Lecture 20: WED 04 MAR
Magnetic fields
Ch.28.9-10
Torque on a Current Loop:

Rectangular coil: \( A = ab \), current = \( i \)

Principle behind electric motors.

Net force on current loop = 0

But: Net torque is NOT zero!

\[
F_1 = F_3 = iaB
\]

\[
F_\perp = F_1 \sin(\theta)
\]

\[
\text{Torque} = |\tau| = F_\perp b = iabB \sin(\theta)
\]

For a coil with \( N \) turns,

\[
\tau = NIAB \sin \theta,
\]

where \( A \) is the area of coil.
Magnetic Dipole Moment

We just showed: \( \tau = N i A B \sin \theta \)

\( N = \) number of turns in coil

\( A = \) area of coil.

Define: magnetic dipole moment \( \mu \)

\( \vec{\mu} = (N i A) \hat{n} \)

\( \vec{\tau} = \vec{\mu} \times \vec{B} \)

Right hand rule:
- curl fingers in direction of current;
- thumb points along \( \mu \)

As in the case of electric dipoles, magnetic dipoles tend to align with the magnetic field.
**Electric vs. Magnetic Dipoles**

\[ \vec{\mu} = (NiA) \hat{n} \]

\[ \vec{\tau}_E = \vec{p} \times \vec{E} \]

\[ U_E = -\vec{p} \cdot \vec{E} \]

\[ \vec{\tau}_B = \vec{\mu} \times \vec{B} \]

\[ U_B = -\vec{\mu} \cdot \vec{B} \]