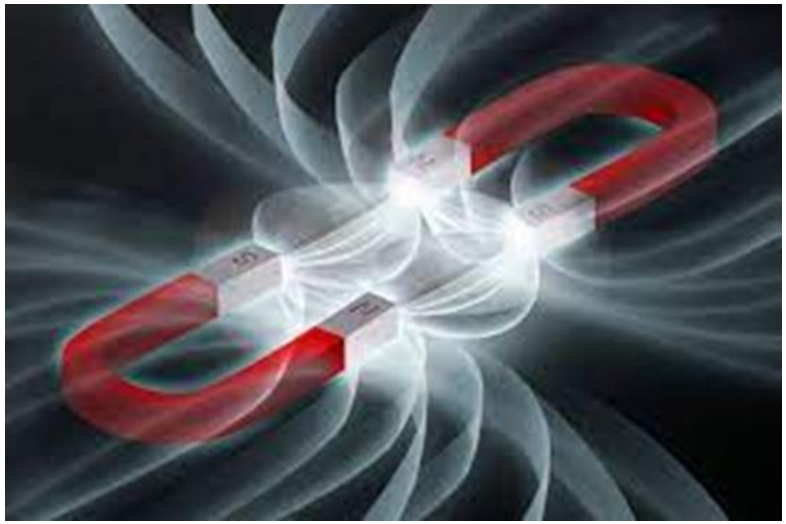
Tishk International University
Faculty of Applied Science

Medical Technical Radiology
General Physics



Magnetism

First Grade- 2024-2025

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Learning outcomes

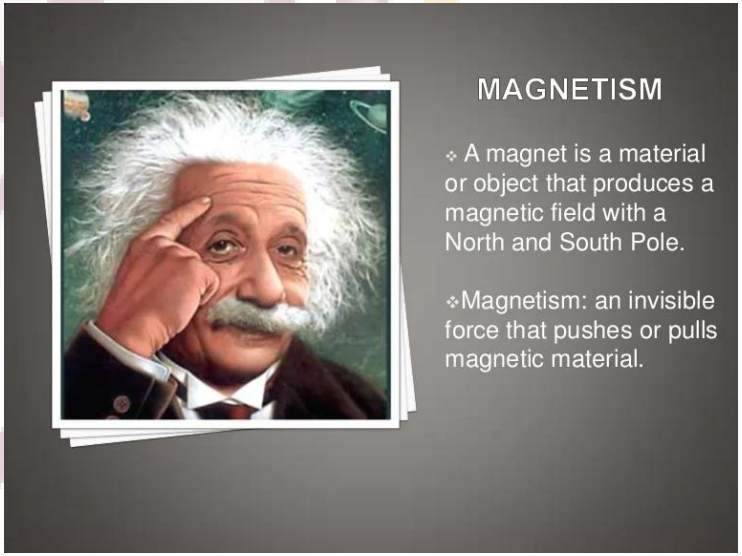
At the end of the session, you should be able to:-

5. Magnetism

5.1 Magnetic Fields

5.2 Sources of the Magnetic Field

5.3 Faraday's Law

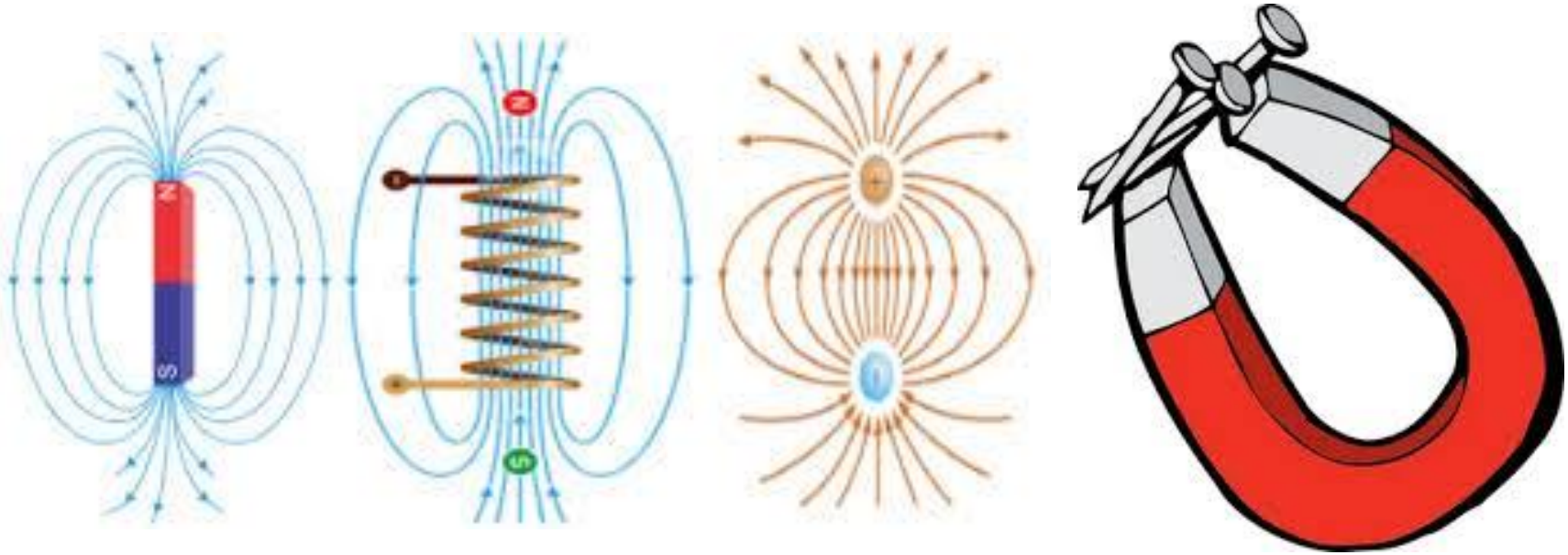


Magnetism

- **Magnetism** is a fundamental property of matter, generated by moving charges, usually electrons. Magnetic properties of materials result from the organization and motion of the electrons in either a random or a nonrandom alignment of magnetic “domains,” which are the smallest units of magnetism

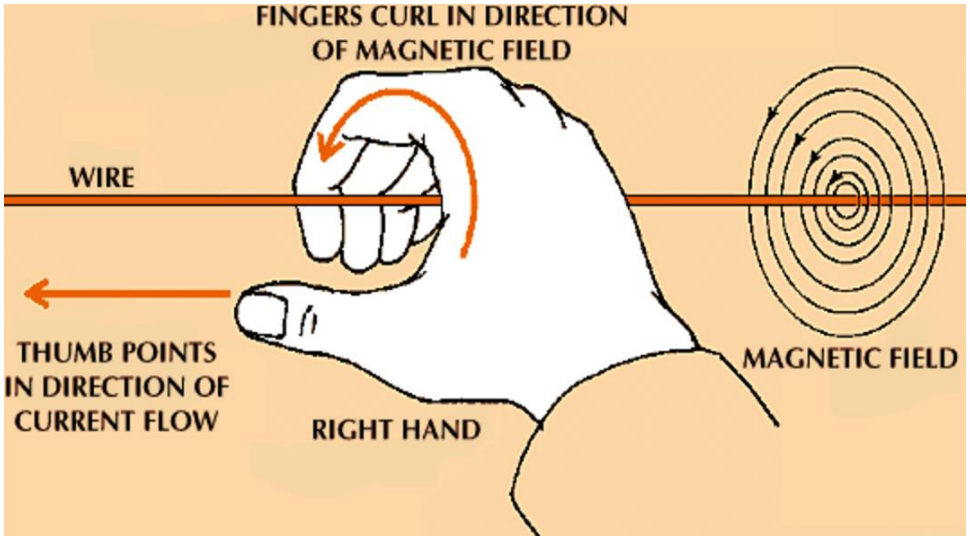
Properties of magnetism?

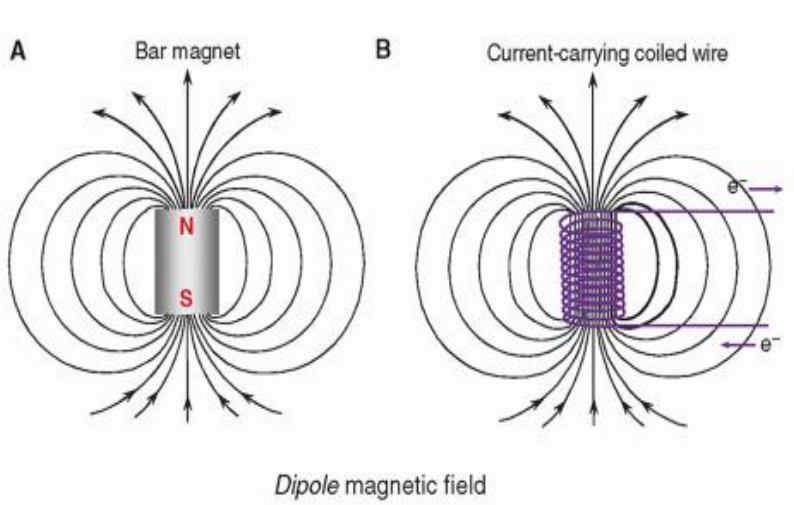
- Force of attraction or repulsion due to electron arrangement
- Magnetic forces are the strongest at the poles
- Magnets have two poles: North and South
- When free to rotate, come to rest pointing in a north-south direction
- Like magnetic poles repel Unlike magnetic poles attract.



Magnetic Fields

Magnetic fields can be induced by a moving charge in a wire The direction of the magnetic field depends on the sign and the direction of the charge in the wire, as described by the “right-hand rule” The fingers point in the direction of the magnetic field when the thumb points in the direction of a moving positive charge (i.e., opposite to the direction of electron movement).





Dipole magnetic field

The Main sources to produce a magnetic field are:

Type	Properties	Uses
Permanent Magnets	Retain magnetism without power. Durable and stable.	Motors, electronics, industrial tools.
Temporary Magnets	Magnetic only with an external field. Easy to magnetize.	Electromagnets, transformers, relays.
Electromagnets	Magnetic field from electric current. Controllable strength.	Motors, generators, magnetic lifts, MRI.
Superconducting Magnets	Extremely strong. Require cooling to work.	MRI, particle accelerators, scientific research.

Magnets

The magnet is the heart of the MR system. For any magnet type, performance criteria include field strength, temporal stability, and field homogeneity.

Magnetic Fields

Magnetic field: $B = \dfrac{F_B}{|q|v}$

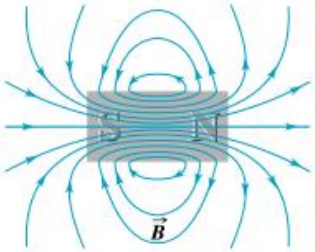
SI unit of magnetic field: tesla (T)

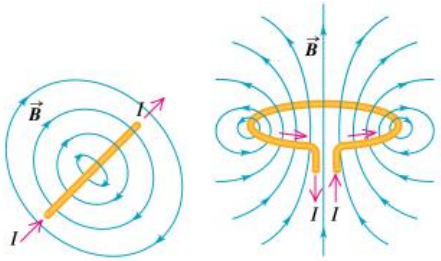
- 1T = 1 N/[Cm/s] = 1 N/[Am] = 10^4 gauss

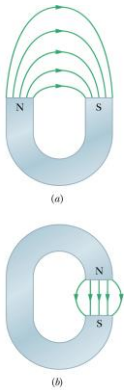
Magnetic field lines with similar rules:

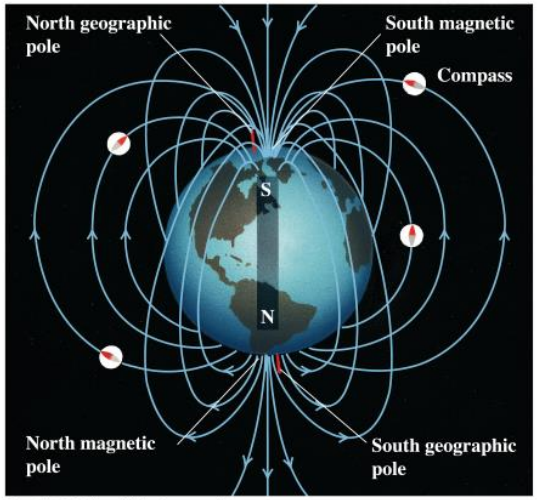
- The direction of the tangent to a magnetic field line at any point gives the direction of **B** at that point;
- The spacing of the lines represents the magnitude of **B** – the magnetic field is stronger where the lines are closer together, and conversely.

At surface of neutron star	10^8 T
Near big electromagnet	1.5 T
Inside sunspot	10^{-1} T
Near small bar magnet	10^{-2} T
At Earth's surface	10^{-4} T
In interstellar space	10^{-10} T





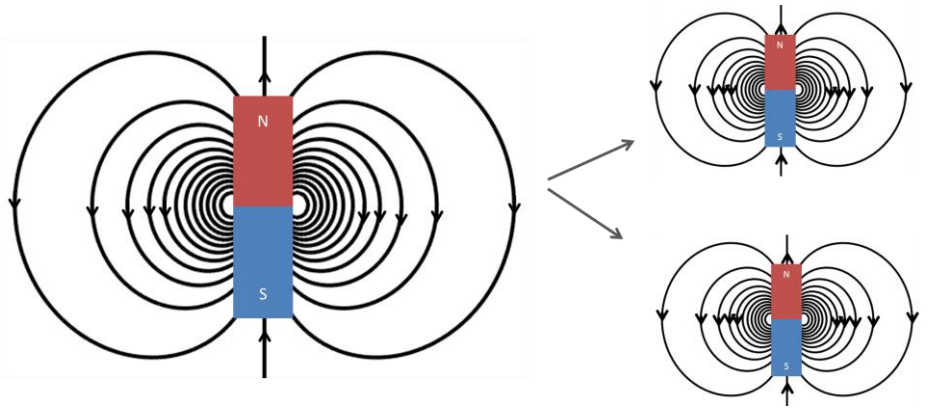




Magnetic field

Gauss's Law for Magnetic Fields

Gauss's law for magnetism states that no magnetic monopoles exist and that the total flux through a closed surface must be zero.



$$\text{Net flux} = \int \mathbf{B} \cdot d\mathbf{A} = 0$$

Laws of Magnetism

The laws of magnetism include the following:

- **Repulsion–Attraction:** Like poles repel, unlike poles attract.
- **Magnetic poles:** Every magnet has a north pole and a south pole.
- **Inverse square law:** The magnetic force between two magnetic fields is directly proportional to the product of their magnitudes and inversely proportional to the square of the distance between them.

Units of Magnetism

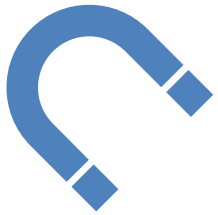
The SI units of magnetism are the **gauss (G)** and the **tesla (T)**.

One tesla is equal to 10,000 gauss.

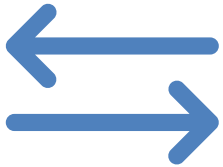
The **Earth's magnetic** field is about 0.5 G or 5×10^{-5} T.

A **refrigerator magnet** is about 10 G or 0.001 T.

MRI units typically have magnetic fields of 0.1 to 3 T.

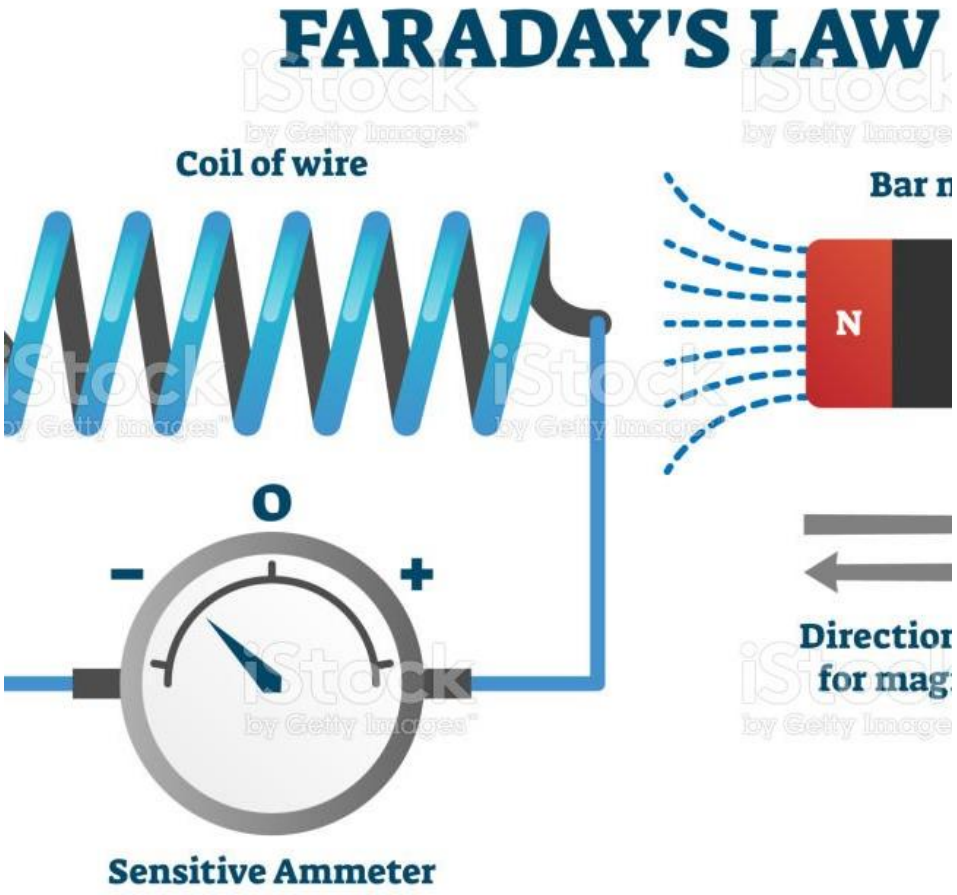


Magnetic polarity Magnetic poles lie at the end of the coil and the polarity of each pole depends upon:



1. Direction of current flow: reversal of current reverses the direction of the mag. lines of forces

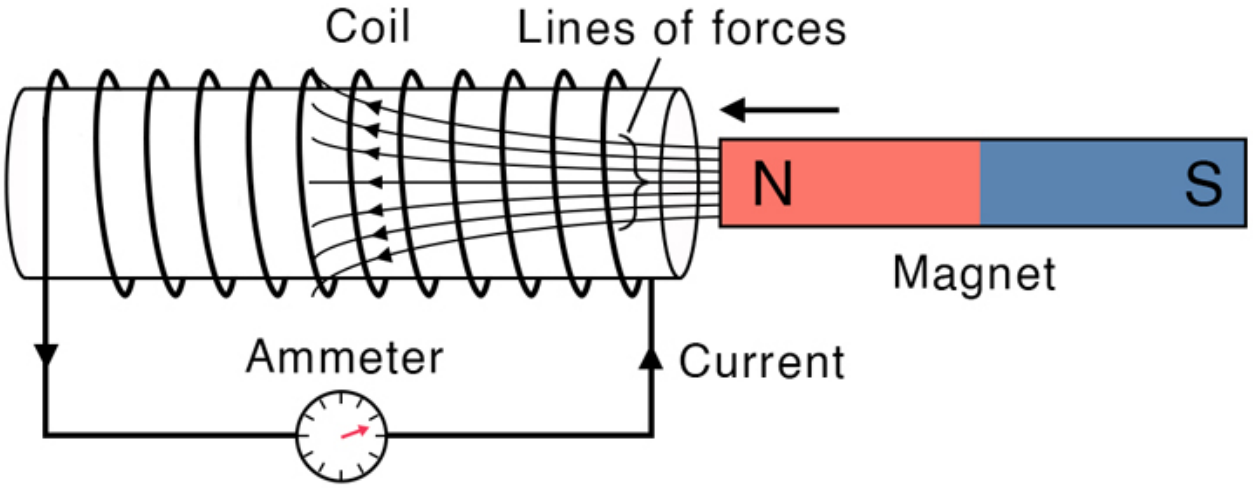
2. Direction in which coil wound Many rules for determining magnetic polarity assume the current flow to be from positive to negative



Faraday's Law

- **Faraday's Law**
- The magnitude of the induced current depends on **four factors**:
- 1. The strength of the magnetic field
- 2. The velocity of the magnetic field as it moves past the conductor
- 3. The angle of the conductor to the magnetic field
- 4. The number of turns in the conductor

Faraday's Law Equation



$$\varepsilon = -N\frac{d\phi}{dt}$$

ε : Electromotive force (EMF)

N : Number of turns of the coil

$\frac{d\phi}{dt}$: Instaneous change of magnetic flux with time

Thank You