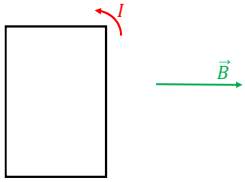
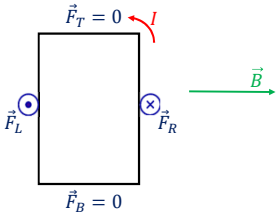
Magnetic Forces on Current Loops
Rectangular Loops

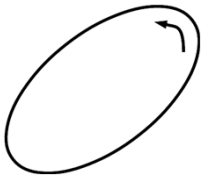


Magnetic Forces on Current Loops
Rectangular Loops

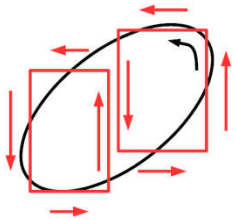


$\vec{F}_{\text{Total}} = 0$

Magnetic Forces on Current Loops
General Loops

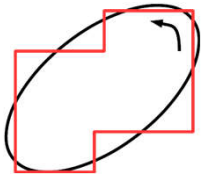


Magnetic Forces on Current Loops
General Loops



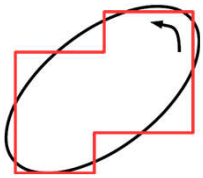
Approximate loop by set of rectangular loops.

Magnetic Forces on Current Loops
General Loops



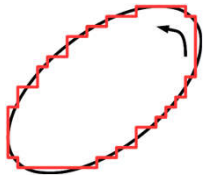
Approximate loop by set of rectangular loops.
Interior sections cancel.

Magnetic Forces on Current Loops
General Loops



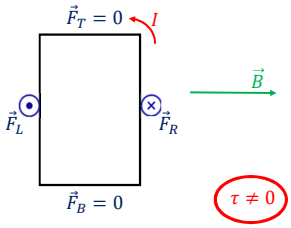
Approximate loop by set of rectangular loops.
Interior sections cancel. $\vec{F}_{\text{Total}} = 0$

Magnetic Forces on Current Loops
General Loops



Approximate loop by set of rectangular loops.
Interior sections cancel. $\vec{F}_{\text{Total}} = 0$

Magnetic Torques on Current Loops
Rectangular Loops



$\vec{F}_{\text{Total}} = 0$

$\tau \neq 0$

Magnetic Torques on Current Loops
Rectangular Loops

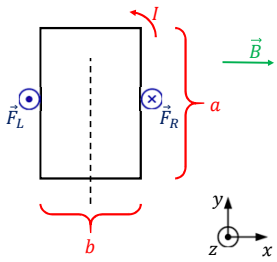
$\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{\tau}_L = \frac{b}{2}(-\hat{\imath}) \times IaB\hat{k}$

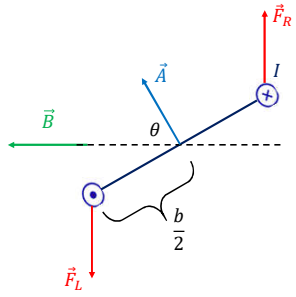
$\vec{\tau}_L = \frac{1}{2}IabB\hat{\jmath}$

$\vec{\tau}_R = \frac{1}{2}IabB\hat{\jmath}$

$\vec{\tau}_{\text{Total}} = \text{IAB}\hat{\jmath}$



Magnetic Torques on Current Loops
Field not necessarily in plane of loop



$$\tau_L = \frac{b}{2}\sin\theta\, IaB$$

$$\tau_R = \frac{b}{2}\sin\theta\, IaB$$

$$\tau_{\text{Total}} = IabB\sin\theta$$

$$\vec{\tau} = I\vec{A}\times\vec{B}$$

Magnetic Dipole Moment

$$\vec{\tau} = I\vec{A}\times\vec{B}$$

Can be written as

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

Where

$$\vec{\mu} = NI\vec{A}$$

(N is the number of wire loops.)

Magnetic Dipole Moment

$$\vec{\mu} = NI\vec{A}$$

Torque: $\vec{\tau} = \vec{\mu}\times\vec{B}$

Energy: $U = -\vec{\mu}\cdot\vec{B}$

Magnetic Dipole Moment

$$\vec{\mu} = NI\vec{A}$$

Torque: $\vec{\tau} = \vec{\mu} \times \vec{B}$

Energy: $U = -\vec{\mu} \cdot \vec{B}$

Recall electric dipoles.

$\vec{\tau} = \vec{p} \times \vec{E}$ $\quad U = -\vec{p} \cdot \vec{E}$

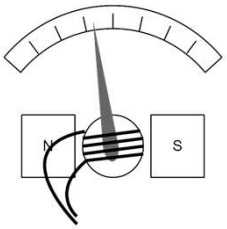
Example: A magnetic dipole is in a uniform magnetic field. Under what conditions is (a) the torque a minimum, (b) the torque zero, (c) the potential energy a minimum, (d) the potential energy zero?

$$\vec{\mu} = NI\vec{A}$$

Torque: $\vec{\tau} = \vec{\mu} \times \vec{B}$

Energy: $U = -\vec{\mu} \cdot \vec{B}$

Galvanometer



What causes the forces on the needle?