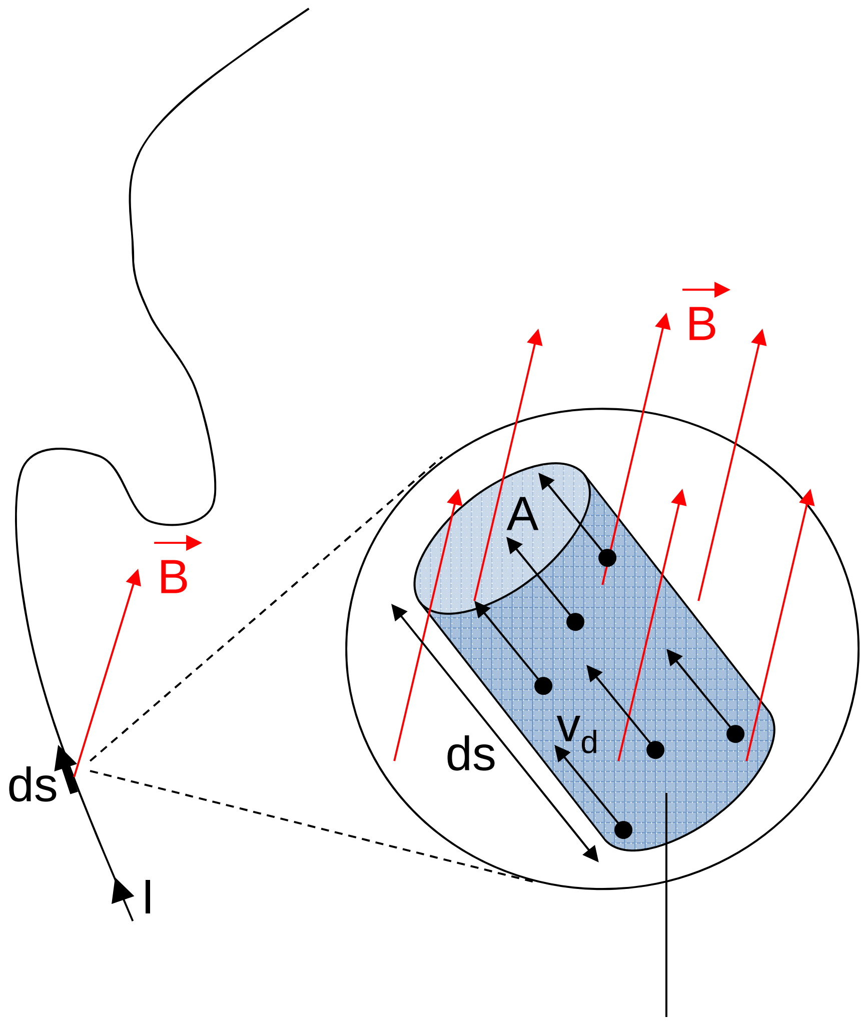
Class 24 Magnetic Torque and Hall Effect

Magnetic Force Acting on a Current



Force acting on one electron (note that in a current electron is considered as positive in charge):

$$\vec{F}_B = q\vec{v} \times \vec{B} = e\,\vec{v}_d \times \vec{B}$$

Force acting on the infinitesimal element:

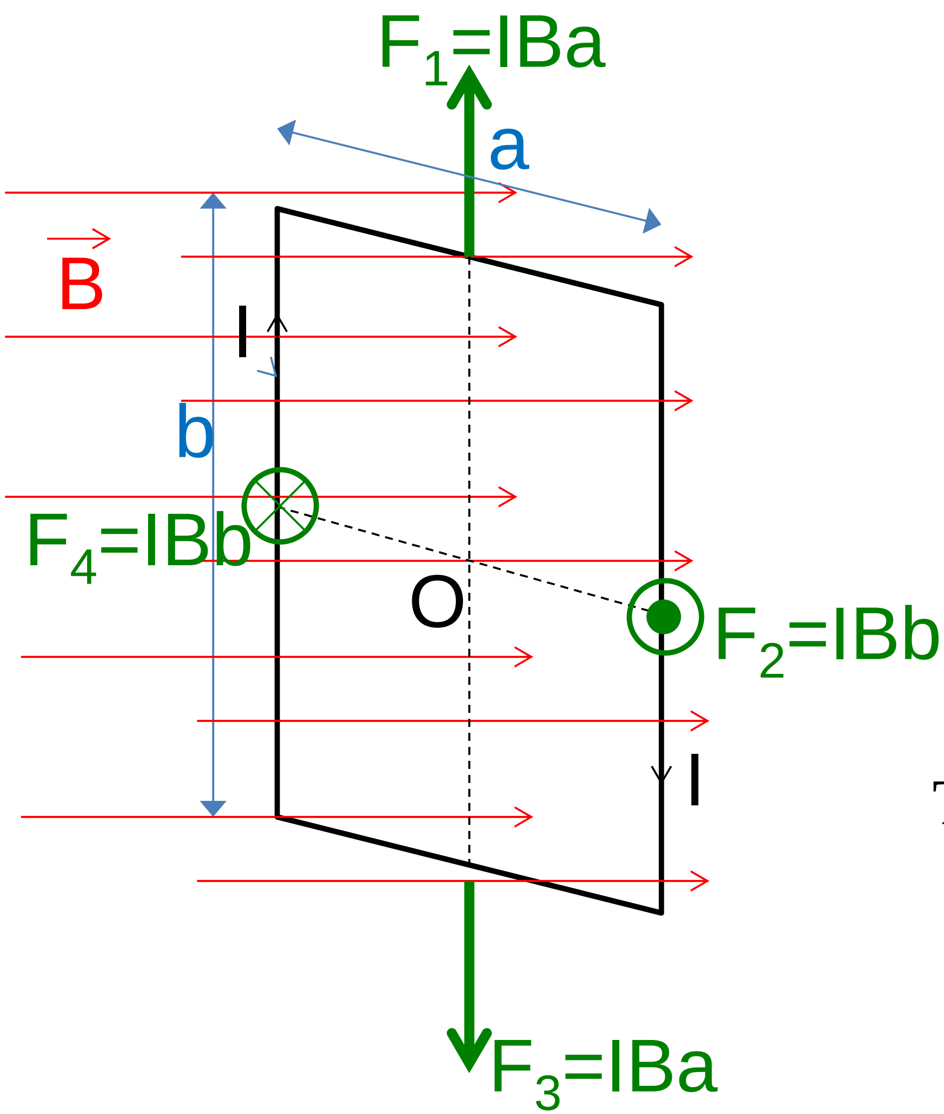
$$d\vec{F}_B = (e\,\vec{v}_d \times \vec{B})\,(nAds)$$

$$\Rightarrow \boxed{d\vec{F}_B = I\,d\vec{s} \times \vec{B}}$$

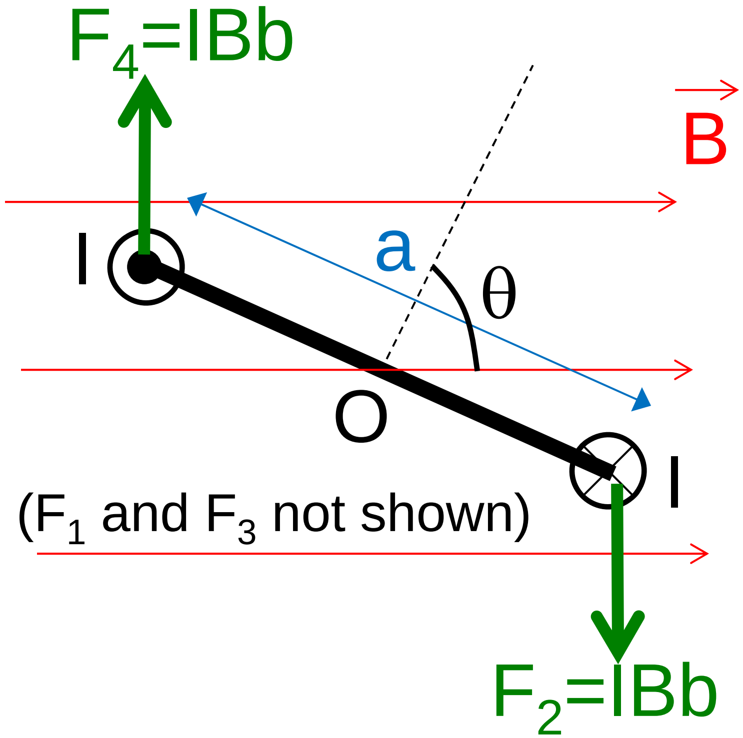
Force on the whole wire:

$$\vec{F}_B = \int_{\text{wire}} d\vec{F}_B = I \int_{\text{wire}} d\vec{s} \times \vec{B}$$

Magnetic Force on a Rectangular Loop



Top view

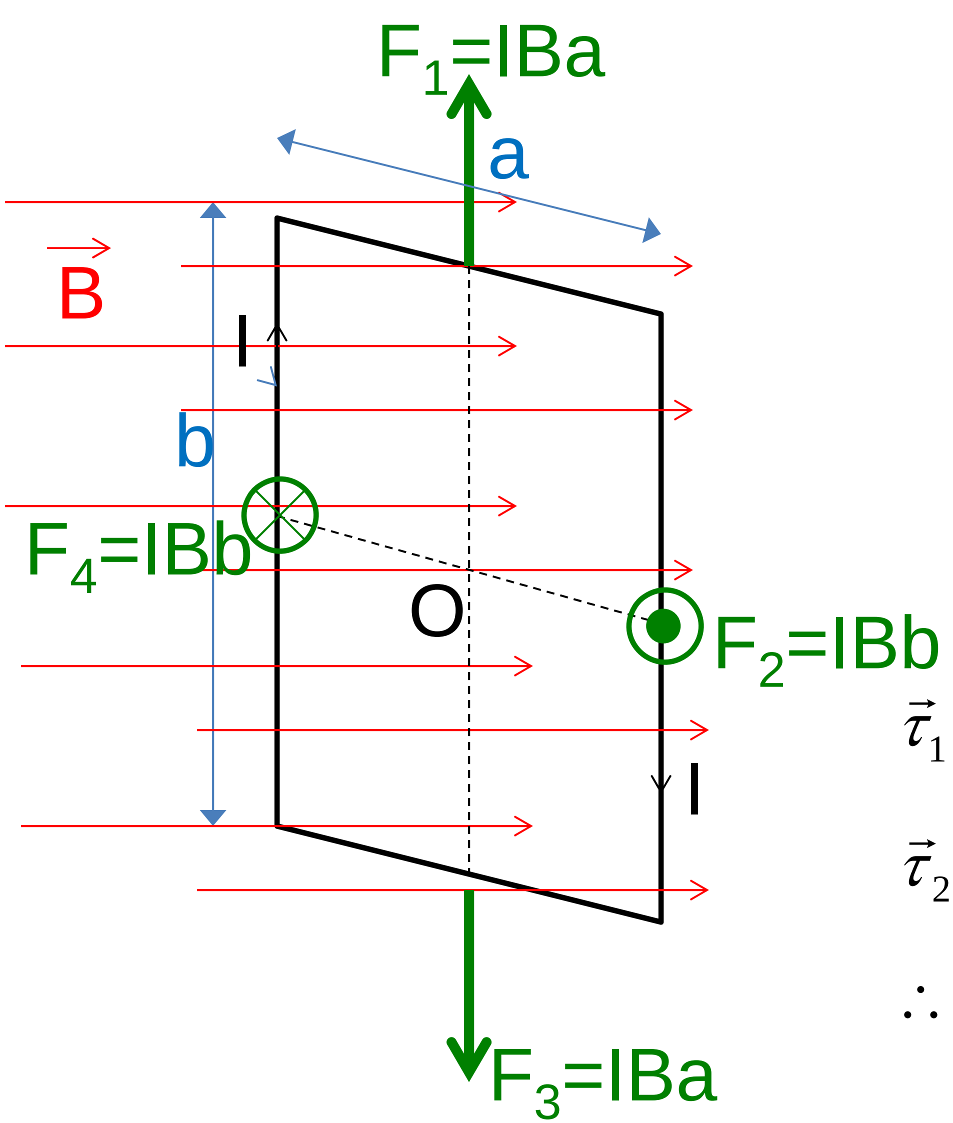


Total force acting on the loop

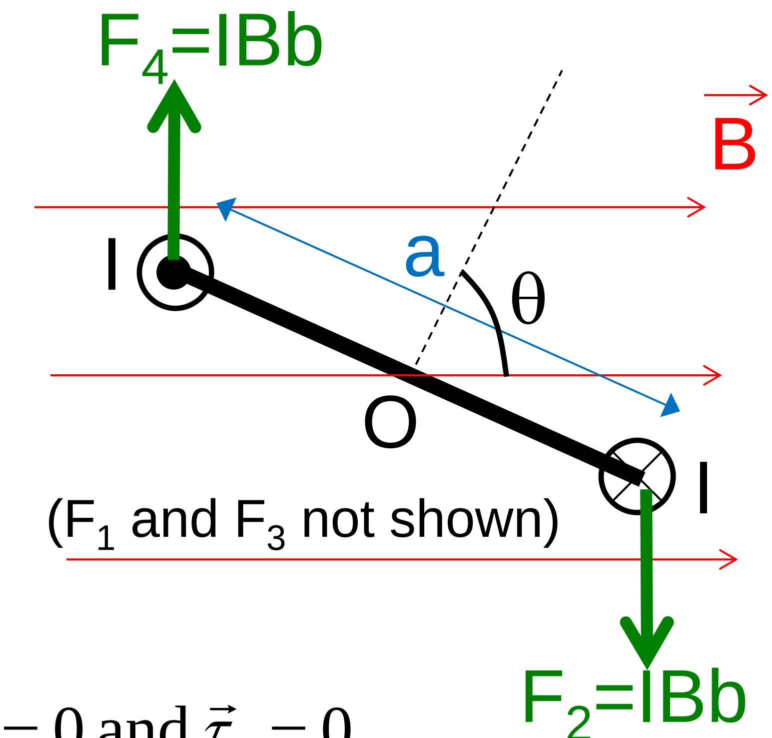
$$= \underbrace{\vec{F}_1 + \vec{F}_3}_{=0} + \underbrace{\vec{F}_2 + \vec{F}_4}_{=0}$$

$$= 0$$

Magnetic torque on a Rectangular Loop



Top view



$$\vec{\tau}_1 = 0 \text{ and } \vec{\tau}_3 = 0$$

$$\vec{\tau}_2 = \vec{\tau}_4 = \mathrm{IBb} \cdot \frac{a}{2} \cos\theta \otimes$$

$$\therefore \ \vec{\tau} = \mathrm{IBa} \cdot \mathrm{b} \cos\theta \otimes = \mathrm{IBA} \cos\theta \otimes$$

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