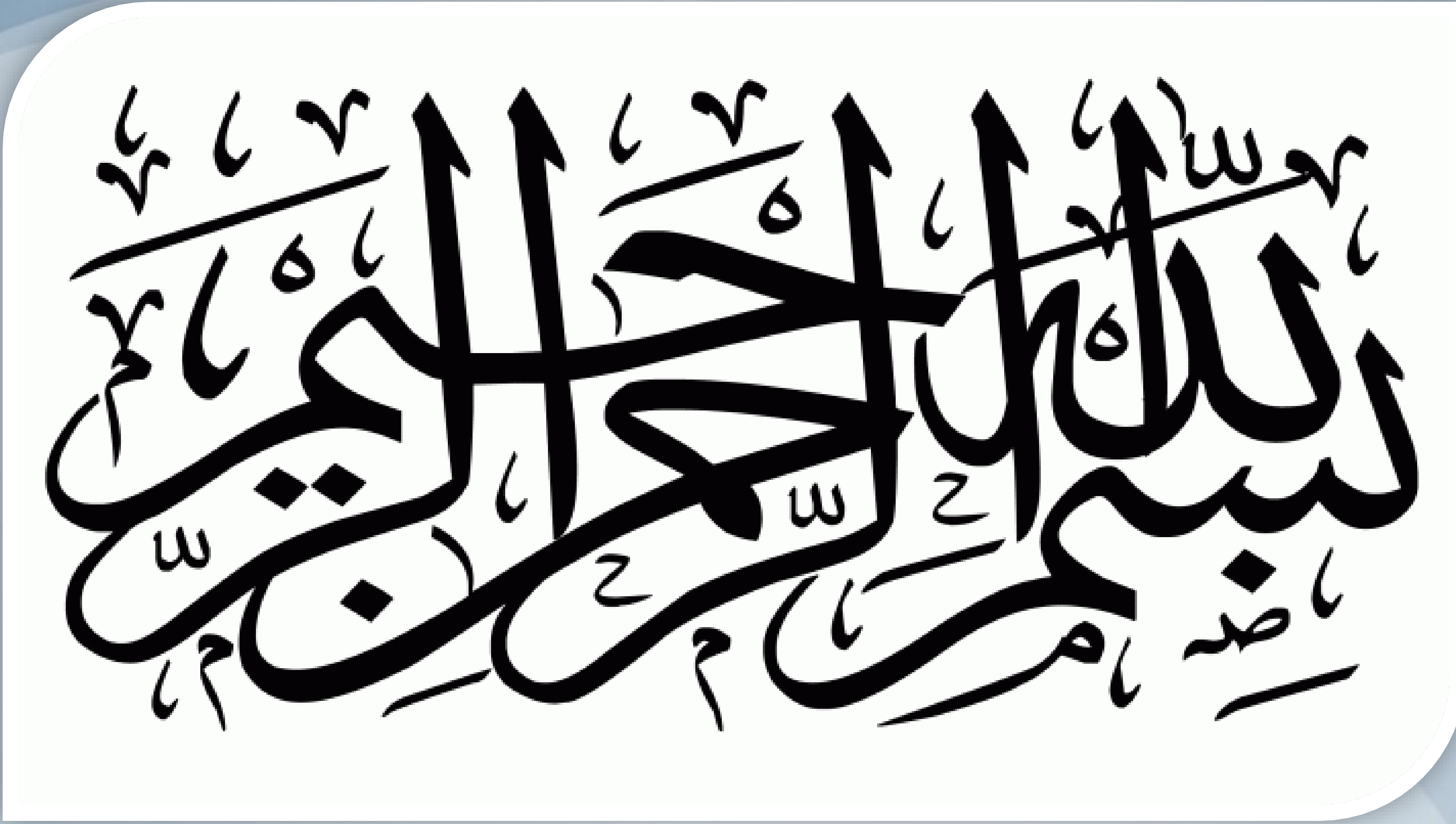
بسم الله الرحمن الرحيم

Al-Mustaqbal University-College

Department of medical physics

Magnetism

First lecture

The magnetic field

By:

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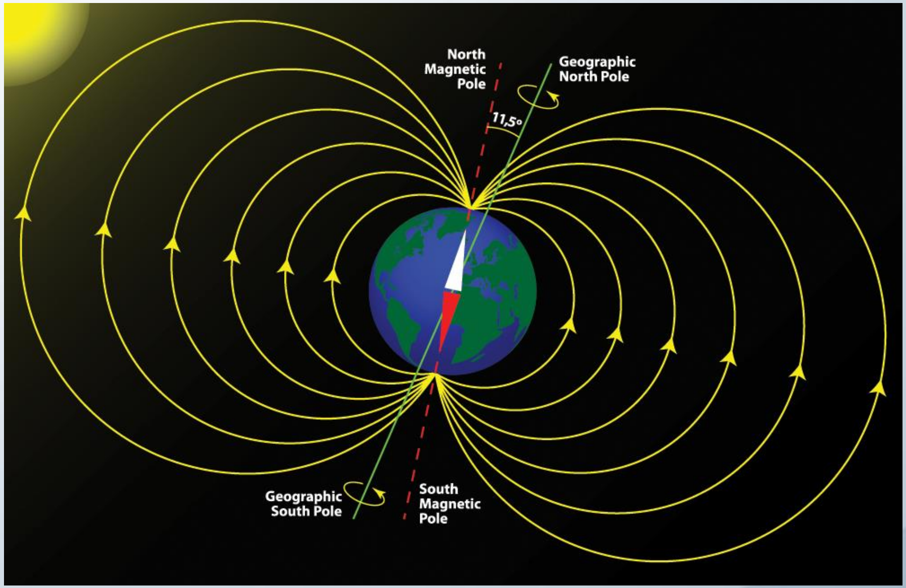
Introduction to magnetism

- The story of magnetism begins with a mineral called **magnetite (Fe_3O_4)**, the first magnetic material known to man.
- Its early history is obscure, but its power of attracting iron was certainly known **2500 years** ago.
- **Magnetite** is widely distributed. In the ancient world the most plentiful deposits occurred in the district of **Magnesia**, in what is now **modern Turkey.**

Introduction to magnetism

- This north-pointing property of magnetite accounts for the old English word **lodestone** for this substance; it means "**waystone**," because it pointsthe way.

- The first truly scientific study of magnetism was made by the **Englishman William Gilbert (1540–1603)**, who published his classic book On the Magnet in 1600.



The applications of magnetic fields:

- ✓ the magnetic recording of music and images on audiotape and videotape.
- ✓ CD and DVD players and computer hard drives.
- ✓ the speaker cones in headphones, TVs, computers, and telephones.

What is the Magnetic Field ?

- Magnetic field, a **vector field** in the neighborhood of a magnet, electric current, or changing electric field, in which magnetic forces are observable.
- Magnetic fields such as that of Earth cause magnetic compass needles and other permanent magnets to line up in the direction of the field.
- Magnetic fields force moving electrically charged particles in a circular or helical path.

What Produces a Magnetic Field?

There are two ways:

- ✓ One way is to use **moving electrically charged particles**, such as a **current in a wire**, to make an electromagnet.
- ✓ The other way to produce a magnetic field is by means of **elementary particles** such as **electrons** because these particles have an intrinsic magnetic field around them.

The Definition of $\vec{B}$

We can then define a magnetic field $\vec{B}$ to be a vector quantity that is directed along the zero-force axis. We can next measure the magnitude of $\vec{F_B}$ when $\vec{v}$ is directed perpendicular to that axis and then define the magnitude of $\vec{B}$ in terms of that force magnitude:

$$B = \frac{F_B}{|q|\, v}$$

$$\overrightarrow{F_B} = q\vec{v} \times \vec{B}$$

$$F_B = |q| v\, B\, sin\emptyset$$

Finding the Magnetic Force on a Particle

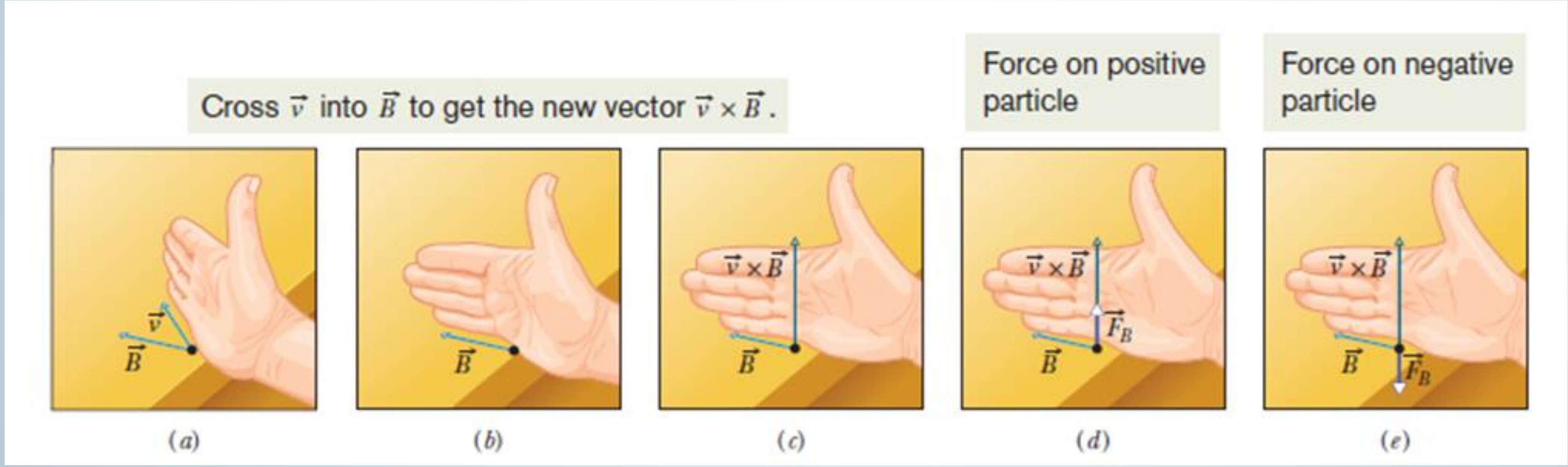
$$F_B = |q|v\, B\, sin\emptyset$$

This equation tells us that the magnitude of the force (F_B) $\rightarrow$ acting on a particle in a magnetic field is proportional to the charge q and speed v of the particle.

This equation also tells us that the magnitude of the force is zero if $v \rightarrow$ and $B \rightarrow$ are either parallel (Ø=0°) or antiparallel (Ø=180°), and the force is at its maximum when $v \rightarrow$ and $B \rightarrow$ and are perpendicular to each other.

Directions of Magnetic Force $\overrightarrow{F_B}$.

The right-hand rule tells us that the thumb of the right hand points in the direction of $\vec{v} \times \vec{B}$ when the fingers sweep $\vec{v}$ into $\vec{B}$.



The force $\overrightarrow{F_B}$ acting on a charged particle moving with velocity $\vec{v}$ through a magnetic field $\vec{B}$ is always perpendicular to $\vec{v}$ and $\vec{B}$.

The SI unit for $\vec{B}$

$$1\ tesla = 1\ T = 1\ \frac{newton}{(coulomb)(meter/second)}$$

Recalling that a coulomb per second is an ampere, we have:

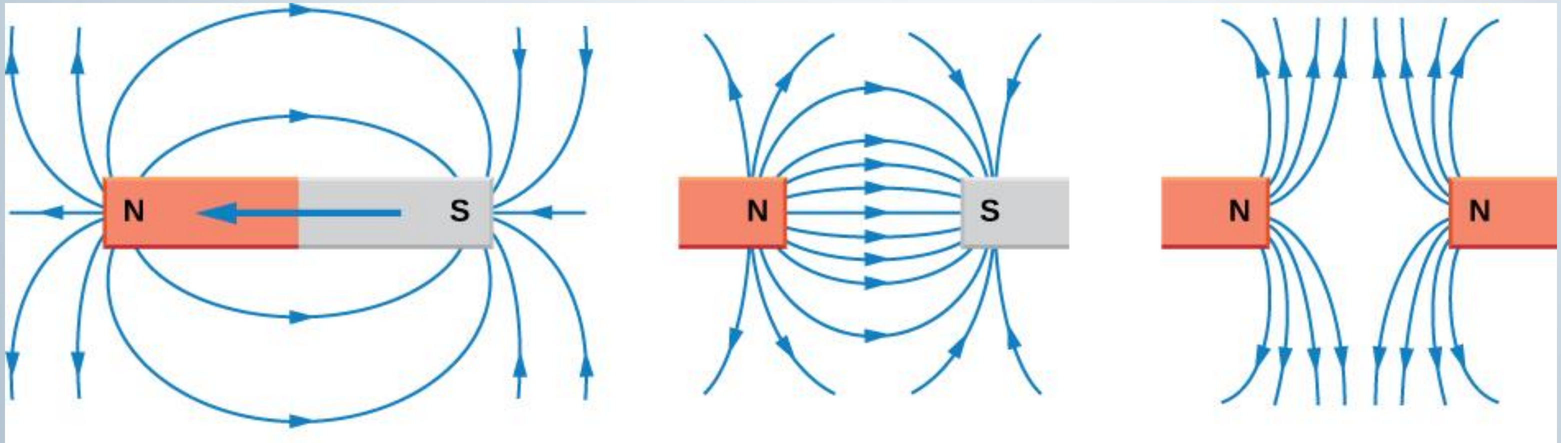
$$1\ T = 1\ \frac{newton}{(coulomb/second)(meter)} = 1\ \frac{N}{A\ .\ m}$$

An earlier (non-SI) unit for $\vec{B}$, still in common use, is the gauss (G), and

$$1\ \text{tesla} = 10^4\ \text{gauss}$$

Magnetic Field Lines:

- The direction of the magnetic field line at any point gives the direction of $\vec{B}$ at that point.
- the spacing of the lines represents the magnitude of the magnetic field $\vec{B}$ is stronger where the lines are closer together.



Magnetic field lines of a bar magnet (a)

Magnetic field lines between unlike poles (b)

Magnetic field lines between like poles (c)

Example:

Example: A uniform magnetic field $\vec{B}$, with magnitude 1.2 mT, is directed vertically upward throughout the volume of a laboratory chamber. A proton with kinetic energy 5.3 MeV enters the chamber, moving horizontally from south to north. *What magnetic force acts on the proton as it enters the chamber?* The proton mass is 1.67×10^{-27} kg. (Neglect Earth's magnetic field). *Find proton acceleration?*

Solution: To find the magnitude of $\overrightarrow{F_B}$, we can use Eq. (4) ($F_B = |q|v\ B\ sin\emptyset$) provided we first find the proton's speed v. We can find v from the given kinetic energy because $k = \frac{1}{2}\ m\ v^2$. Solving for v, we obtain:

$$v = \sqrt{\frac{2k}{m}} = \sqrt{\frac{(2)(5.3\ Mev)\left(1.60 \times \frac{10^{-13} J}{Mev}\right)}{1.67 \times 10^{-27}\ kg}}$$

$v = 3.2 \times 10^7$ m/s

Example:

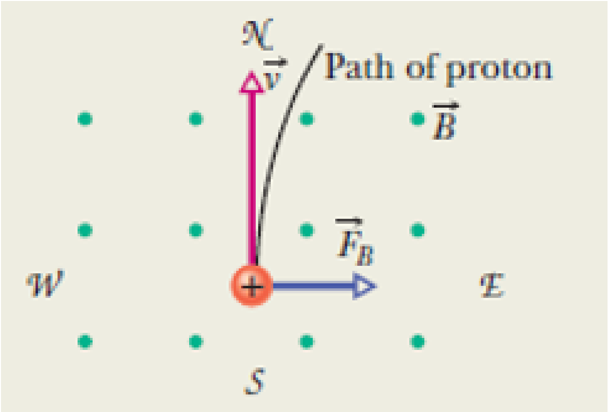
$$F_B = |q|v\,B\,sin\emptyset$$

$$F_B = (1.60 \times 10^{-19}\ \text{C})(3.2 \times 10^{7}\ \text{m/s}) \times (1.2 \times 10^{-3}\ \text{T})(\sin 90°)$$

$$F_B = 6.1 \times 10^{-15}\ \text{N}$$

This may seem like a small force, but it acts on a particle of small mass, producing a large acceleration. **a = ? H.W**

Direction: To find the direction of $\overrightarrow{F_B}$, we use the fact that $\overrightarrow{F_B}$ has the direction of the cross product $\vec{v} \times \vec{B}$ Because the charge q is positive.



An overhead view of a proton moving from south to north with velocity in a chamber. The array of dots in the figure represents a magnetic field directed out of the plane of the figure.


Thank you