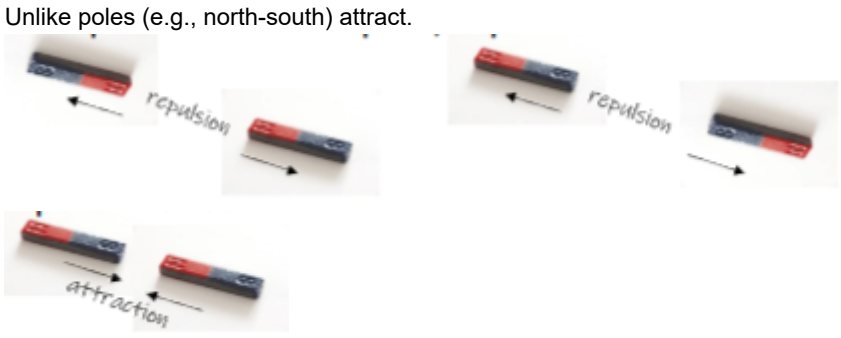
# Chapter 28 Magnetic Fields

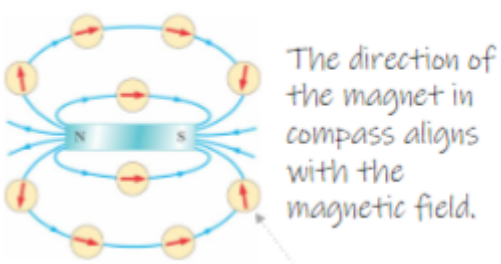
## Introduction to Magnetic Poles

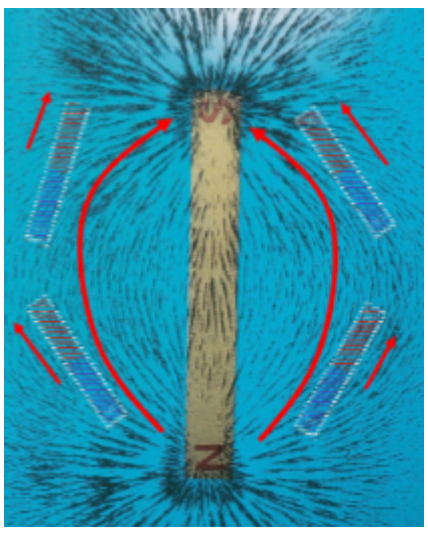
- **Magnetic poles**: Every magnet has a north and a south pole.
- **Interactions**:
  - Like poles (e.g., north-north or south-south) repel.
  - Unlike poles (e.g., north-south) attract.




## Magnetic Field Concepts

- **Magnetic field (B)**: A vector quantity whose direction is defined from the north to the south pole outside a magnet.
- **Magnetic field lines**:
  - Show the direction of the field.
  - Can be traced using a compass.



## Magnetic Force on a Moving Charge

- **Force $F_B$ on a charge in a magnetic field**:
  - A charge $q$ moving with velocity $v$ in a magnetic field $B$ experiences a force:

$$F_B = q \cdot (v \times B)$$

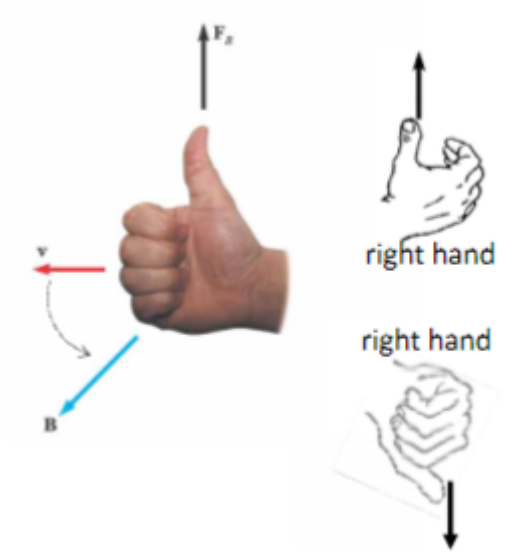
  - Magnitude of the force:

$$F_B = q \cdot v \cdot B \cdot \sin\theta$$

  - The force is maximum when $\theta = 90^\circ$ and zero when $\theta = 0^\circ$ or $180^\circ$.

## Right-Hand Rule for Magnetic Force

- **Procedure**:
  - Point fingers in the direction of $v$.
  - Curl fingers towards $B$.
  - The thumb points in the direction of $F_B$ for a positive charge.



### Tesla ($T$)

From magnetic force $F_B$ on a charge $q$ moving with velocity $v$ in a magnetic field $B$
SI Unit for Magnetic Field : Gauss ($G$)

- $1\,Tesla = 10^4\,Gauss$

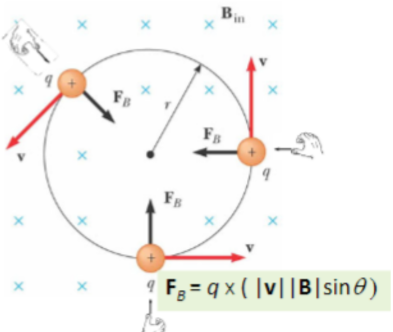
# Effects of Magnetic Force

- **Charged particle motion**:
  - If $v$ is perpendicular to $B$, the particle moves in a circular path.
  - The radius $r$ of the path is given by:

$$r = \frac{mv}{qB}$$

  - The angular speed $\omega$:

$$\omega = \frac{qB}{m}$$




# Comparison with Electric Fields

- **Differences**:
  - The electric field acts on a charge regardless of its motion.
  - The magnetic force only acts when the charge is moving and is perpendicular to both $v$ and $B$.

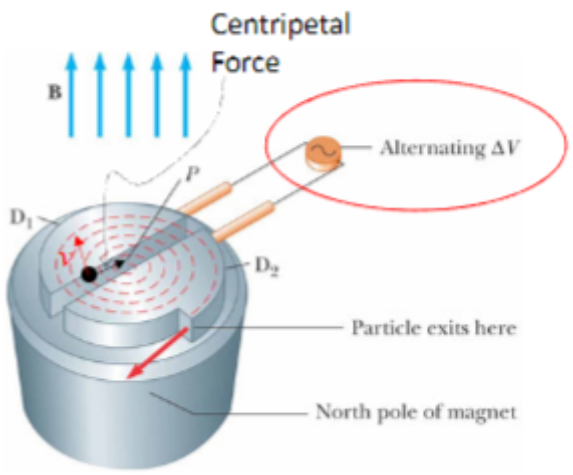
# Cyclotron Principles

- **Cyclotron**: A device used to accelerate charged particles using a magnetic field.
- **Exit speed**:

$$v = \frac{qBR}{m}$$

- **Kinetic energy**:

$$KE = \frac{1}{2}mv^2 = \frac{q^2B^2R^2}{2m}$$

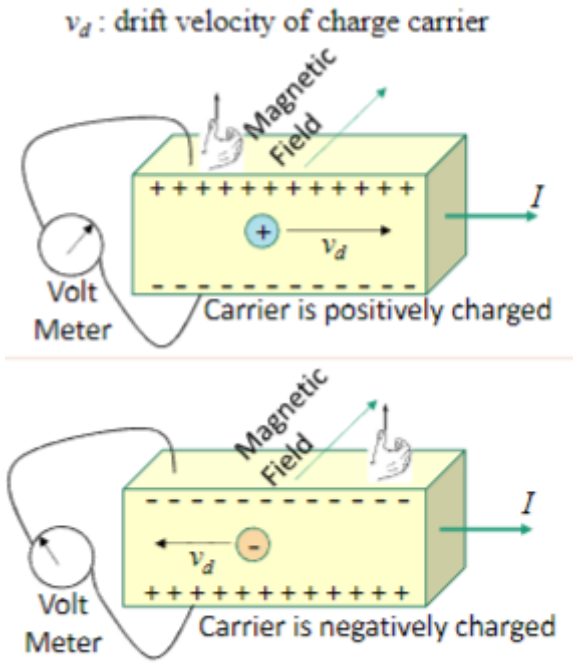



# Hall Effect

- **Phenomenon**:
  - When a current-carrying conductor is placed in a magnetic field, a voltage is generated perpendicular to the current and field direction.
- **Equation**:

$$E_H = v_d \cdot B$$

$$V_H = E_H \cdot d$$




# Applications of Magnetic Fields

- **Mass spectrometer**:
  - Separates ions by their mass-to-charge ratio.
  - Equation for the radius of the path:

$$r = \frac{mv}{qB}$$

$$r = \left(\frac{m}{q}\right)\frac{v}{B}$$