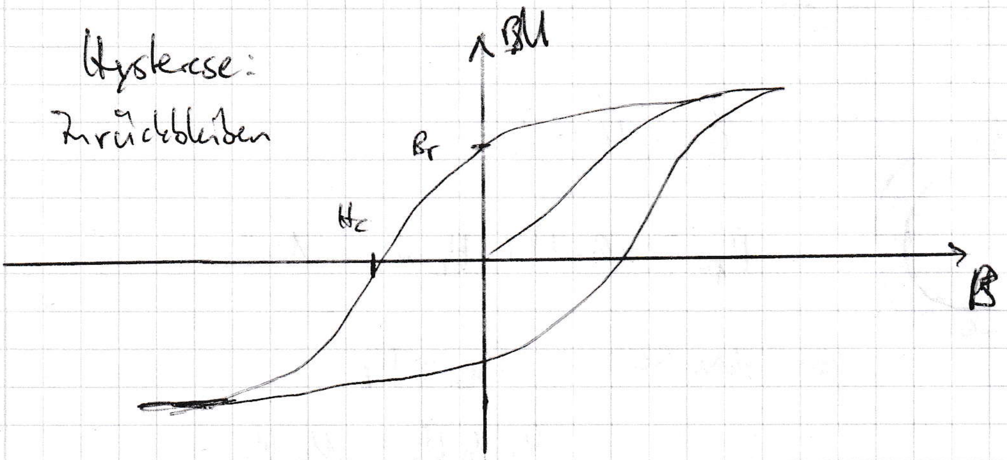
Ex 2 / Blatt 8

28 Hysterese: Zurückbleiben



Remanenz: Magnetisierung die bei Feld $H=0$ übrig bleibt

Koerzitivfeld: Feld, dass benötigt wird um keine Magnetisierung zu erreichen

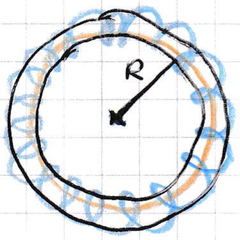
Sättigung: maximale Magnetisierung

Fläche: Energie zum Magnetisieren des Materials

29 Ampere Gesetz $\oint \vec{B}\, d\vec{l} = \mu_0 I \mu_r$

bzw. $\oint H\, d\vec{l} = I$

a)



~~Ampere-Schleife~~ H

Im Torus: $H \cdot 2\pi R = N \cdot I$

$\Rightarrow \quad H = \frac{N \cdot I}{2\pi R} = 1{,}59 \cdot 10^3 \frac{A}{m}$

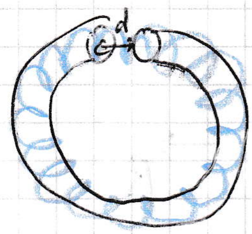
$B = \mu_0 \mu_r H = 4\,T$

$M = \chi \cdot H = (\mu_r - 1) H = 3{,}18 \cdot 10^6 \frac{A}{m}$

b) H gleich

$B = \mu_0 H = 2\,mT$

c)



$$\oint H \, d\vec{l} = I$$

$$H_E (2\pi R - d) + H_L d = N \cdot I$$

da $\operatorname{div} B = 0$ $\quad B_E = B_L$

$$\mu_r \mu_0 H_E = \mu_0 H_L$$

$$\Rightarrow H_E = \frac{H_L}{\mu_r}$$

$$H_L \left(\frac{2\pi R - d}{\mu_r} + d \right) = N \cdot I$$

$$H_L = \frac{N \cdot I}{\left(\frac{2\pi R - d}{\mu_r} + d \right)} = 1{,}88 \cdot 10^5 \frac{A}{m}$$

$$\Rightarrow B_E = B_L = \mu_0 H_L = \cancel{1{,}88 \cdot 10 \frac{A}{m}} \; 0{,}237\,T$$

$$H_E = \frac{H_L}{\mu_r} = 94 \frac{A}{m}$$

d) Mittelpunkt: Torus wie ein Ring durch den Strom fließt ~~[illegible]~~ Biot Savart

$$B = \frac{\mu_0 I}{2R} \qquad \cancel{B 2R = \mu I}$$

$$= \underline{31{,}4\,\mu T}$$

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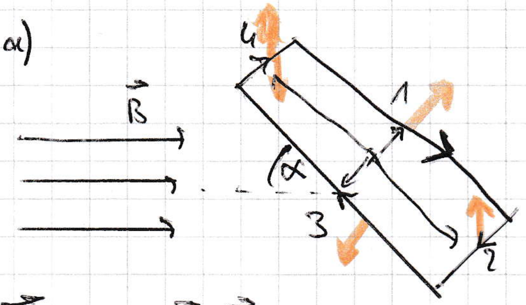
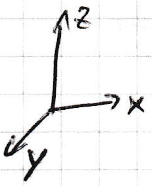
a)





$\vec{r} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$

$\vec{F} = q \; \vec{v} \times \vec{B}$

$= \cancel{I dt} \frac{d\vec{x}}{\cancel{dt}} \times \vec{B} = I \cdot d\vec{x} \times \vec{B}$

$\vec{l}_4 = l \cdot \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = \vec{l}_2$

$\vec{B} = B \cdot \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

$\vec{l}_3 = l \cdot \begin{pmatrix} \cos(\alpha) \\ 0 \\ \sin(\alpha) \end{pmatrix} = \vec{l}_1$

$\vec{F}_1 = -IBl \sin(\alpha) \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

$\vec{F}_3 = IBl \sin(\alpha) \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

$\vec{F}_2 = IBl \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$ $\qquad F_4 = -IBl \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$

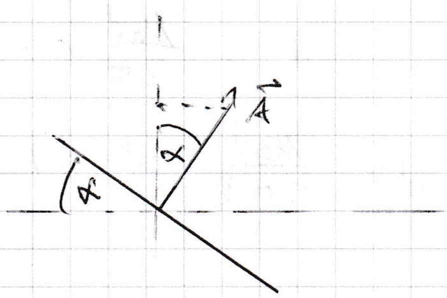
b) $\vec{M} = \vec{r} \times \vec{F}$ $\qquad \vec{r}_1 \parallel \vec{F}_1$, $\vec{r}_3 \parallel \vec{F}_3 \Rightarrow \vec{M}_{1/3} = 0$

$\vec{r}_2 = \frac{l}{2} \begin{pmatrix} \cos\alpha \\ 0 \\ -\sin\alpha \end{pmatrix}$ $\qquad \vec{r}_4 = \frac{l}{2} \begin{pmatrix} -\cos(\alpha) \\ 0 \\ \sin(\alpha) \end{pmatrix}$

$\vec{M}_2 = \frac{l^2}{2} B \cdot I \cos(\alpha) \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = \vec{M}_4$

$\vec{M}_{ges} = l^2 B I \cos(\alpha) \; \vec{e}_y$

c) $\vec{m} = I \cdot \vec{A}$ $\qquad \vec{A} = l^2 \begin{pmatrix} \sin(\alpha) \\ 0 \\ \cos(\alpha) \end{pmatrix}$



$\vec{B} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

$\Rightarrow \vec{M} = -\vec{B} \times \vec{m} = \underline{\vec{m} \times \vec{B}}$

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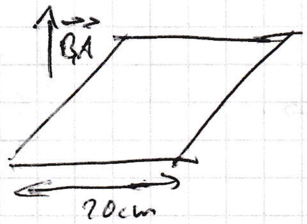

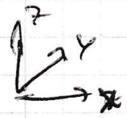

a) $\phi = \int \vec{B}\, d\vec{A} = B \cdot A \cos\varphi \qquad \cos\varphi = 0$

$\Rightarrow \quad \phi = B \cdot A = \underline{\underline{2{,}51 \cdot 10^{-3}\ Vs}}$

b) $U_{ind} = -\dot{\phi} \qquad \phi(t) = B \cdot A \cdot \cos(\omega t)$

$\dot{\phi}(t) = -B \cdot A \cdot \sin(\omega t) \cdot \omega$

$U_{ind} = \underbrace{B \cdot A \cdot \omega}_{U_0 = 0{,}79\ V} \cdot \sin(\omega t)$

$\omega = 2\pi f$

c) $U_{ind} = -\dot{\phi} = -\frac{d}{dt}(A \cdot B) = -(A \cdot \dot{B} + B \cdot \dot{A}) = 0$

$\dot{B} = 0 \qquad \dot{A} = 0$

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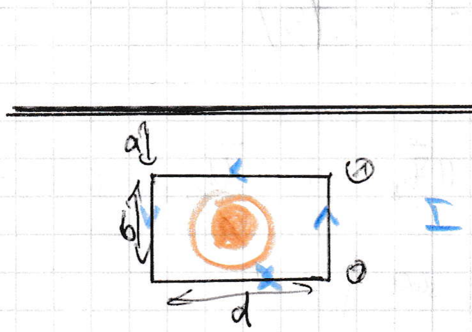
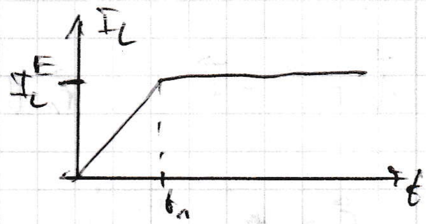


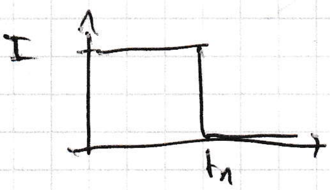
a)



$\vec{B} = \frac{\mu_0 I_L}{2\pi y} \qquad \phi = \int B\, d\vec{A} = \int_a^{a+b} \frac{\mu_0 I_L d\, dy}{2\pi y} = \frac{\mu_0 d}{2\pi} \ln\left(1 + \frac{b}{a}\right) \cdot I_L$

$U_{ind} = -\dot{\phi} = \frac{-\mu_0 d}{2\pi} c \cdot \ln\left(1 + \frac{b}{a}\right) \qquad I = \frac{U}{R}$

$I_{ind} = \frac{-\mu_0 d c}{2\pi R} \ln\left(1 + \frac{b}{a}\right) \quad t < t_1 \quad \Big| \quad = 0 \quad t > t_1$



b) $\vec{F} = I\,(\vec{L} \times \vec{B})$

Strecke ① hat größere Kraft als ⓪, da $\vec{B}$ dort höher ist

Schleife ~~sol~~ bewegt sich vom Leiter weg!