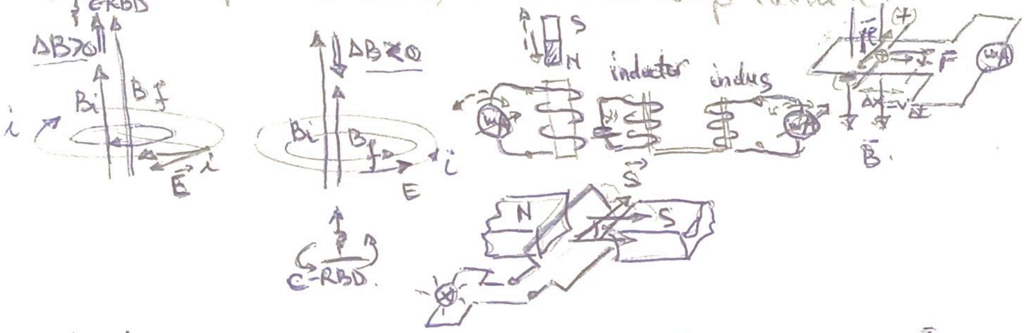
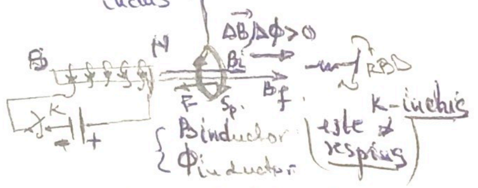
Fen. Inducţia el-magnetică

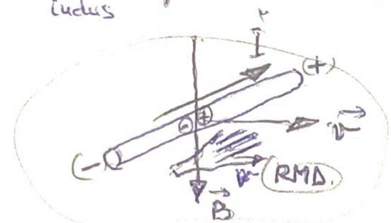
Temă: pb. 240/122

- Def: $e = -\frac{\Delta\phi}{\Delta t}$, $\Phi = \vec{B}\cdot\vec{S}$, $\Delta\phi = \Delta\vec{B}\cdot\vec{S} + \vec{B}\cdot\Delta\vec{S}$ (← transf. el.), ş.a.m.d. gen.
- Dovezi experimentale:
- obs: (e)-circuit deschis → (i)-circ. închis ($i = \frac{e}{R}$) – curentul indus
- Regula lui Lenz: "Eu curentul cel indus totdeauna m-am opus cauzei ce m-a produs."
- Princ. lui Maxwell: În jurul unui câmp magn. variabil apare un câmp el. (variabil) cu linii de câmp închise.



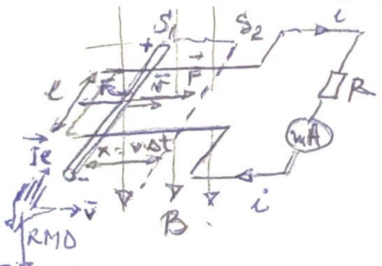
- R. Lenz: (e, i) au un astfel de sens încât Φ_i (indus) să se opună $\Delta\Phi_{inductor}$





K - deschis, inelul - atras.

- Legea inducţiei el-magnetice (Faraday) $e = -\frac{\Delta\phi}{\Delta t}$



$\vec{l}, \vec{B}, \vec{F} \rightarrow F = -F_{em} = -i l B \sin\alpha$

$L = F\cdot\Delta x = F\cdot v\cdot\Delta t = -i l B v \Delta t = -i B(l\Delta x)$ (Δx, ΔS)

$e = \frac{L}{q}$

$q = i\cdot\Delta t$

$= -i B(S_2 - S_1) =$

$= -i(BS_2 - BS_1) = -i(\phi_2 - \phi_1) = -i\cdot\Delta\phi$

deci $e = \frac{L}{q} = \frac{-i\cdot\Delta\phi}{i\cdot\Delta t} = -\frac{\Delta\phi}{\Delta t}$

deci $e = -\frac{\Delta\phi}{\Delta t}$ (leg. Faraday); $e = -N\frac{\Delta\phi}{\Delta t}$

$e = -\frac{i l B v \Delta t \sin\alpha}{i\Delta t} \Rightarrow e = l\cdot(\vec{v}\times\vec{B}) = l v B \sin\alpha$; $\alpha = \hat{\vec{v},\vec{B}}$

$i = \frac{e}{R}$ → curentul indus → (RMD)

Fenom. de inducţie el-magn.

$\Phi = \vec{B}\cdot\vec{S}$, $\Delta\Phi = B\cdot\Delta S$

$L = F\cdot\Delta x = -F_{em}\Delta x = -i l B\cdot\Delta x$

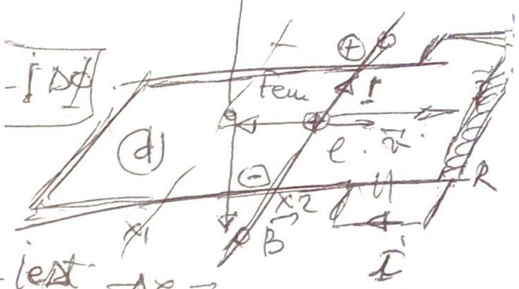
$F_{em} = i l B$

$L = -iB(l\cdot\Delta x) = -i B\Delta S = -i\Delta\phi$

$e = \frac{L}{q}$

$L = q\cdot U$

$q = i\cdot\Delta t$ → $L = i e \Delta t$



$L = I e\cdot\Delta t = -I\Delta\phi$ → $e = -\frac{\Delta\phi}{\Delta t}$, $i = \frac{e}{R}$

$f_L = q v B$, $I = ne/t$

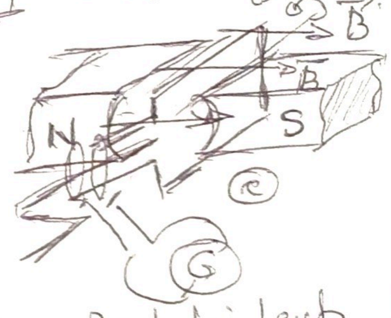
$f_L = \frac{ne}{t}\cdot v B$

$e = l v B$

$e = \frac{L}{q} = \frac{-I l B\Delta x}{ne}$, $I = \frac{ne}{t}$

$e = -\frac{ne}{t}\cdot\frac{l B\Delta x}{ne} = -lB\frac{\Delta x}{\Delta t}$

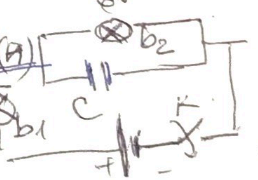
$e = -lBv$



Autoinducţia. Legea

$e \stackrel{def}{=} \frac{\Delta\phi}{\Delta t}$, $\Phi = L\cdot I$, $L = \frac{\Phi}{I}$ (H)

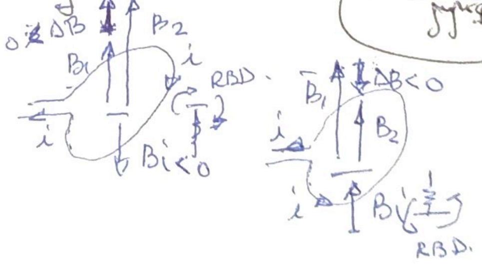
$\Delta\phi = L\Delta I$



$e = -\frac{L\Delta I}{\Delta t}$

Leg. autoinducţiei

$L = \frac{\mu N^2 S}{l}$



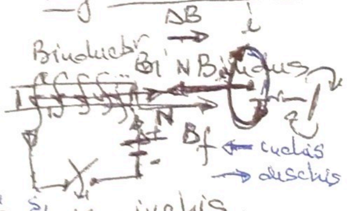
$S_t = NS_1$

$B = \mu_0\mu_r\frac{NI}{l}$

$\Phi_t = B\cdot S_t = \mu_0\mu_r\frac{N^2 I S}{l}$

$\Phi_t = L\cdot I \rightarrow L = \mu_0\mu_r\frac{N^2 S}{l}$

Regula lui Lenz



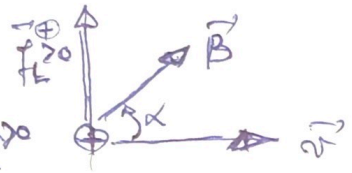
* Forta Lorentz

$F_{em} = I(\vec{\ell} \times \vec{B})$ $\quad I = \frac{ne}{t} = \frac{q}{t}$

$$\begin{cases} \vec{f} = \frac{\vec{F}_{em}}{n} = \frac{ne}{nt}(\vec{\ell} \times \vec{B}) = \frac{ne}{n}\left(\frac{\vec{\ell}}{t} \times \vec{B}\right) = \\ \boxed{\vec{f}_L = e(\vec{v} \times \vec{B})} = \boxed{q(\vec{v} \times \vec{B} = \vec{f}_L)} \end{cases}$$

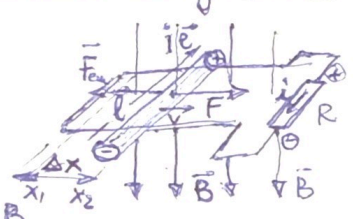
$$f_L = qvB\sin\alpha$$

$$\begin{cases} \vec{f}^{(+)} > 0, \ q > 0 \quad \alpha = \sphericalangle(\vec{v}, \vec{B}) \\ \vec{f}^{(-)} < 0, \ q < 0 \end{cases}$$



* Legea inductiei el-magnetice

$\Delta V = U \overset{def}{=} \frac{L}{q}$



$L = F \cdot \Delta x$

$q = i \cdot \Delta t$

$\vec{F} = -\vec{F}_{em} = -i\vec{\ell}\vec{B}$

$$\begin{cases} \Delta x = v \cdot \Delta t \\ \Delta S = \ell \cdot \Delta x = S_2 - S_1 = \ell(x_2 - x_1) = \ell(v \cdot \Delta t) \end{cases}$$

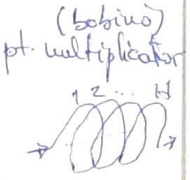
$L = -F_{em} \cdot \Delta x = -i\ell B \Delta x = -i \cdot B \cdot \Delta S = -i \cdot \Delta\phi$

$U \equiv e \equiv \frac{L}{q} = \frac{-i \cdot \Delta\phi}{i \cdot \Delta t} = \boxed{-\frac{\Delta\phi}{\Delta t} = e}$; $\boxed{e = -N \cdot \frac{\Delta\phi}{\Delta t}}$ pt. (bobina) cu multiplicator

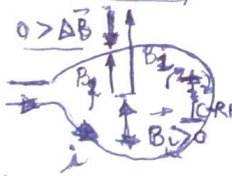
$i = \frac{e}{R} = -\frac{\Delta\phi/\Delta t}{R} = -\frac{B \cdot \Delta S}{R \cdot \Delta t} = -B \cdot \frac{v \cdot \ell}{R}\left[\frac{\Delta t}{\Delta t}\right]$

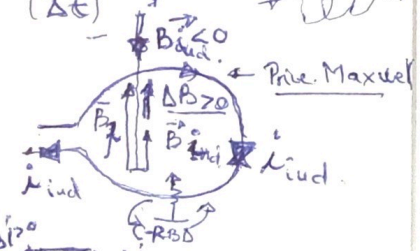
$\boxed{e = \ell v B = \ell(\vec{v} \times \vec{B})}$

$L = qU = q \cdot e$



* Regula lui Lentz



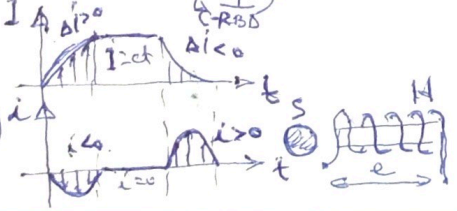


* Autoinductia

$e = -\frac{\Delta\phi}{\Delta t}$, $\phi = L \cdot i$, $\Delta\phi = L \cdot \Delta i$

$\boxed{e = -L\left[\frac{\Delta i}{\Delta t}\right]}$; $\boxed{L \overset{def}{=} \frac{\phi}{I}}$; $\frac{Wb}{A} = H$ (Henry)

$i = \frac{e}{R} = -\frac{L}{R}\left[\frac{\Delta i}{\Delta t}\right]$; $L = \mu\frac{N^2 S}{\ell}$



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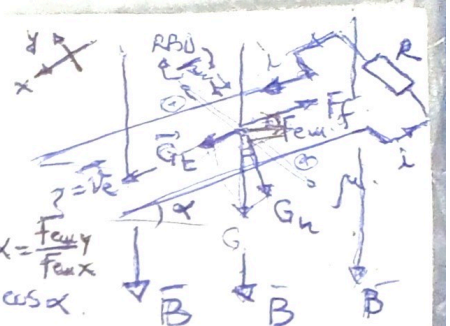
$\ell = 0,1$ m
$\alpha = 30°$
$R = 0,1\Omega$
$m = 0,02$ kg
$\mu = 0,2$
$B = 0,5$ T

$v_c = ?$

$$\begin{cases} G_t - F_f - F_{em} = 0 \ (1) \\ F_f = \mu \cdot N = \mu G_n \ (2) \end{cases}$$

$$\begin{cases} e = B\ell v \\ i = \frac{e}{R} = \frac{B\ell v}{R} : \frac{F_{em}}{\sin\alpha} \end{cases}$$

$$\begin{cases} G_t = mg\sin\alpha \\ G_n = mg\cos\alpha \end{cases} \ (2) \qquad F_f = \mu \cdot mg\cos\alpha$$



$mg\sin\alpha - \mu mg\cos\alpha - i\ell B = 0$

$mg(\sin\alpha - \mu\cos\alpha) - \frac{B^2\ell^2 v_c}{R} = 0 \rightarrow v_c\frac{B^2\ell^2}{R} = mg(\sin\alpha - \mu\cos\alpha)$

$$\Rightarrow \boxed{v_c = \frac{R}{B^2\ell^2} mg(\sin\alpha - \mu\cos\alpha)}$$

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$\begin{cases} m_1 = m_2 \\ R_1 = R_2 \end{cases}$

$\left(\frac{\rho_1}{\rho_2}\right) = f = 0,5$

$(D_1/D_2) \overset{(**)}{=} n = 2$

$d_1/d_2 = ?$

$m_1 = m_2$

$\begin{cases} \ell_{01} \cdot S_{01} = \alpha_2 \cdot \ell_{02} \cdot S_2 \\ \ell_2 = \ell_1\left(\frac{S_1}{S_2}\right) \ (*) \end{cases}$

$S_1 = \frac{\pi D_1^2}{4}$ $\quad S_2 = \frac{\pi D_2^2}{4}$

$\begin{cases} \rho_2 = \rho_1/f \\ D_2 = D_1/n \end{cases}$

$\begin{cases} R_1 = R_2 \\ \rho_1\frac{\ell_1}{S_1} = \rho_2\frac{\ell_2}{S_2} \rightarrow \rho_1\frac{\ell_1 \cdot 4}{\pi D_1^2} = \rho_2\frac{\ell_2 4}{\pi D_2^2} \ (**) \end{cases}$

$\rho_1\left(\frac{4 \cdot \ell_1}{\pi D_1^2}\right) = \left(\frac{\rho_1}{f}\right)\frac{4}{\pi}\frac{\pi D_1^2}{n^2}$

2.4/118

RE

ρ_0, S_0, ℓ_0, t_0

$\alpha = 3,92 \cdot 10^{-3}$ grd^{-1}

$S_0 = 0,2$ mm^2

$\ell_0 = 20$ m

$t_0 = 20°C$

$\rho_0 = 11 \cdot 10^{-6}\Omega$m

$R = 53\Omega$

$t = ?$ $(R = 53\Omega)$

$$\begin{cases} R = R_0(1 + \alpha \cdot \Delta t) = \left(\rho_0\frac{\ell_0}{S_0}\right)(1 + \alpha t) \\ R_0 = \left(\rho_0\frac{\ell_0}{S_0}\right) \end{cases}$$

$\frac{R \cdot S_0}{\rho_0 \cdot \ell_0} = (1 + \alpha \cdot t) \rightarrow \boxed{t = \left[\frac{RS_0}{\rho_0\ell_0} - 1\right]/\alpha}$

Se înlocuiesc val. în S.I.

$$\begin{cases} t = \left[\frac{(53\Omega)(0,2 \cdot 10^{-6}\Omega m^2)}{11 \cdot 10^{-6}\Omega m \cdot 20 m} - 1\right]/3,92 \cdot 10^{-3} grd^{-1} = \\ t \simeq 994°C = (994 - 273)K = 721\,K \end{cases}$$