Permeability of free space

μ_0 = permeability of free space

Units: Tm/A

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

Magnetic Field Produced by Moving Charges

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

Magnetic Field Produced by Straight Currents

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

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

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

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

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

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

Direction:

- Current curves: Fingers
- B is straight: Thumb

Solenoid (very long loop)

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

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

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

Magnetic Field by Toroidal Solenoids

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

r: distance from center

Direction: Same as Loops

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

Biot-Savart Law

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

Magnetic Field by Finite Straight Line of Current

$$\mathrm{B} = \frac{\mu_0 I}{4\pi x} \frac{2a}{\sqrt{x^2 + a^2}}$$