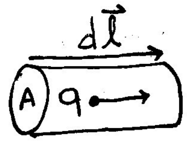
Force on a current-carrying wire

Force on a microscopic segment



$$\vec{F}_{\substack{\text{point}\\\text{charge}}} = q\vec{v}\times\vec{B} \Rightarrow d\vec{F}_{\substack{\text{on wire}\\\text{segment}}} = (\underbrace{q\vec{V}_d\times\vec{B}}_{\text{force/carrier}})\ \underset{\uparrow\ \frac{\text{carriers}}{\text{volume}}}{n}\ \underbrace{A\,dl}_{\text{volume}}$$

$$d\vec{F} = (q\,d\vec{l}\times\vec{B})\,n\,A\,v_d$$

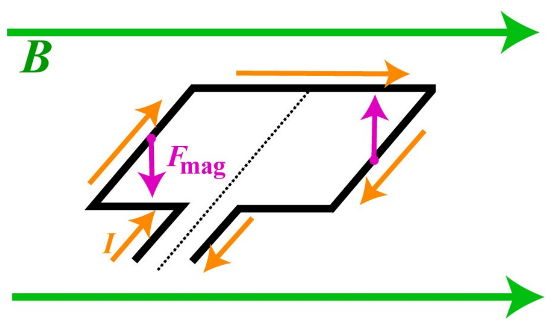
$$I \equiv \Delta Q / \Delta t$$

$$= \underset{\uparrow\ \frac{\text{charge}}{\text{carrier}}}{q}\ \underset{\uparrow\ \frac{\text{carriers}}{\text{vol.}}}{n}\ \underbrace{A\,dl}_{\text{vol.}} \Big/ \underbrace{(dl/v_d)}_{\tau\ \text{time to travel } dl} = qnAv_d$$

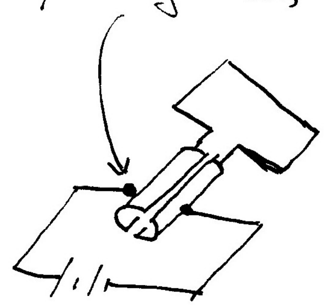
$\rightarrow d\vec{F} = I\,d\vec{l}\times\vec{B} \Rightarrow$ Force on straight wire, uniform $\vec{B}$:

$$\boxed{\vec{F} = I\vec{l}\times\vec{B}}$$

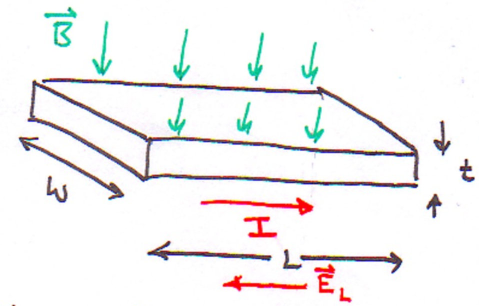
Motors



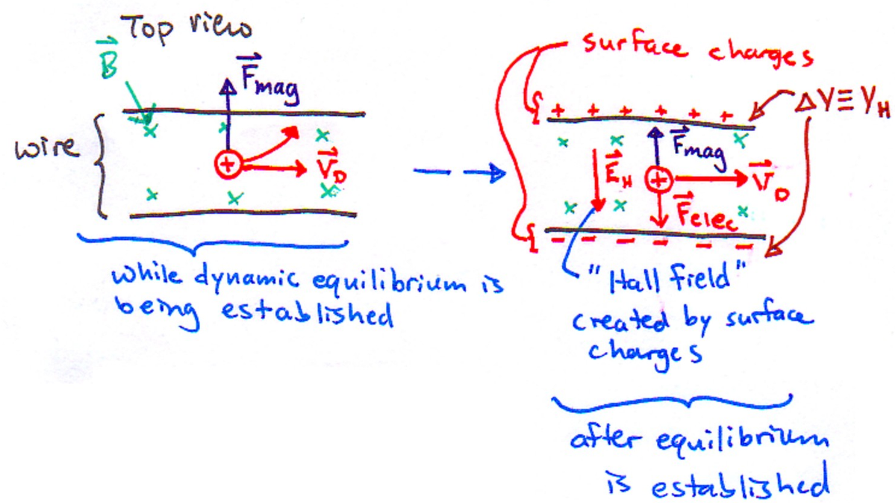
For continuous rotation, the current direction must be reversed each time the loop reaches the vertical position. In DC motors, this is done by sliding contacts ("brushes"):



Hall effect



Situation if I is carried by + charges:



Book $\rightarrow$ $V_H = \frac{I B}{n q t}$

n: $\frac{\#\text{ of carriers}}{m^3}$ t: Thickness of wire in direction of $\vec{B}$