Magnetism

Lecture 1

The Magnetic field

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2nd stage

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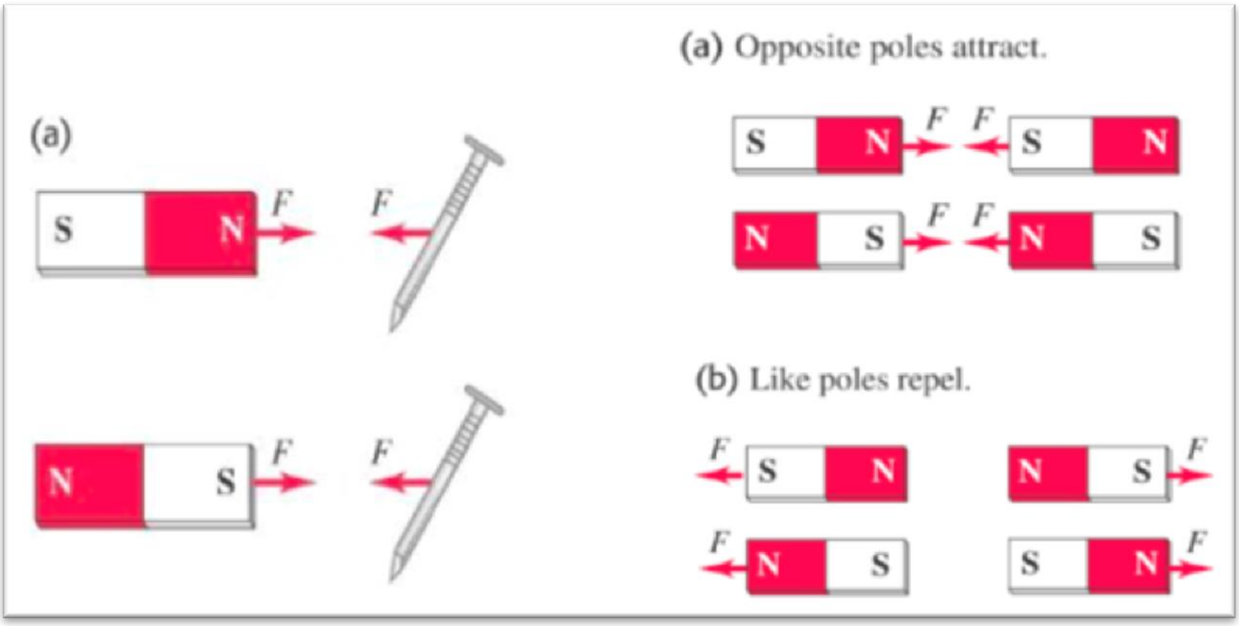
1-1 Magnetism

Magnets exert forces on each other just like charges. You can draw magnetic field lines just like you drew electric field lines. Magnetic north and south pole's behavior is not unlike electric charges. For magnets, like poles repel and opposite poles attract .

A permanent magnet will attract a metal like iron with either the north or South Pole.



$$\vec{F}_m = |q|\ v\perp B \ ....(1)$$

$$= |q|\ (\vec{v}\ \times \vec{B}\ )\ ....(2)$$

$$= |q|\ vB \sin \theta ....(3)$$

Remember that in cross products: $|\vec{a} \times \vec{b}| = a\ b \sin\theta$

$$\vec{F}_m = q\ (\vec{v}\ \times \vec{B}\ )\ ....(4)$$

$\vec{F}_m$ *Is always perpendicular to* $((\vec{v})$ *And* $(\vec{B}\ )$.

1-2 Magnetic Field Lines

1- Magnetic field lines may be traced

from N to S (similar to the electric field lines).

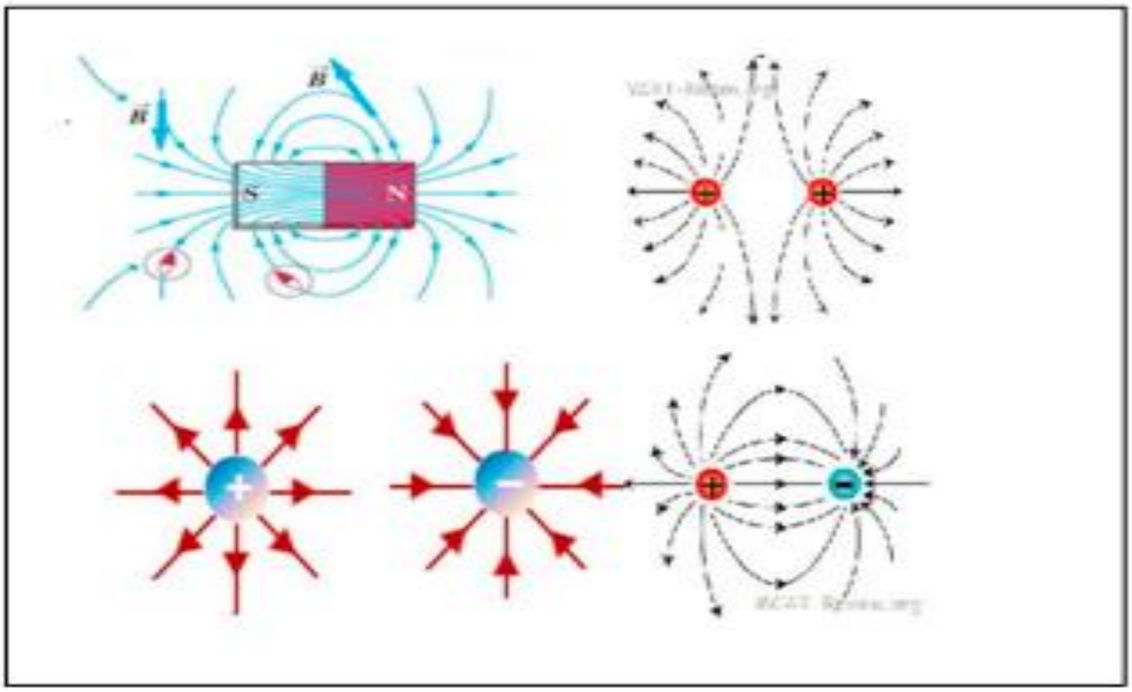
2- At each point they are tangent to magnetic field vector.

3- The more densely packed the field lines, the stronger the field at a point.

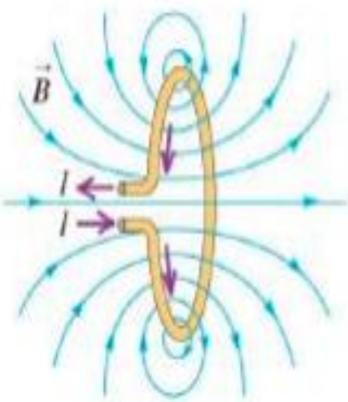
4- Field lines never intersect.

5- The field lines point in the same direction as a compass (from N to S).

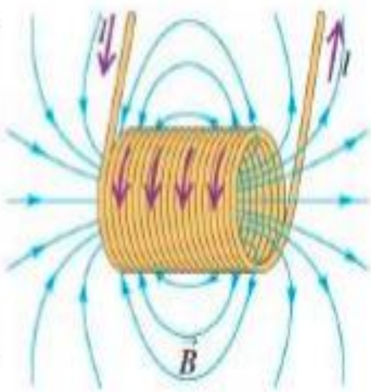
6- Magnetic field lines are not “lines of force” Magnetic field lines have no ends, they continue through the interior of the magnet.



(c) Magnetic fields of a current-carrying loop and a current-carrying coil (solenoid)

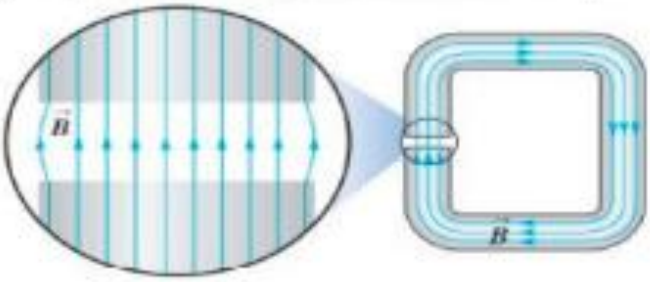


Notice that the filed of the loop and especially that of the coil look like the filed of a bar magnet.



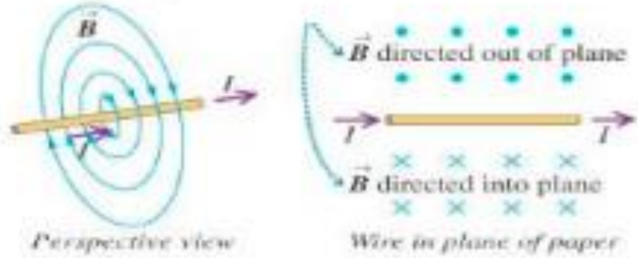
(a) Magnetic fied of C- shape magnet

Between flat parallel magnetic poles the magnetic filed is nearly uniform



(b) Magnetic filed of straight current carrying wier

To represent the magnetic filed coming out of the plane of the paper we use dot and crosses respectively



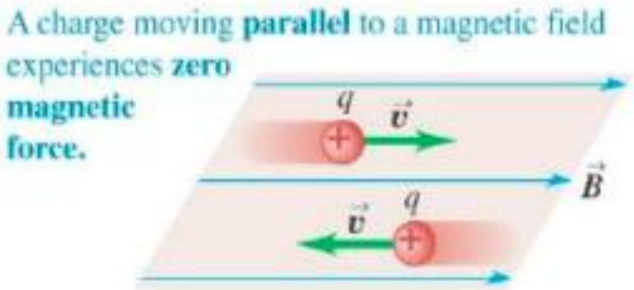
1-3 Magnetic Fields and Forces

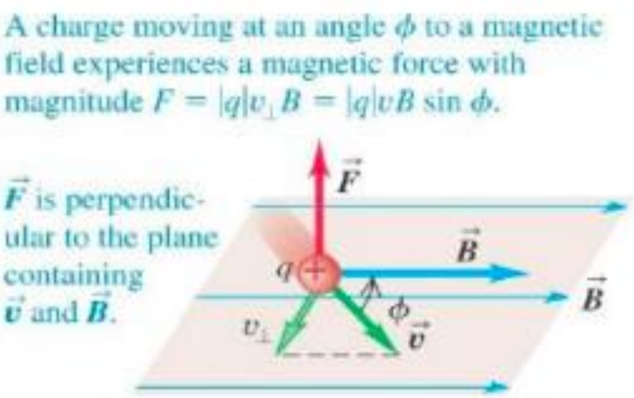
Experiments on various charged particles moving in a magnetic field give the following results:

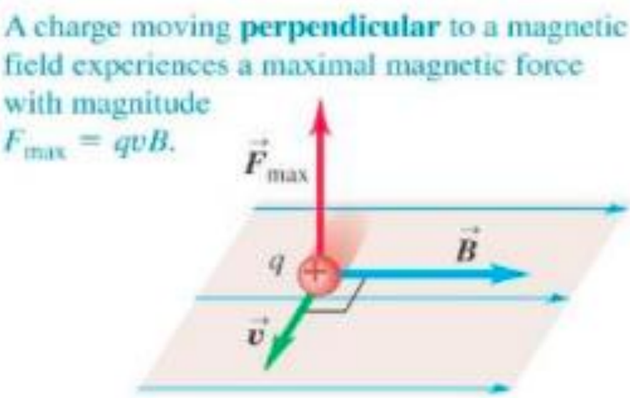
1. The magnitude FB of the magnetic force applied to the particle is proportional to the charge q and to the speed v of the particle.

2. The magnitude and direction of FB depend on the velocity of the particle and on the magnitude and direction of the magnetic field B.

3. When a charged particle moves parallel to the magnetic field vector, the magnetic force acting on the particle is zero.







Notes:

1.When the particle's velocity vector makes any angle with the magnetic field, the magnetic force acts in a direction perpendicular to both v and B; that is, FB is perpendicular to the plane formed by v and B.

2.The magnetic force applied to a positive charge is in the direction opposite the direction of the magnetic force applied on a negative charge moving in the same direction.

3. The magnitude of the magnetic force applied to the moving particle is proportional to sinθ, where θ is the angle the particle's velocity vector makes with the direction of B. We can summarize these observations by writing the magnetic force in the form:

$$\text{As} \quad \vec{E} = \frac{\vec{F}}{q} \quad \text{............(5)}$$

$$\vec{B} = \frac{\vec{F}}{qv \sin\theta} \quad \text{............(6)}$$

$$\vec{F} = \vec{B}(qv \, sin\theta)$$

Or

$$\vec{F}_B = q(v \times \vec{B})$$