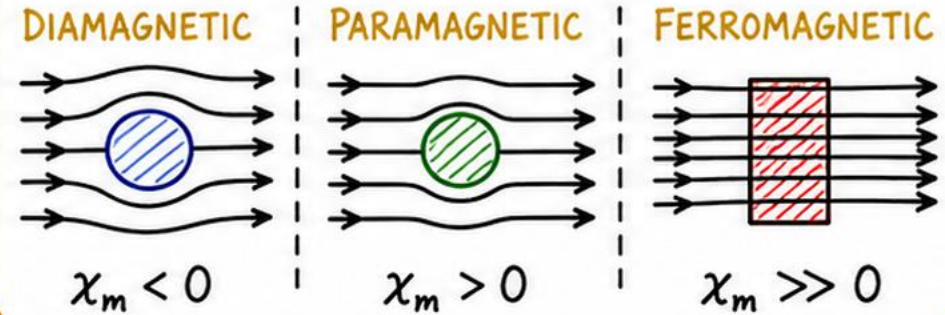
4. GAUSS'S LAW



5. MAGNETIC MEDIA

$$\vec{B} = \mu_0 (\vec{H} + \vec{M})$$

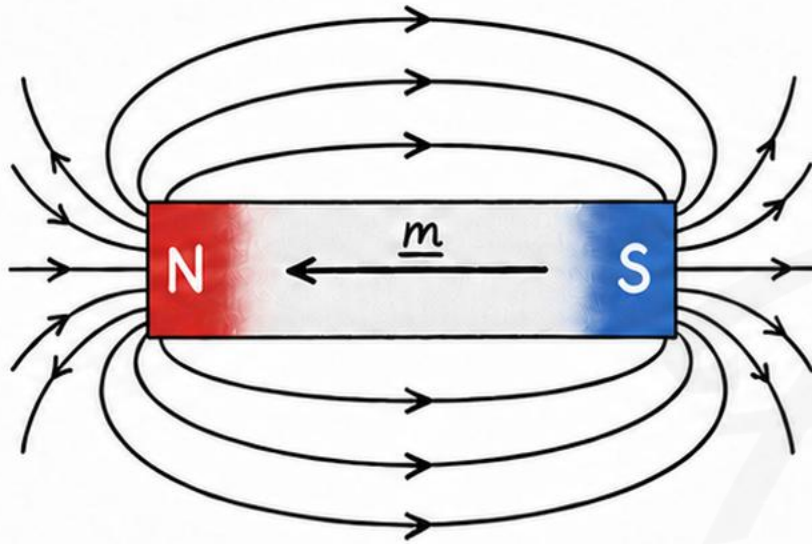
6. MATERIAL CLASSES



NO MAGNETIC SOURCES OR SINKS • DIPOLES RESPOND TO FIELDS • MATTER MODIFIES $\vec{B}$

BAR MAGNET — POLES, MOMENT & CUTTING

1. BAR MAGNET: POLES & FIELD

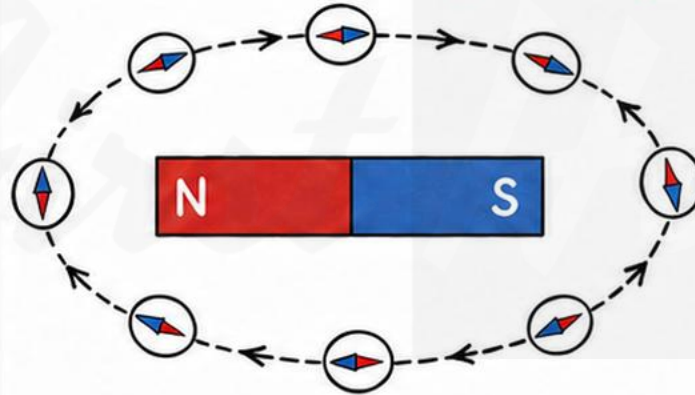


- Unlike poles attract.
- Like poles repel.
- A freely suspended magnet aligns approximately north-south.

2. MAGNETIC DIPOLE

A bar magnet acts as a magnetic dipole having equal and opposite poles separated by a small distance.

COMPASS MAPPING (TOP VIEW)

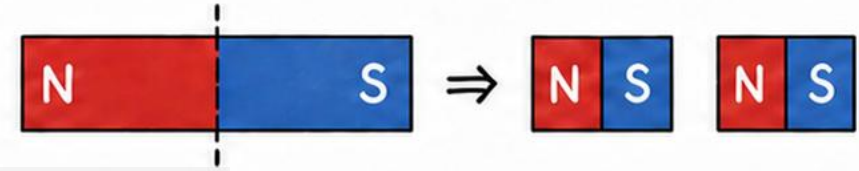


The magnetic field lines form closed loops: outside the magnet from N to S and inside from S to N.

Isolated magnetic poles have not been observed.

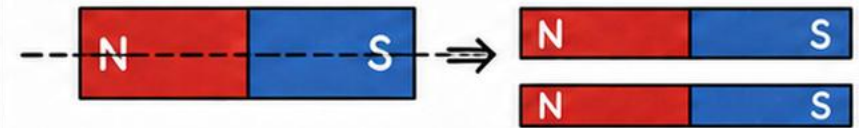
3. CUTTING A BAR MAGNET

(a) TRANSVERSE CUT (PERPENDICULAR TO LENGTH)



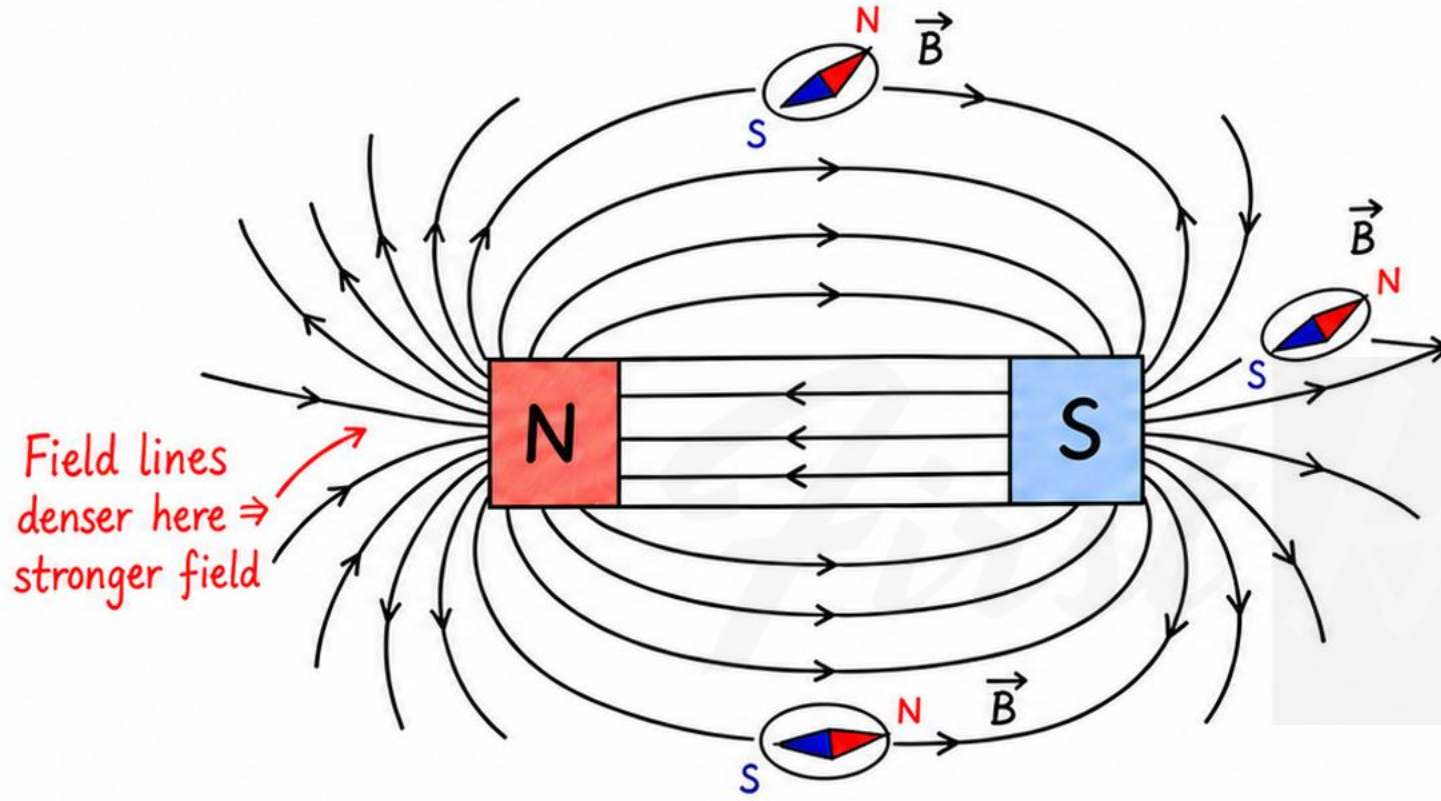
Result: each piece has both poles.
For a uniformly magnetised ideal bar, each piece has moment $\approx m/2$.

(b) LONGITUDINAL CUT (ALONG THE LENGTH)



Result: each piece has both poles.
For a uniformly magnetised ideal bar, each piece has moment $\approx m/2$.

MAGNETIC FIELD LINES & COMPASS MAPPING

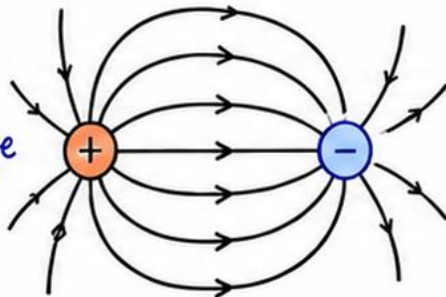


- ① The tangent to a magnetic field line at any point gives the direction of $\vec{B}$ at that point.
- ② The relative density of field lines indicates the relative magnitude (strength) of the magnetic field.
- ③ No two magnetic field lines intersect each other.
- ④ Magnetic field lines have no beginnings or endings.

Comparison with Electric Dipole

Electric Dipole

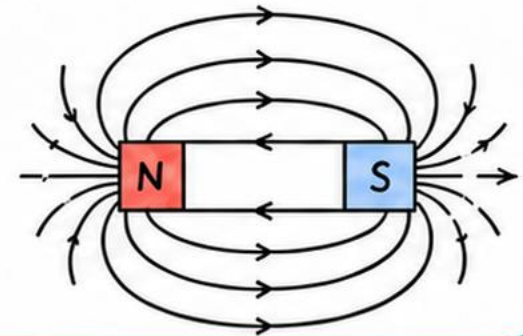
Electric field lines begin on + charge and end on - charge.



VS

Magnetic Field $\vec{B}$

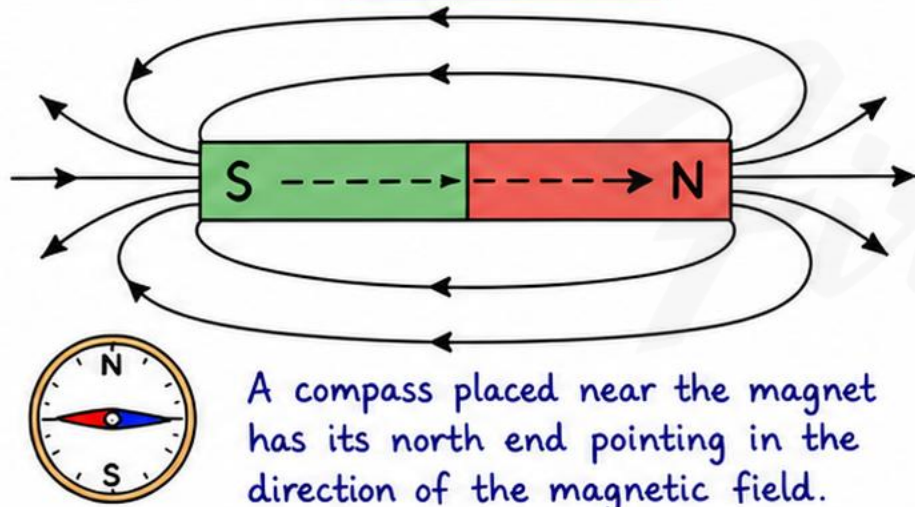
In magnetostatics, $\nabla \cdot \vec{B} = 0$.
Hence, magnetic field lines form closed loops or continue to infinity; they do not start or end at any point.



BAR MAGNET AS AN EQUIVALENT SOLENOID

At the microscopic level, each atom in a magnetic material has tiny circular electron currents. Their magnetic moments (or microscopic circulating currents) get aligned in the same direction, giving the material a net magnetic moment. Hence, a bar magnet behaves like a magnetic dipole.

(A) BAR MAGNET

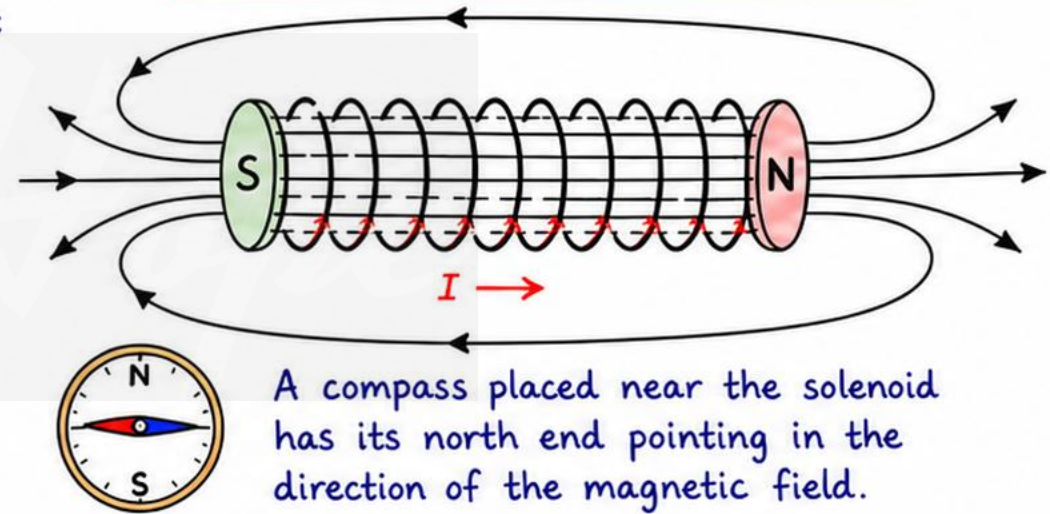


A compass placed near the magnet has its north end pointing in the direction of the magnetic field.

Magnetic moment of a current loop:

$$m_{\text{loop}} = IA$$

(B) FINITE CURRENT-CARRYING SOLENOID



A compass placed near the solenoid has its north end pointing in the direction of the magnetic field.

Magnetic moment of a solenoid (N turns):

$$m_{\text{solenoid}} = NIA$$

If a bar magnet is cut into two pieces, each piece is again a smaller magnet.

Similarly, if a finite solenoid is cut into two parts, each part behaves like a smaller solenoid.

In the far field (outside the magnet / solenoid), only the magnetic moment matters.

same $m \Rightarrow$ same dipole field when $r \gg$ magnet size.

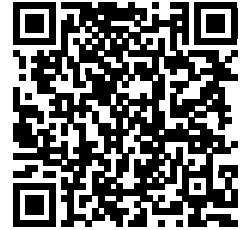


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