Review

Chapter 4: Magnetism

Magnetic force acting on a moving charged particle

$F = qE$

charge

$$\boxed{\vec{F}_B = q\vec{v} \times \vec{B}}$$

$$\boxed{F_B = |q| vB\sin\phi}$$

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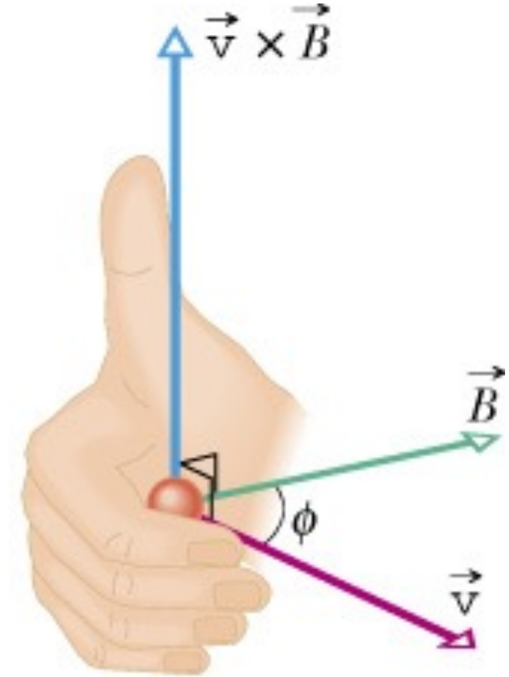
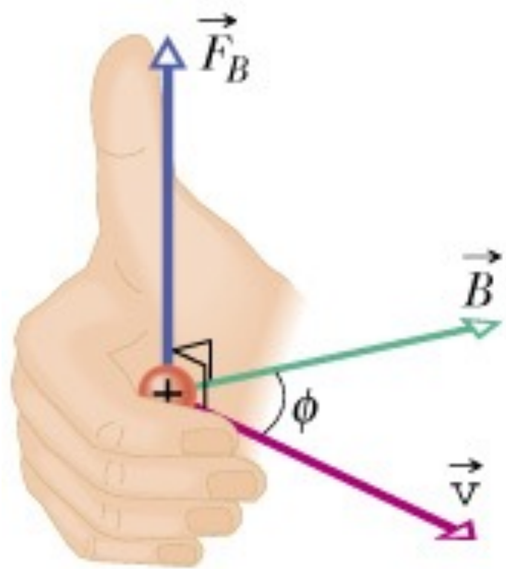


(a)



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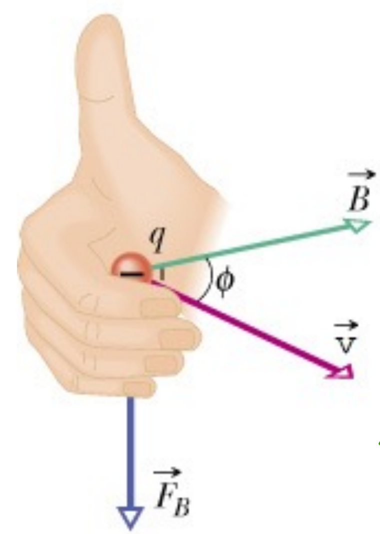
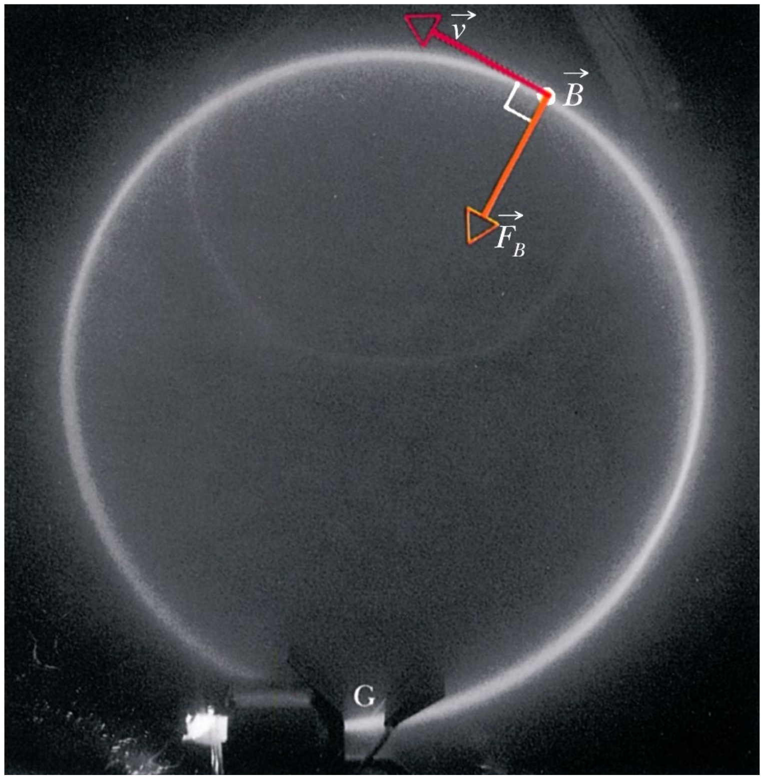


(c)

$F = qvB\sin\theta$

- If $q > 0$ (figure b): the force is directed along the thumb
- If $q < 0$ (figure c): the force is directed opposite the thumb

Motion of a Charged Particle in a Magnetic Field



$$\boxed{F_B = qvB = m\frac{v^2}{r}}$$

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

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

$$\boxed{T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}}$$

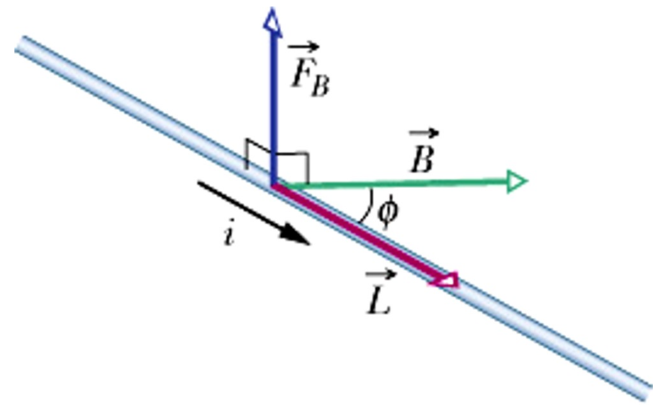
$$f = \frac{1}{T}$$

$$\omega = 2\pi f = \frac{qB}{m}$$

Magnetic Force on a Current-Carrying Wire

$$\boxed{\vec{F}_B = i\vec{L} \times \vec{B}}$$

$$\boxed{F_B = iLB\sin\phi}$$



Torque on a Current-Carying Coil

Mag dipole

$$\boxed{\mu = NiA}$$

$$\boxed{\vec{\tau} = \vec{\mu} \times \vec{B}}$$

torque

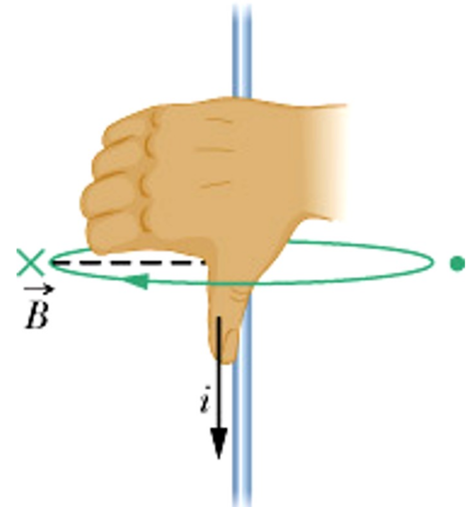
$$\tau = \mu B \sin\theta$$

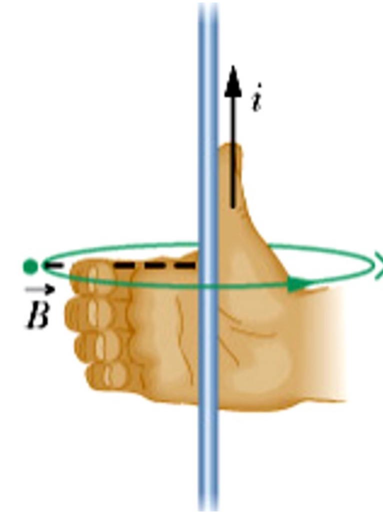
Potential energy of a magnetic dipole

$$U(\theta) = -\vec{\mu}\vec{B} = -\mu B\cos\theta$$

Magnetic Field Due to a Current in a Long Straight Wire

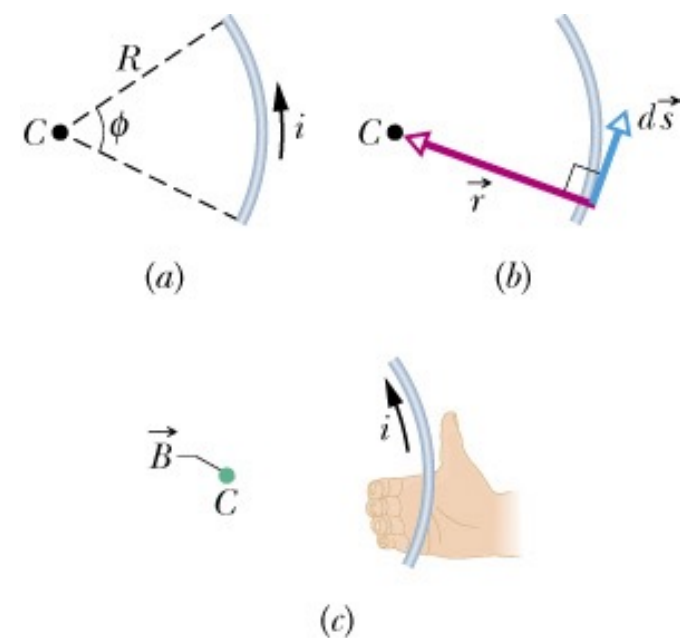
$$\boxed{B = \frac{\mu_0 i}{2\pi R}}$$





Magnetic Field Due to a Current in a Circular Arc of Wire

$$\boxed{B = \frac{\mu_0 i \phi}{4\pi R}}$$

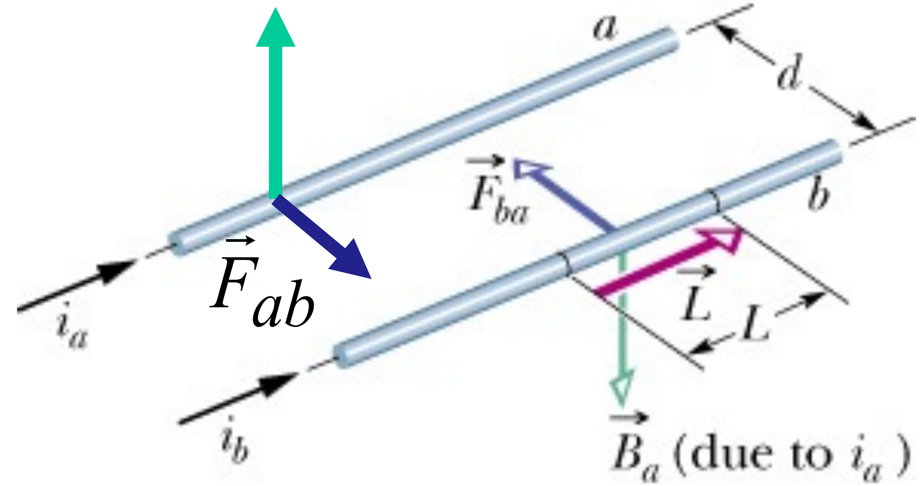


- For a full circle, the field at the center:

$$\boxed{B = \frac{\mu_0 i 2\pi}{4\pi R} = \frac{\mu_0 i}{2R}}$$

Force Between Two Parallel Currents

$$\boxed{F_{ba} = i_b L B_a \sin 90^0 = \frac{\mu_0 L i_a i_b}{2\pi d}}$$



If the two currents are antiparallel, the forces push the currents apart

$\boxed{\tau = \mu B \sin\theta}$

Work done

magnetic field

$W = -\Delta U = -(U_f - U_i)$

applied Force

$W_a = -W = U_f - U_i$

$U = -\mu B \cos\theta$

Chapter 5: Electromagnetic Induction

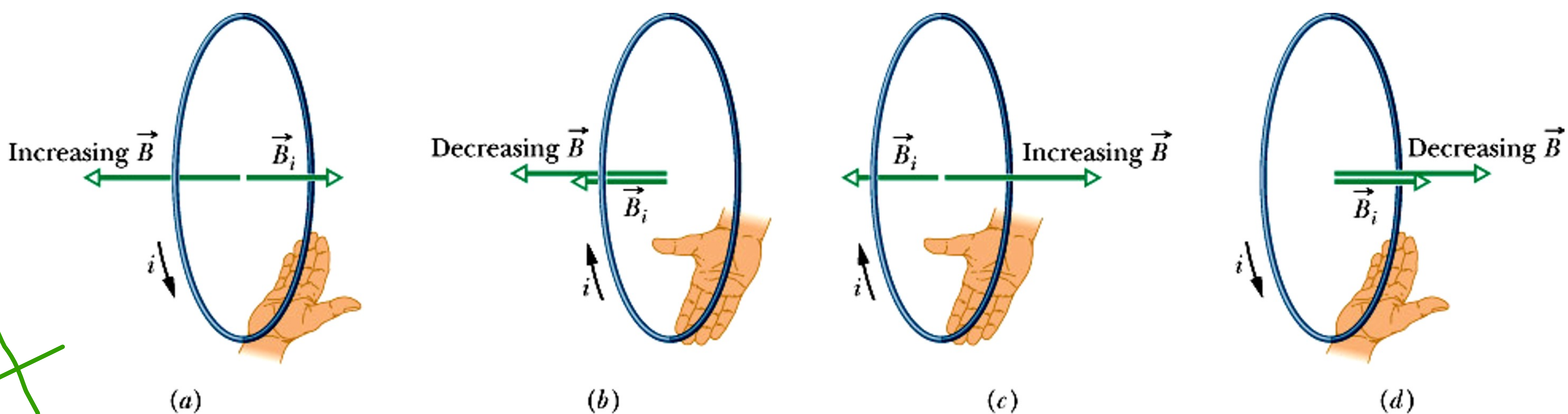
$$\varepsilon = -\frac{d\Phi_B}{dt} \text{ (Faraday's law)}$$

$\Phi = BA\cos\theta$

- If a coil has N turns (closely packed):

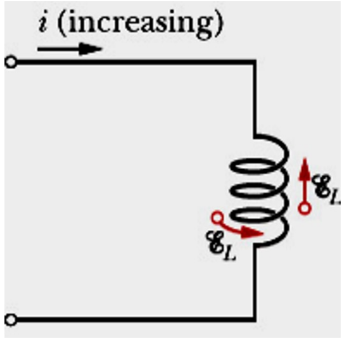
$$\varepsilon = -N\frac{d\Phi_B}{dt} \text{ (coil of N turns)}$$

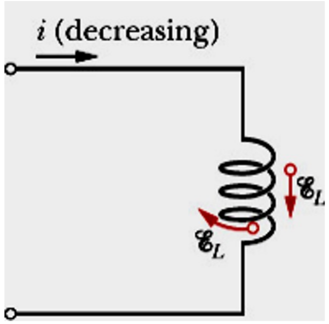
Lenz's Law (the direction of induced current)



Self-Induction

$$\boxed{\varepsilon_L = -L\frac{di}{dt}\ \text{(self - induced emf)}}$$





RL Circuits

$$\boxed{\tau_L = \frac{L}{R}\ \text{(inductive time constant)}}$$

$$\boxed{i = \frac{\varepsilon}{R}\left(1 - e^{-t/\tau_L}\right)\ \text{(rise of current)}}$$

$$\boxed{i = \frac{\varepsilon}{R}e^{-t/\tau_L} = i_0 e^{-t/\tau_L}\ \text{(decay of current)}}$$

Energy Stored in a Magnetic Field

$$\boxed{U_B = \frac{1}{2} L i^2 \text{ (magnetic energy)}}$$

$$\boxed{u_B = \frac{B^2}{2\mu_0} \text{ (magnetic energy density)}}$$

LC Oscillations

$$\begin{cases} q = Q\cos(\omega t + \phi) \text{ (charge)} \\ I = \omega Q \Rightarrow i = -I\sin(\omega t + \phi) \end{cases}$$

The energy stored in the electric field of the capacitor at any time is

$$U_E = \frac{q^2}{2C}$$

The energy stored in the magnetic field of the inductor at any time

$$U_B = \frac{Li^2}{2}$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$V_{max} = \frac{Q}{C_{max}}$$

Alternating Current

$$\boxed{\varepsilon = \varepsilon_m \sin \omega_d t}$$

$$\boxed{i = I \sin(\omega_d t - \phi)}$$

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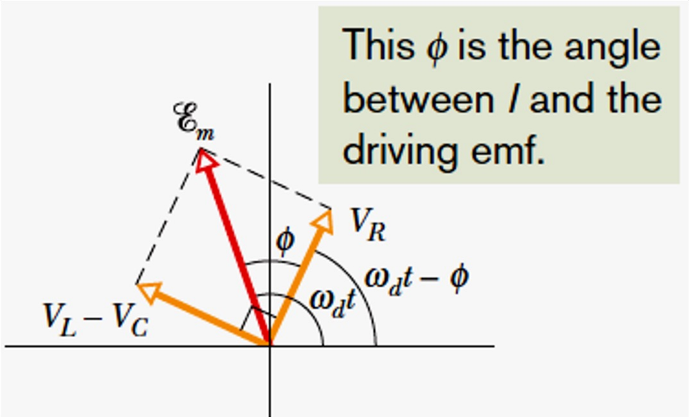
$$\boxed{Z = \sqrt{R^2 + (X_L - X_C)^2} \text{ (impedance defined)}}$$



$$\frac{U}{R} = \boxed{I = \frac{\varepsilon_m}{\sqrt{R^2 + (\omega_d L - 1/\omega_d C)^2}} \text{ (current amplitude)}}$$

$$\boxed{\Rightarrow \tan\phi = \frac{X_L - X_C}{R} \text{ (phase constant)}}$$