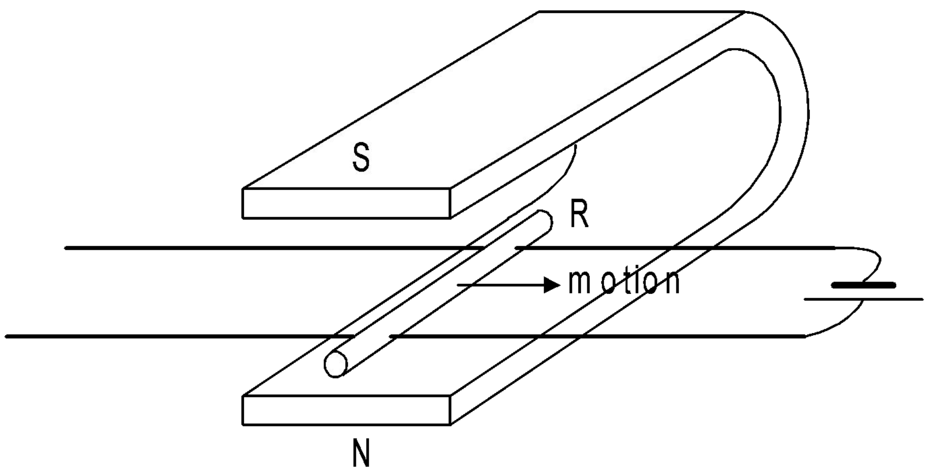
Forces in Magnetic Field

- Force on Current in Magnetic Field
- Forces between Currents
- Force on Moving Charges in Magnetic Field
- Magnetic Flux. Gauss's Theorem
- Work Done on Displacement of a Wire with Current in Magnetic Field
- Laws of Magnetic Circuits

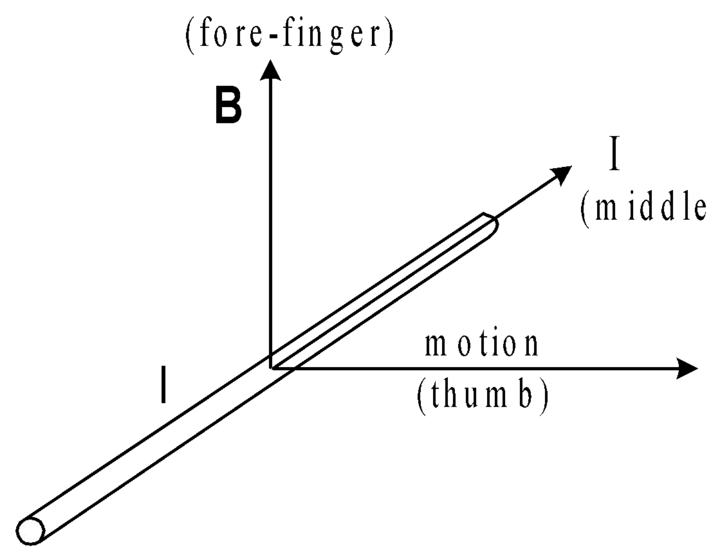
Force on Current in Magnetic Field



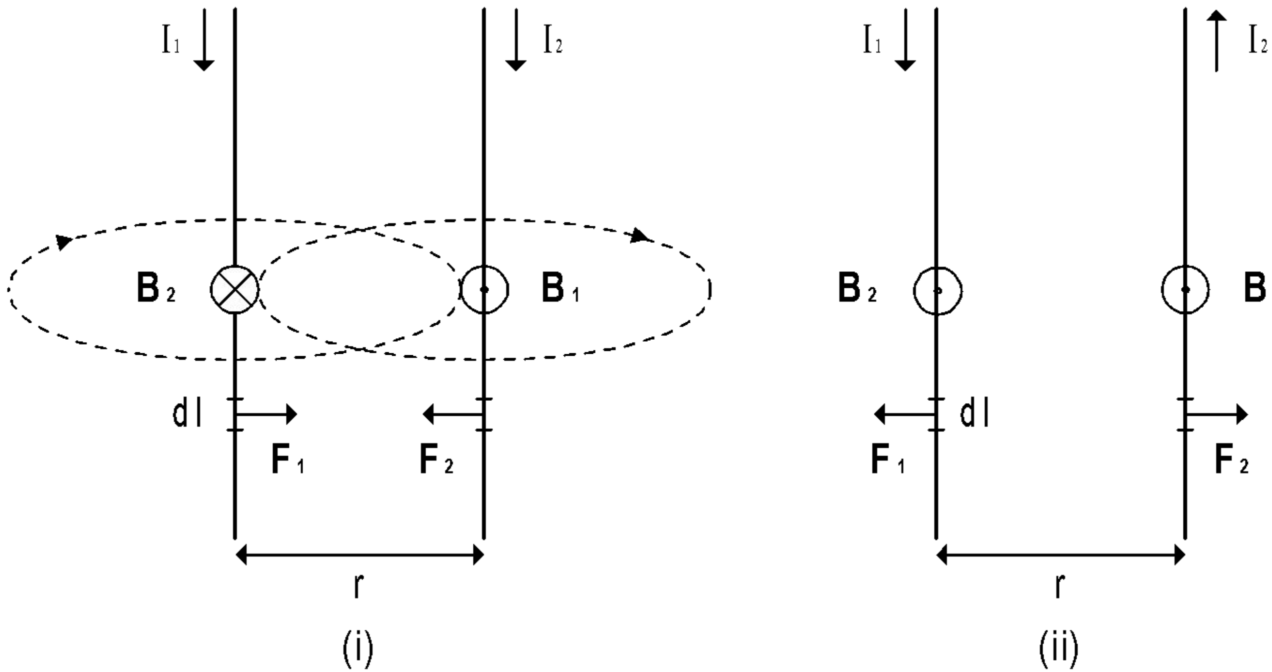
$$\mathbf{F} = I[\mathbf{l} \times \mathbf{B}]$$

$$F = IBl \sin\alpha$$

Left-hand rule:



Forces between Currents

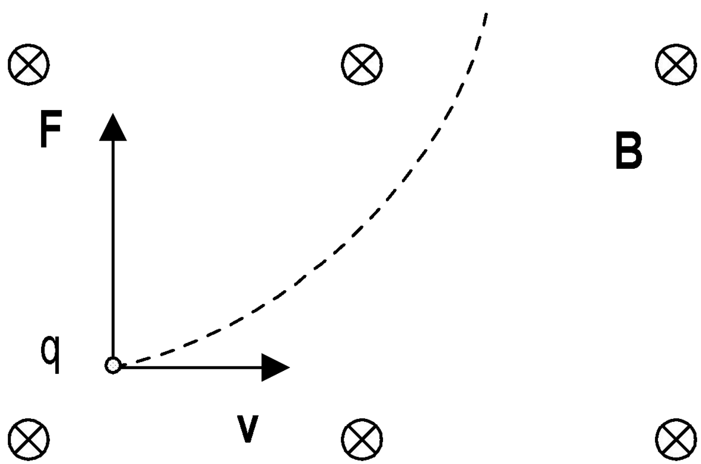


$$F_1 = I_1 B_2 dl \sin\frac{\pi}{2} = \frac{\mu_0 \mu I_1 I_2 dl}{2\pi r} \qquad F_2 = I_2 B_1 dl \sin\frac{\pi}{2} = \frac{\mu_0 \mu I_2 I_1 dl}{2\pi r}$$

Force on Moving Charges in Magnetic Field

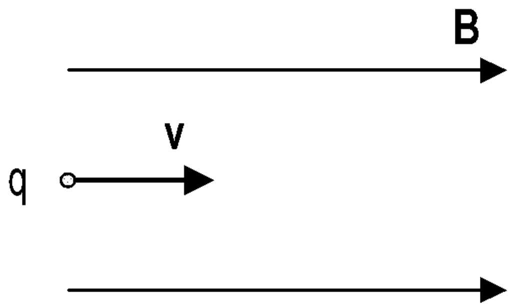
$$F = qvB\sin\alpha \qquad \mathbf{F} = q[\mathbf{vB}]$$

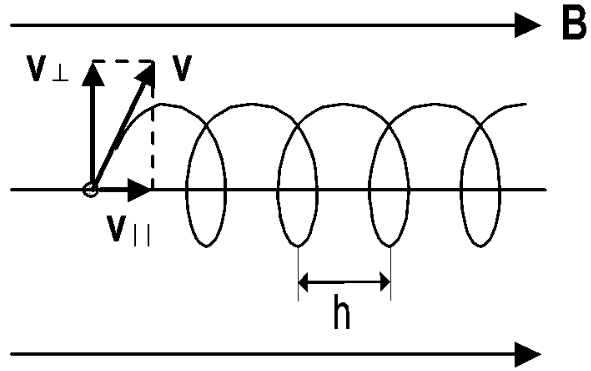
1. Charge moves at a right angle to a magnetic field



$$qvB = m\frac{v^2}{R}$$

Force on Moving Charges in Magnetic Field (cont.)





Force = 0

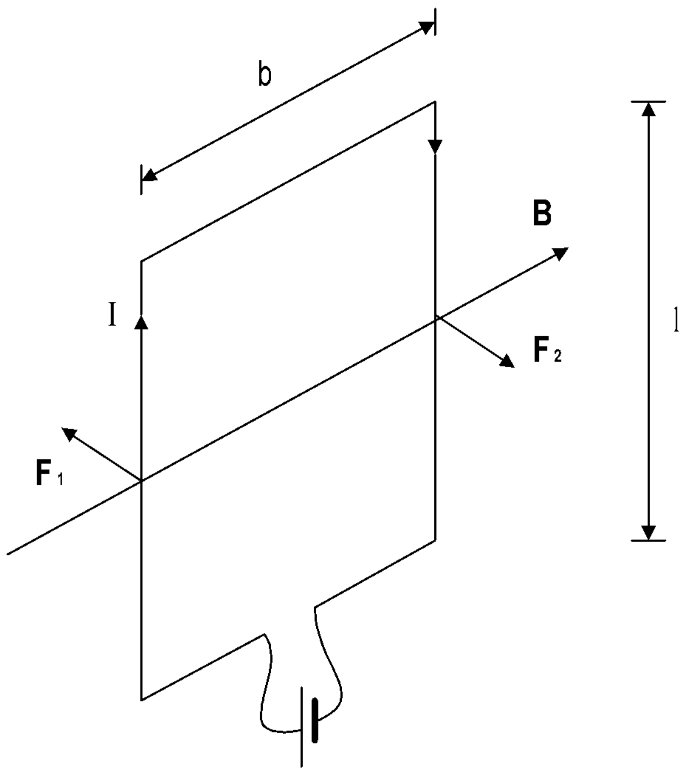
(ii)

(iii)

$$qv_{\perp}B = m\frac{v_{\perp}^{2}}{R}$$

$$h = v_{\parallel}T$$

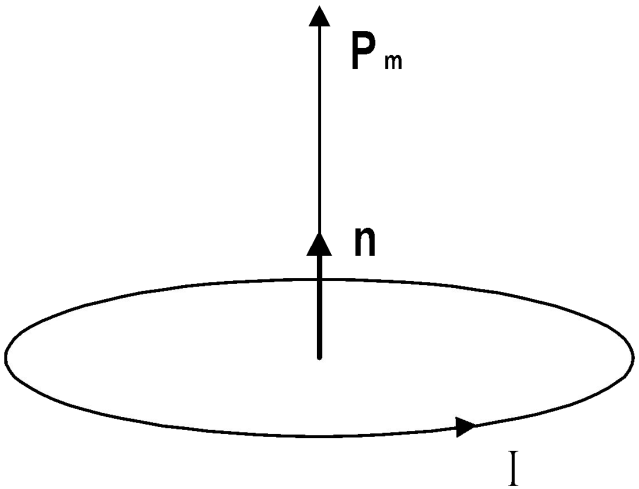
Torque on a Coil in a Uniform Magnetic Field



$$F_1 = F_2 = BIl$$

$$M = Fb = BIlb = BIS$$

Magnetic Moment



$$\mathbf{M} = [\mathbf{p}_m \mathbf{B}]$$

$$\mathbf{p}_m = IS\mathbf{n}$$

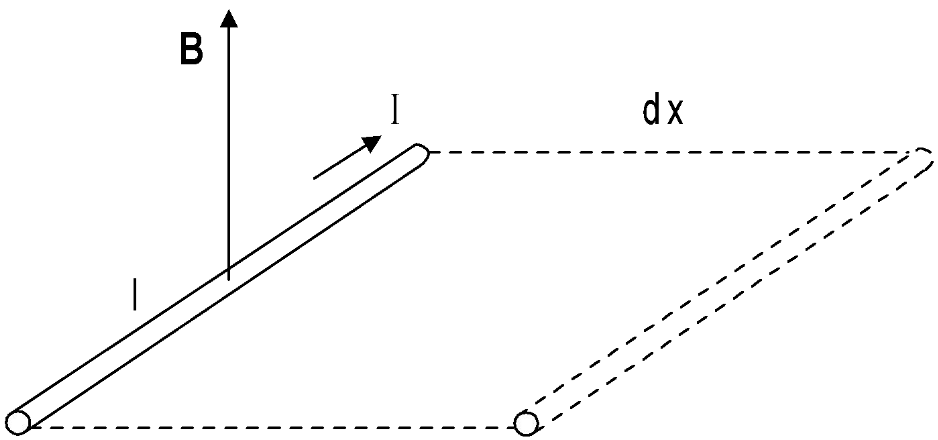
Magnetic Flux. Gauss's Theorem

$$\Phi = \int B dS \cos\alpha \qquad \Phi = \int \mathbf{B}\, d\mathbf{S}$$

$$\oint \mathbf{B}\, d\mathbf{S} = 0$$

The magnetic flux through any closed surface is zero.

Work Done on Displacement of a Wire with Current in Magnetic Field

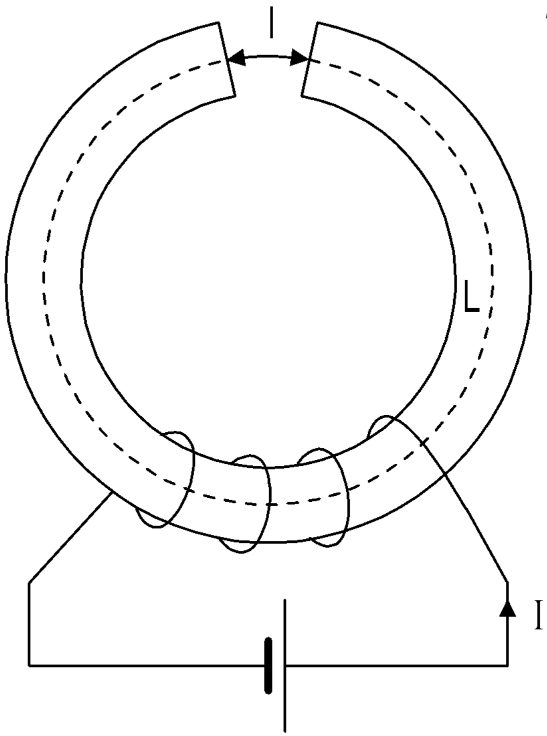


$$dW = F \cdot dx = IBldx \sin\alpha$$

$$dW = IBdS = Id\Phi$$

Work done by Ampere's force on moving a wire with current in a magnetic field, is equal to the product of the current and the increase of the magnetic flux due to the displacement of the wire.

Laws of Magnetic Circuits



$$B_g = \mu_0 H_g \qquad\qquad B_m = \mu_0 \mu H_m$$

Ampere's theorem: $H_g l + H_m L = NI$

$$\frac{B_g l}{\mu_0} + \frac{B_m L}{\mu_0 \mu} = NI$$

As Φ = const and S = const, $B_g = B_m$

$$\therefore B_g \left(\frac{l}{\mu_0} + \frac{L}{\mu_0 \mu} \right) = NI$$

Laws of Magnetic Circuits (cont.)

$$\therefore \Phi = B_g S = \frac{NI}{\left(\dfrac{l}{\mu_0 S} + \dfrac{L}{\mu_0 \mu S}\right)}$$

NI is called usually the *magnetomotive force*, MMF.

$$\left(\frac{l}{\mu_0 S} + \frac{L}{\mu_0 \mu S}\right)$$

- is called the *reluctance* of the magnetic circuit.