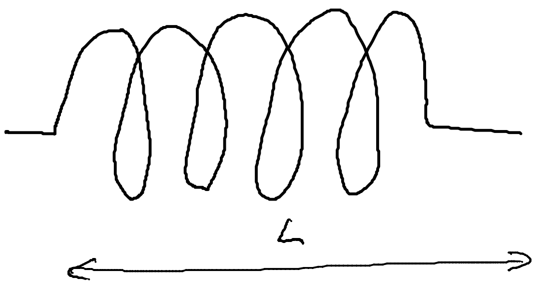
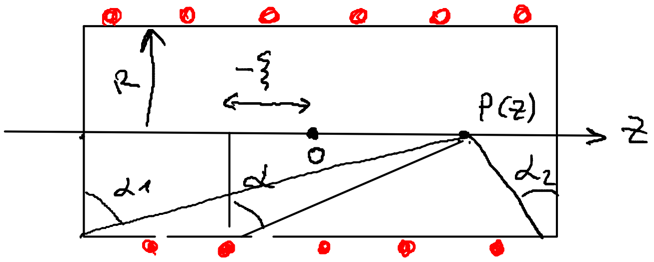
Das Feld einer Zylinderspule



n Windungen pro 1 m

$$B \cong \mu_0 n I$$

Jetzt: Einfluss der Randeffekte



$$-\frac{L}{2} \leq \xi \leq \frac{L}{2}$$

$$dB = \frac{\mu_0 \cdot I \cdot n \, d\xi \cdot \pi R^2}{2\pi \left[R^2 + (z-\xi)^2\right]^{3/2}}$$

$$z - \xi = R \tan \alpha$$

$$1 + \tan^2 \alpha = \frac{1}{\cos^2 \alpha}$$

$$d\xi = -\frac{d\alpha}{\cos^2 \alpha} R$$

$$B(z) = \int_{-L/2}^{+L/2} dB$$

$$= -\frac{\mu_0 I n}{2} \int_{\alpha_1}^{\alpha_2} \cos\alpha \, d\alpha$$

$$= \frac{\mu_0 n I}{2} \left\{ \frac{z + L/2}{\sqrt{R^2 + (z + L/2)^2}} - \frac{z - L/2}{\sqrt{R^2 + (z - L/2)^2}} \right\}$$

Für $z = 0$

$$B(0) = \frac{\mu_0 n I}{2} \cdot \frac{L}{\sqrt{R^2 + L^2/4}}$$

mit $L \gg R$

$$B(0) \approx \underbrace{\mu_0 n I}$$

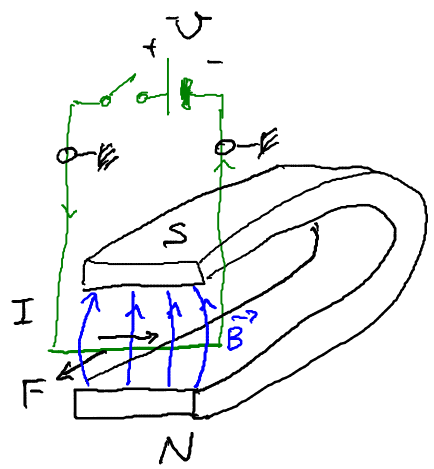
Für $z = \pm L/2$

$$B\left(\pm \frac{L}{2}\right) = \frac{\mu_0 n I}{2} \cdot \frac{L}{\sqrt{R^2 + L^2}} \approx \frac{\mu_0 n I}{2}$$

mit $L \gg R$ Spule $\equiv$ Solenoid

Kräfte auf bewegte Ladungen im Magnetfeld

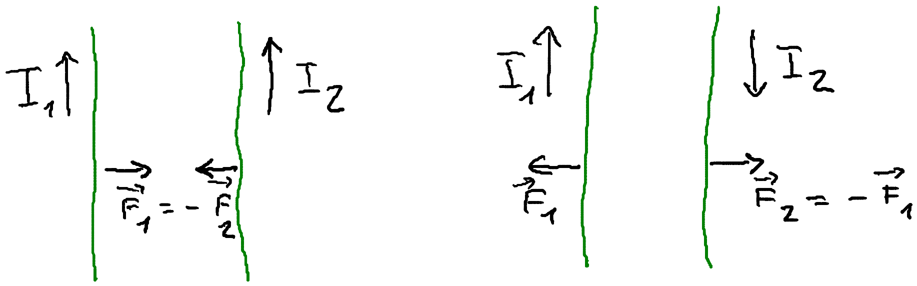
a)



$\vec{F} \perp \vec{B}$

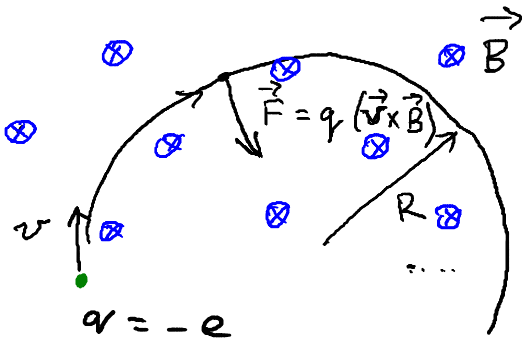
$\vec{F} \perp$ Stromrichtung $\vec{I}$

b) zwei parallele Drähte



$$|\vec{F}_{1,2}| \sim I_1 \cdot I_2$$

c) Elektronenstrahl im Magnetfeld



⊙ zu uns

⊗ von uns

$$|\vec{F}| \sim v$$

$$\vec{F} = \underbrace{const}_{=\,1 \text{ in SI-System}} \cdot q \cdot (\vec{v} \times \vec{B})$$

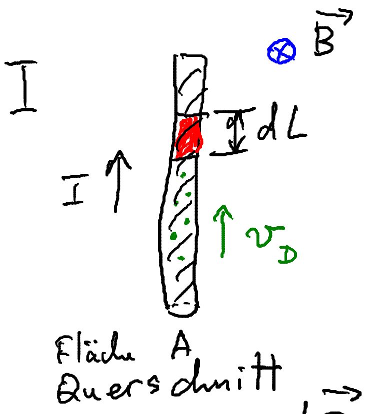
$[B] = 1\,T = \frac{1\,N}{} = 1\,\frac{N}{}$

$$[B] = 1 \ldots \frac{\ldots}{1\,A\cdot\cancel{s}\cdot 1\,m/\cancel{s}} \ldots A\cdot m$$

$$\boxed{\vec{F} = q\cdot(\vec{v}\times\vec{B})}$$ Lorentzkraft

mit $\vec{E} \neq 0$ $$\vec{F} = q\cdot(\vec{E}+\vec{v}\times\vec{B})$$

Kräfte auf stromdurchflossene Leiter



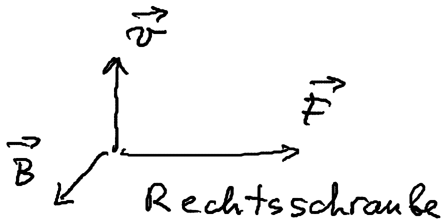
$\rho = n q$ Ladungsdichte

v_D ist Driftgeschwindigkeit

$$dQ = n \cdot A \cdot dL \cdot q$$

$$d\vec{F} = n \underbrace{A\, dL}_{dV} q \left(\vec{v}_D \times \vec{B}\right) = dV \cdot (\vec{j} \times \vec{B})$$

$$\vec{F} = \int (\vec{j} \times \vec{B})\, dV$$

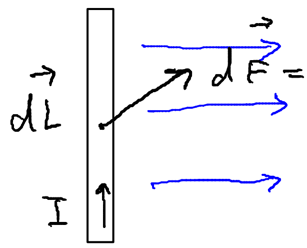


$q = -e$

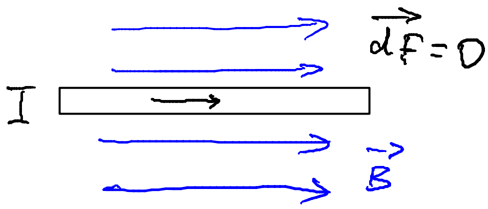
$\hookrightarrow \vec{j} \times \vec{B}$ Linksschraube!

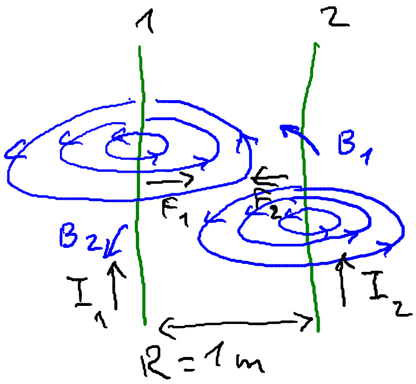
Kraft pro Längenelement $d\vec{L}$

$$d\vec{F} = I \cdot (d\vec{L} \times \vec{B})$$



$d\vec{F} = I \cdot (d\vec{L} \times \vec{B})$





$I_1 = I_2 = I$

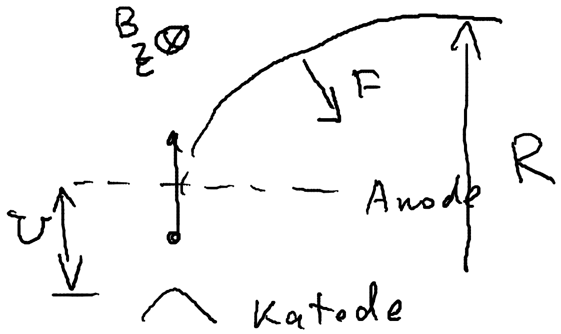
$1\,A \longrightarrow |\vec{F}_{1,2}| = 2 \cdot 10^{-7}\,N$

$$\frac{F}{L} = I_1 \frac{\mu_0}{2\pi} \cdot \frac{I_2}{R} = \frac{\mu_0 I^2}{2\pi R}$$

$R = 1\,m$

$$! \longrightarrow \mu_0 = 4\pi \cdot 10^{-7} \frac{Vs}{Am}$$

Bewegte Ladungen im Magnetfeld



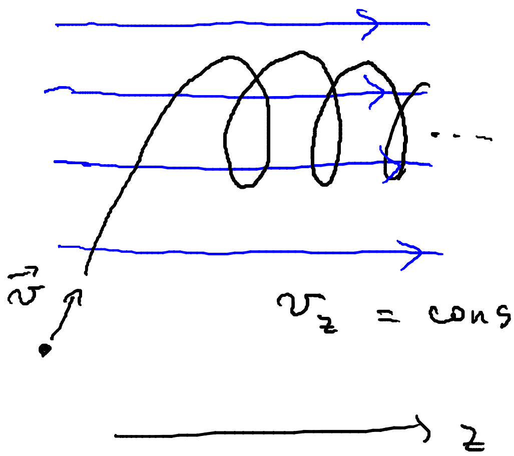
$$\frac{m v^2}{2} = e U$$

$$\Downarrow$$

$$v = \sqrt{\frac{2eU}{m}}$$

Zentripetalkraft $\sim B_z$

$$e v \cdot B_z = \frac{m v^2}{R} \; ; \; \Rightarrow R = \frac{1}{B}\sqrt{\frac{2mU}{e}} = \frac{mv}{eB}$$



Zyklotronfrequenz

$$f_z = \frac{eB}{2\pi m}$$