

## Permeability of free space

$\mu_0$  = permeability of free space

Units: Tm/A

$$\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$$

## Magnetic Field Produced by Moving Charges

$$\vec{B}_{\text{point charge}} = \left(\frac{\mu_0}{4\pi}\right) \left(\frac{q}{r^2}\right) (\vec{v} \times \hat{r})$$

## Magnetic Field Produced by Straight Currents

$$|\vec{B}_{\text{current}}| = \frac{\mu_0 I}{2\pi r}$$

Direction: Point right thumb in direction of current flow, curl fingers around wire. Direction fingers curl represent direction of magnetic field around wire

## Magnetic Force Between Parallel Currents

$$|\vec{F}_{\text{mutual}}| = \frac{\mu_0 I_1 I_2 L}{2\pi r}$$

$$\vec{F}_1 = I_1 (\vec{L}_1 \times \vec{B}_2)$$

Direction:

- Same Current Direction: Attracts
- Opposite Current Direction: Repels

## Mutual Magnetic Force on Parallel Charges

$$|\vec{F}_{\text{mutual}}| = \frac{\mu_0 q_1 q_2 v_1 v_2}{4\pi r^2}$$

Direction:

- Same Direction, Same Charge: Attract
- Opposite Direction, Opposite Charge: Attract
- Anything Else: Repel

## Magnetic Field Produced by Curved Current Loops

### Single or Multiple Loops

$$B_{\text{center of loop}} = \frac{\mu_0 I}{2R} N$$

Direction:

- Current curves: Fingers
- B is straight: Thumb

### Solenoid (very long loop)

$$B = \frac{\mu_0 I}{L} N = \mu_0 I n$$

$$\text{let } n = \frac{N}{L}$$

$$\text{Total Length of Wire} = (2\pi R) N$$

## Magnetic Field by Toroidal Solenoids

$$B = \frac{\mu_0 I}{2\pi r} N$$

$r$ : distance from center

Direction: Same as Loops

$\vec{B}$  exists between  $R_{\text{inner}}$  and  $R_{\text{outer}}$ , zero outside

## Biot-Savart Law

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{l} \times \hat{r}}{r^2}$$