JOINT INSTITUTE
交大密西根学院

Midterm 2 Review

Teaching Assistant
Xie Jinglei

1

DC circuits

DC circuits

Kirchhoff's Rules

Kirchhoff's junction rule (valid at any junction): The sum of the currents into any junction ...

$$\sum I = 0$$

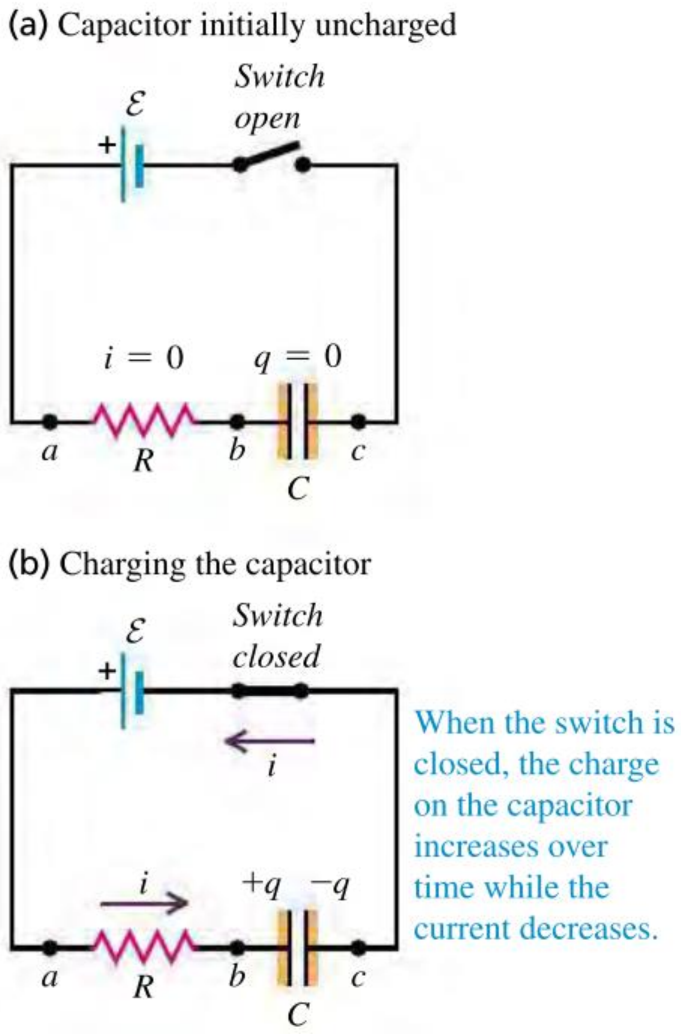
... equals zero.

Kirchhoff's loop rule (valid for any closed loop): The sum of the potential differences around any loop ...

$$\sum V = 0$$

... equals zero.

RC circuits



R-C circuit, charging capacitor:

Current; Battery emf; Time since switch closed

$$i = \frac{dq}{dt} = \frac{\mathcal{E}}{R} e^{-t/RC} = I_0 e^{-t/RC}$$

Initial current $= \mathcal{E}/R$

Rate of change of capacitor charge; Resistance; Capacitance

R-C circuit, discharging capacitor:

Current; Initial capacitor charge; Capacitance

$$i = \frac{dq}{dt} = -\frac{Q_0}{RC} e^{-t/RC} = I_0 e^{-t/RC}$$

Time since switch closed

Rate of change of capacitor charge; Resistance; Initial current $= -Q_0/RC$

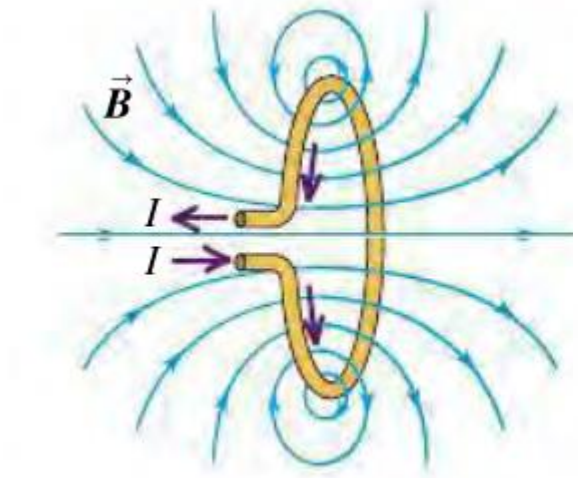
Energy:
50% -> resistor
50% ->capacitor
Refer to lecture notes

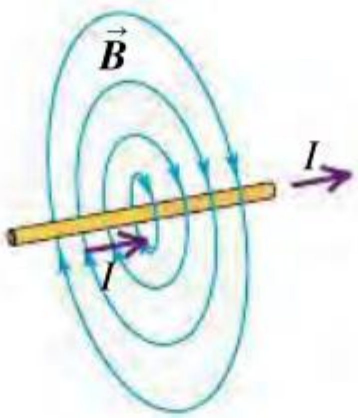
2

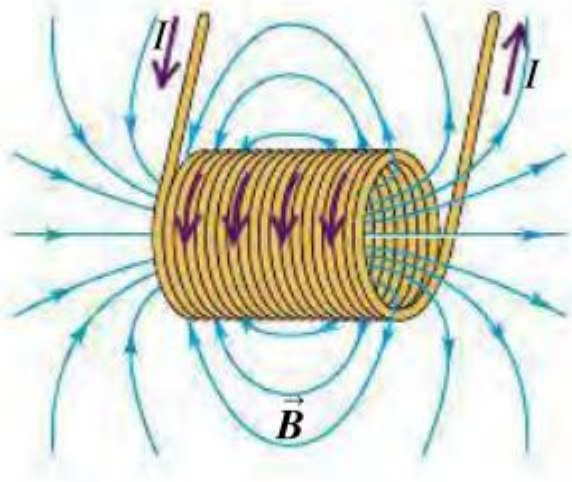
Magnetic field and magnetic forces

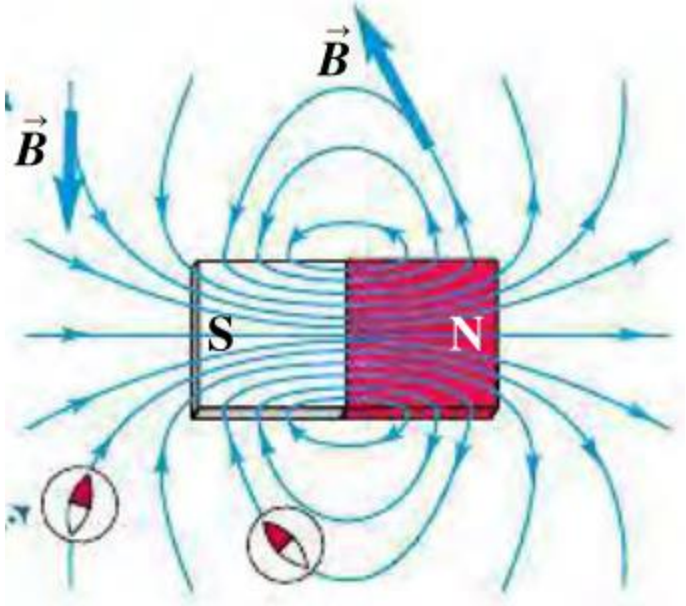
Magnetic field and magnetic forces

- Important models









Magnetic field and magnetic forces

Magnetic force on a moving charged particle $\vec{F} = q\vec{v} \times \vec{B}$

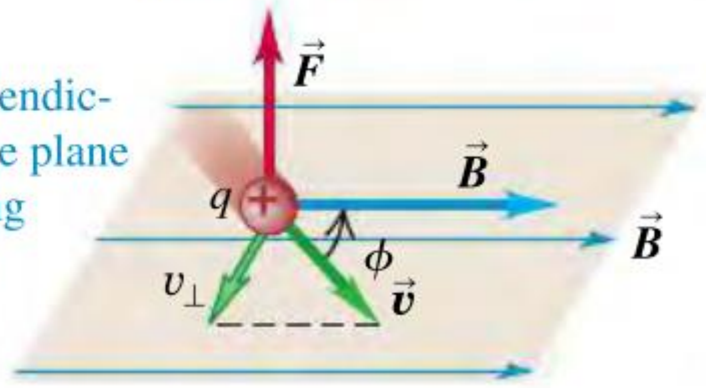
Particle's charge

Particle's velocity

Magnetic field

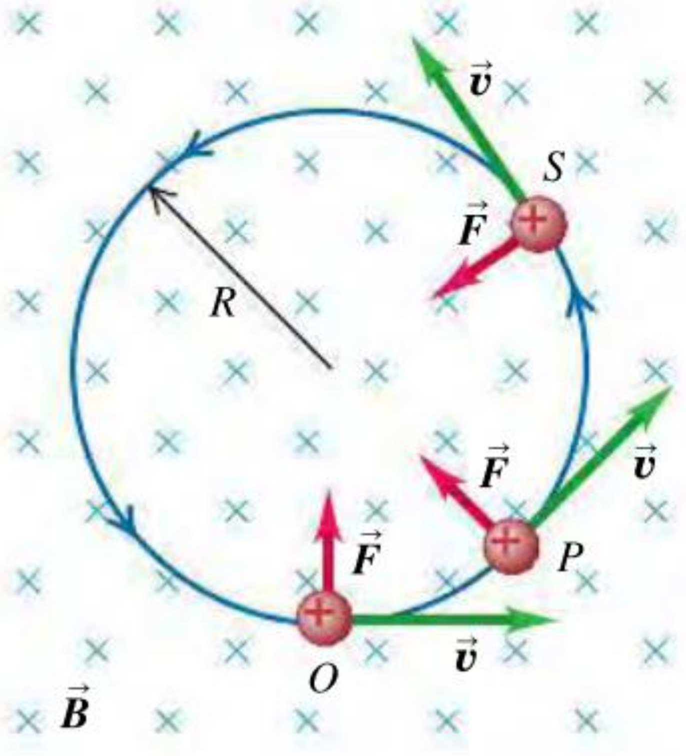
A charge moving at an angle ϕ to a magnetic field experiences a magnetic force with magnitude $F = |q|v_\perp B = |q|vB \sin\phi$.

$\vec{F}$ is perpendicular to the plane containing $\vec{v}$ and $\vec{B}$.

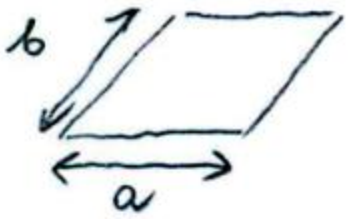


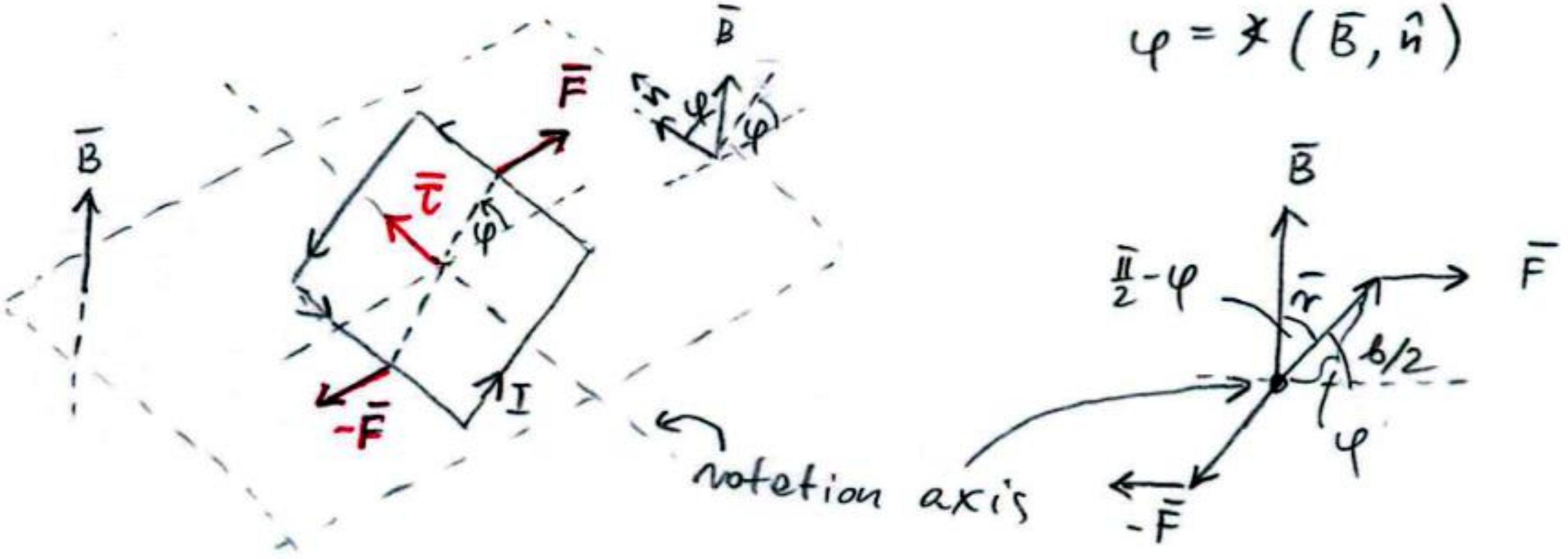
Magnetic field and magnetic forces

A charge moving at right angles to a uniform $\vec{B}$ field moves in a circle at constant speed because $\vec{F}$ and $\vec{v}$ are always perpendicular to each other.



Magnetic field and magnetic forces



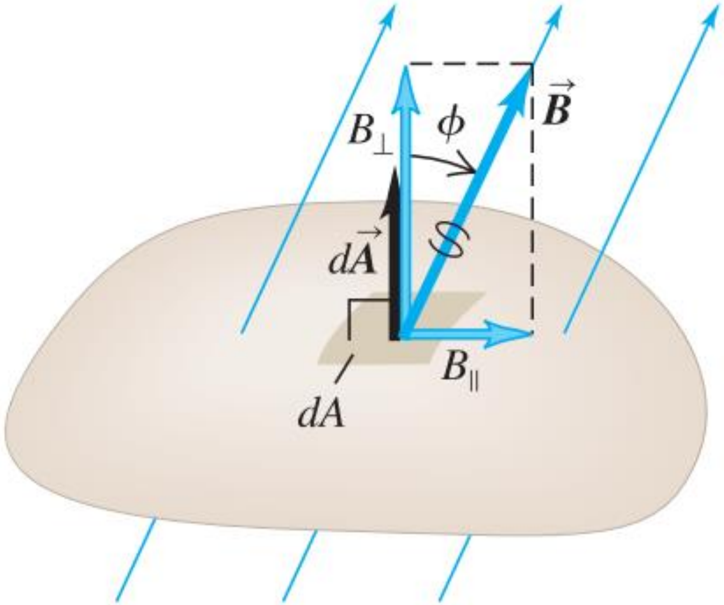


Magnetic field and magnetic forces

Gauss's law for magnetism:

The total magnetic flux through *any* **closed surface** ...

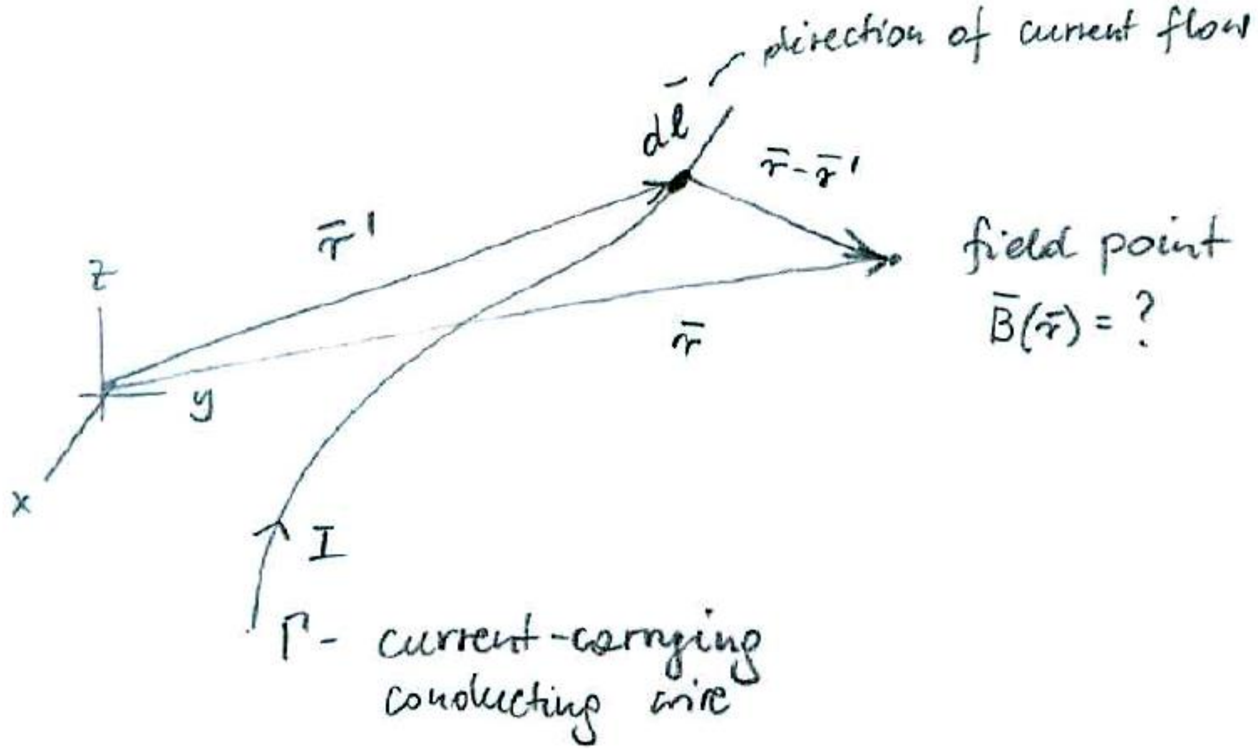
$$\oint \vec{B} \cdot d\vec{A} = 0$$ ... equals zero.

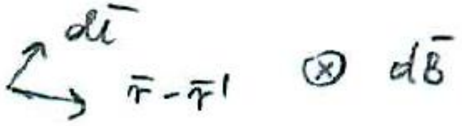


3

Sources of magnetic field

Sources of magnetic field



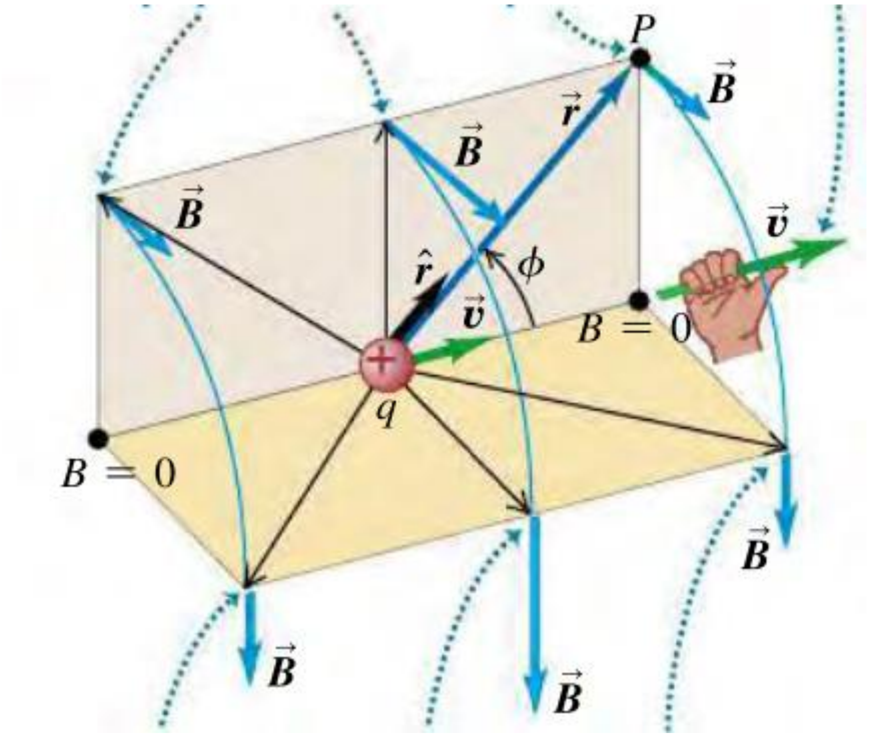


$$\boxed{\begin{aligned}\bar B(\bar r) &= \frac{\mu_0}{4\pi}\int_\Gamma \frac{I\,d\bar l \times (\bar r - \bar r')}{|\bar r - \bar r'|^3} = \\ &= \frac{\mu_0}{4\pi}\int_\Gamma \frac{I\,d\bar l \times \frac{\bar r - \bar r'}{|\bar r - \bar r'|}}{|\bar r - \bar r'|^2}\end{aligned}}$$

→ unit vector

Law of Biot and Savert

Sources of magnetic field



Magnetic field due to a point charge with constant velocity

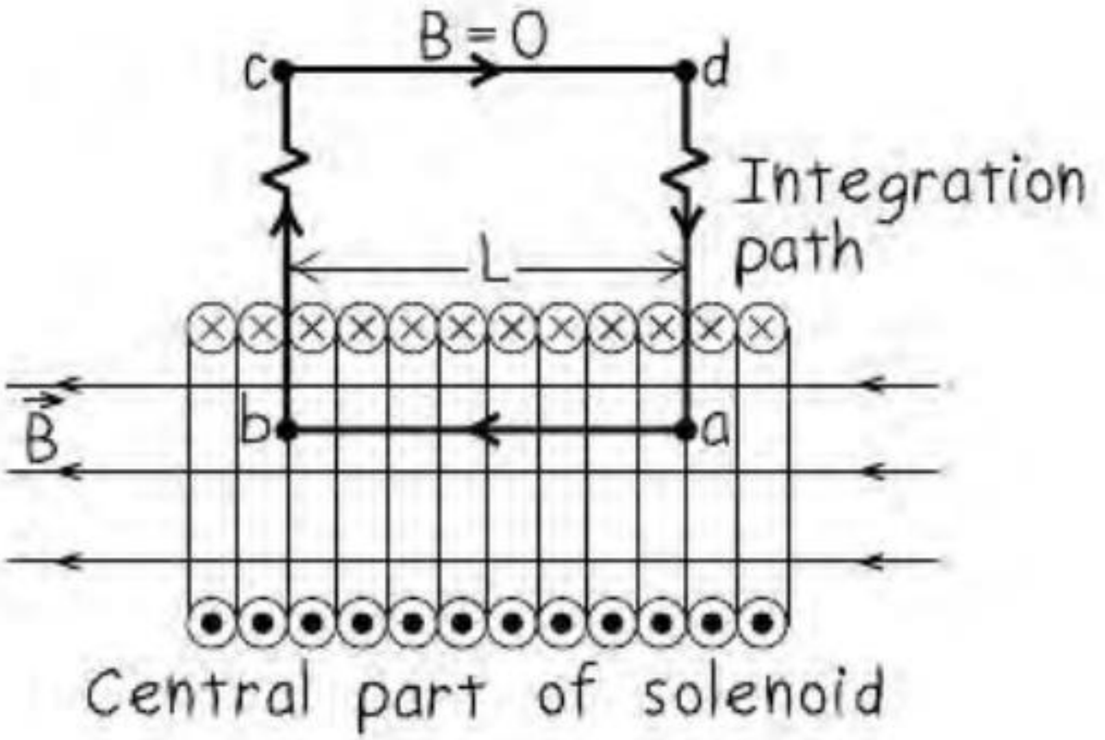
Magnetic constant; Charge; Velocity; Unit vector from point charge toward where field is measured

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v} \times \hat{r}}{r^2}$$

Distance from point charge to where field is measured

(* Not mentioned in lecture notes)

Sources of magnetic field

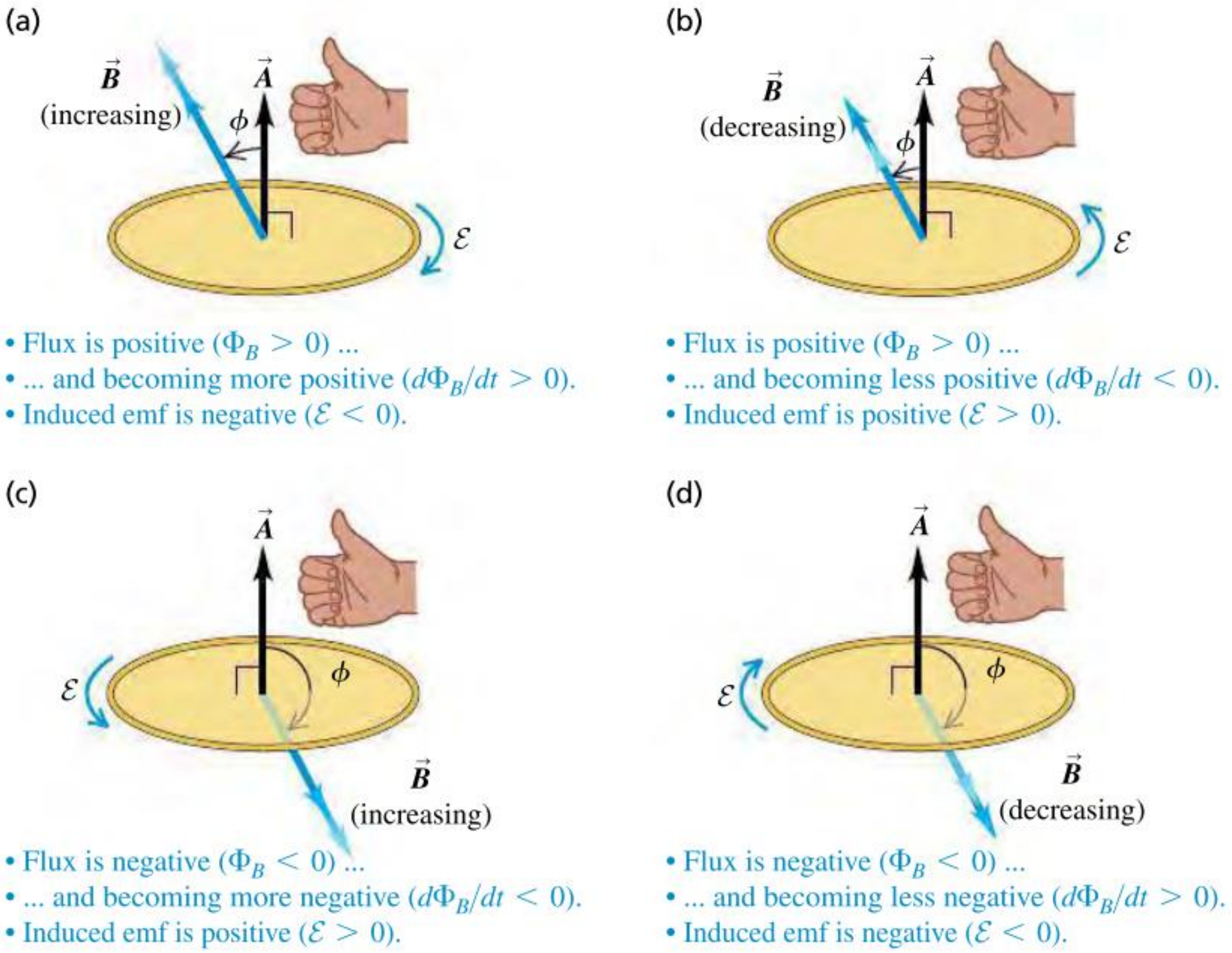


Solenoid: n turns per unit length

4

Electromagnetic induction

Electromagnetic induction

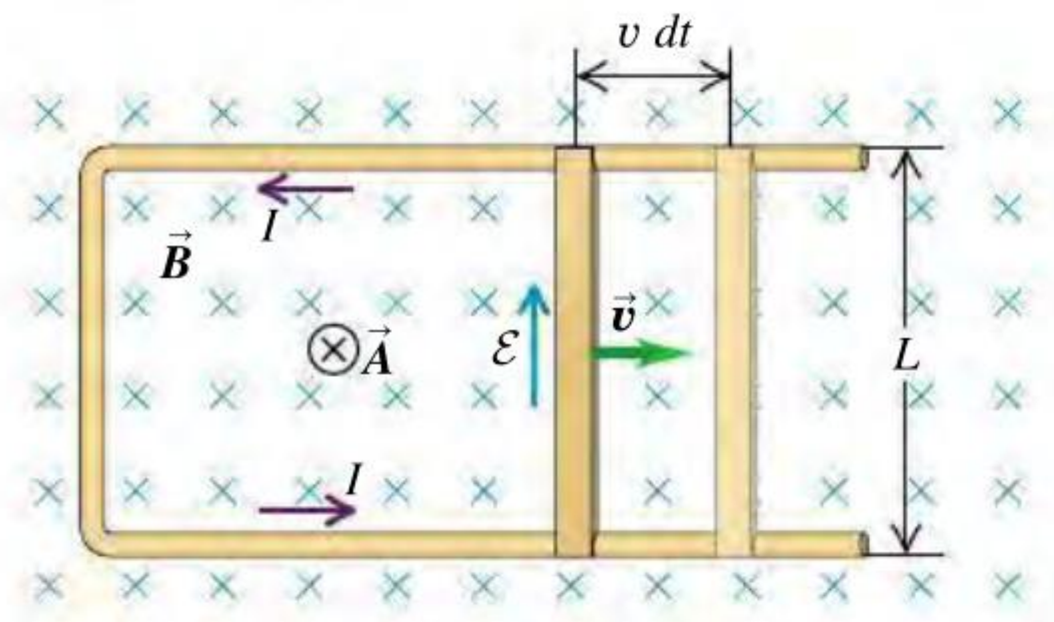


Magnetic field generated by induced EMF is in opposite direction to dΦ

Lenz's Law

The direction of any magnetic induction effect is such as to oppose the cause of the effect.

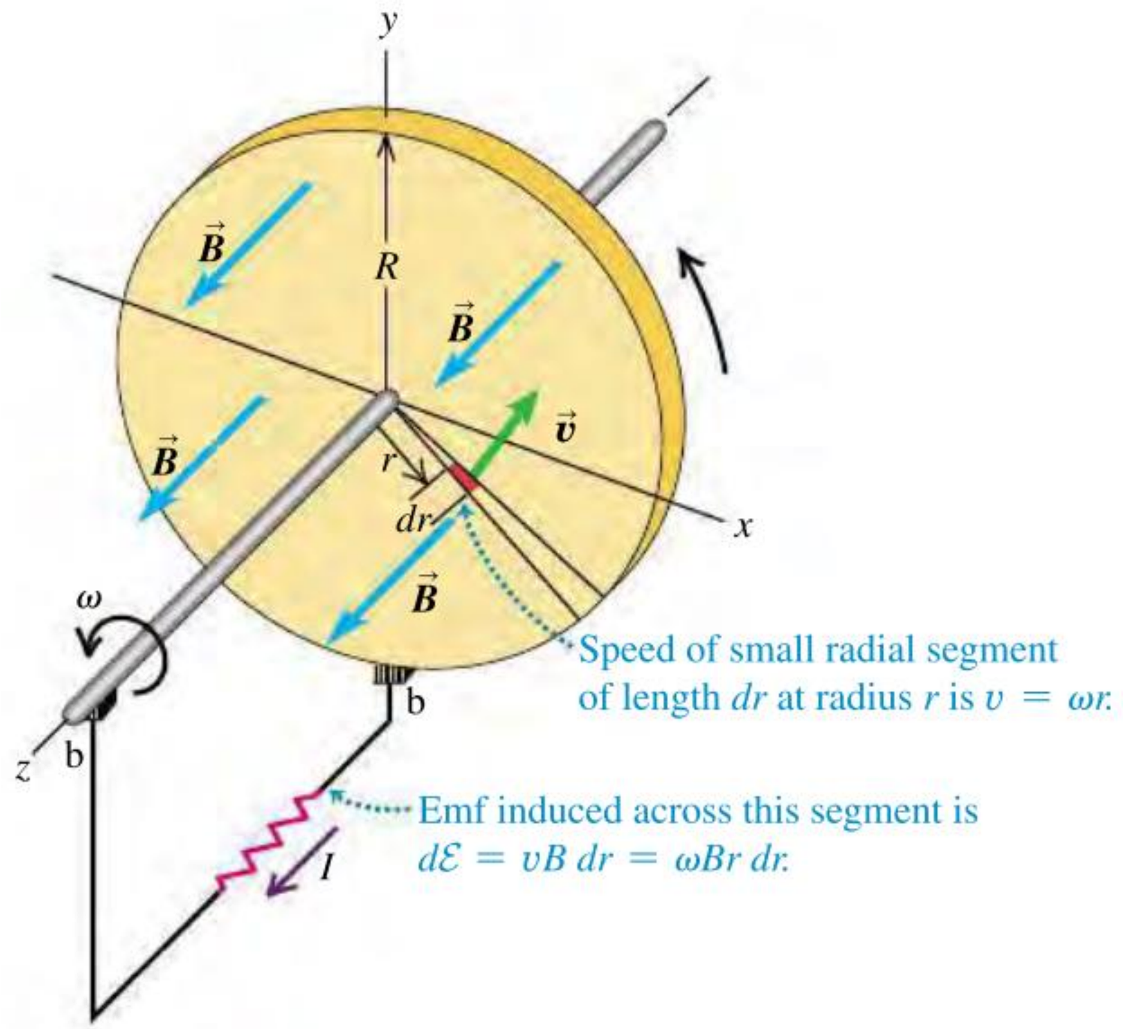
Slide-wire Generator



$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -B\frac{dA}{dt}$$

$$= -B\frac{Lv\,dt}{dt} = -BLv$$

Faraday's disk



Displacement Current