GAUSSOV ZAKON

$$\oint_S \vec{B}\,\vec{n}\,dS = 0$$

$$\boxed{\Phi = \int_S \vec{B}\,\vec{n}\,dS}$$

tok kojeg proizvodi žica

normala dS-a

$$\boxed{\Phi = \oint_c \vec{A}\,\vec{n}\,d\vec{l}}$$

$$\operatorname{div}\vec{B} = \nabla\cdot\vec{B} = \frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y} + \frac{\partial B_z}{\partial z} = 0 \Rightarrow \text{KARTEZIJEV } (x, y, z)$$

$$\nabla\cdot\vec{B} = \frac{1}{r}\left[\frac{\partial}{\partial r}(r\cdot B_r)\right] + \frac{1}{r}\frac{\partial B_\alpha}{\partial \alpha} + \frac{\partial B_z}{\partial z} = 0 \Rightarrow \text{CILINDRIČNI } (r, \alpha, z)$$

$$\nabla\vec{B} = \frac{1}{r^2}\left[\frac{\partial}{\partial r}(r^2 B_r)\right] + \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial\theta}(B_\theta \sin\theta)\right] + \frac{1}{r\cdot\sin\theta}\frac{\partial B_\alpha}{\partial\alpha} = 0 \Rightarrow \text{SFERNI } (r, \theta, \alpha)$$

BIOT-SAVAROV ZAKON

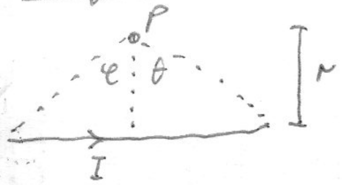
$$\boxed{\vec{B} = \frac{\mu_0}{4\pi}\int_S \frac{\vec{K}\times\vec{R}}{R^3}\,dS}$$

$$\vec{B} = \frac{\mu_0}{4\pi}\int_S \frac{\vec{K}\times\vec{R}}{R^3}\,dS \qquad \vec{B} = \frac{\mu_0}{4\pi}\int_V \frac{\vec{J}\times\vec{R}}{R^3}\,dV$$

$$\boxed{\vec{R} = \vec{r} - \vec{r}'}$$

$$\boxed{\vec{B} = \frac{1}{2}\mu_0 I \frac{r_0^2\,\vec{a}_z}{(r_0^2+z^2)^{3/2}}}$$

strujnica



odredi se pravilom desne ruke

$$\vec{B} = \frac{\mu_0 I}{4\pi r}(\sin\varphi + \sin\theta)\,\vec{a}_x$$

∞ duga strujnica

$$\vec{B} = \frac{\mu_0 I}{2\pi r}\,\vec{a}_x$$

kružna petlja

$$\vec{B} = \frac{\mu_0 I}{4\pi}\int_\alpha \frac{z\,\vec{a}_r + r_0\,\vec{a}_z}{(r_0^2+z^2)^{3/2}}\,r_0\,d\alpha$$

r_0 - polumjer petlje

z - udaljenost točke u kojoj tražimo $\vec{B}$ od središta petlje

-> PUNA KRUŽNA PETLJA $\Rightarrow \boxed{\vec{a}_r \Rightarrow 0}$

AMPEREOV ZAKON

$$\boxed{\oint_c \vec{B}\,d\vec{l} = \mu_0 \iint_S \vec{J}\,\vec{n}\,dS = \mu_0 I} \qquad \boxed{\nabla\times\vec{B} = \mu_0\vec{J}} \qquad \boxed{J = \frac{I}{A}} \qquad \boxed{\vec{H} = \frac{\vec{B}}{\mu_0}}$$

-(+) smjer obilaska krivulje c i normala $\vec{n}$ na površinu S povezani su pravilom DESNE ruke (palac daje (+) smjer normale na površinu

MAGNETSKI KRUGOVI

$$R_{magnetski} = \frac{\oint_c \vec{H}\,d\vec{l}}{\int_S \mu\vec{H}\,\vec{n}\,dS}\left[1/H\right] \qquad NI = \oint_c \vec{H}\,d\vec{l} \rightarrow \text{mag. pobuda}$$

$$\Phi_{magnet.} = \int_S \vec{B}\,\vec{n}\,dS$$

$l_{SR} = N \cdot I = \theta$

↳ duljina mag. silnica

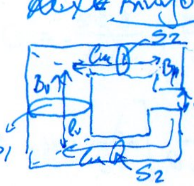
$$\boxed{R_{mg} = \frac{\theta}{\Phi} = \frac{1}{\mu}\frac{l_{SR}}{S_{SR}}}$$

$$\boxed{\Phi = \frac{N \cdot I}{R_m}}$$

$$\boxed{L = \frac{N \cdot \Phi}{I} = \frac{N^2}{R_{m\,uk}}}$$

$$\boxed{I = \frac{R_m B_0 S_m}{N}} \rightarrow \text{pozdrav}$$

Primjer



$$N \cdot I = H_v \cdot l_v + H_m(l_m + l_m) + H_\delta \cdot \delta$$

$$H_\delta = \frac{B_m}{\mu_0}$$

...ZIJSKI MAG. KRUG

$$R_m = \frac{H_1 \cdot l_1}{B_1 \cdot S_1} + \ldots + \frac{H_n \cdot l_n}{B_n \cdot S_n}$$

...TORSKI MAG. POTENCIJAL $\vec{A}$

$$\vec{B} = \nabla \times \vec{A} \qquad \nabla \cdot \vec{A} = 0 \qquad \Phi = \oint_C \vec{A}\,\vec{n}\,dl$$

Coulombovo baždarenje, $\boxed{\Delta \vec{A} = -\mu J_s}$ formule 121. str.

...TEZIJEV

$$\nabla \times \vec{A} = \vec{a_x}\left(\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z}\right) + \vec{a_y}\left(\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x}\right) + \vec{a_z}\left(\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}\right)$$

...DRIČNE

$$\nabla \times \vec{A} = \vec{a_r}\left(\frac{1}{r}\frac{\partial A_z}{\partial \alpha} - \frac{\partial A_\alpha}{\partial z}\right) + \vec{a_\alpha}\left(\frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r}\right) + \vec{a_z}\,\frac{1}{r}\left[\frac{\partial}{\partial r}(r \cdot A_\alpha) - \frac{\partial A_r}{\partial \alpha}\right]$$

...NE (r, θ, α)

$$\nabla \times \vec{A} = \vec{a_r}\,\frac{1}{r \sin\theta}\left[\frac{\partial}{\partial \theta}(\sin\theta \cdot A_\alpha) - \frac{\partial A_\theta}{\partial \alpha}\right] + \vec{a_\theta}\,\frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial A_r}{\partial \alpha} - \frac{\partial}{\partial r}(r \cdot A_\alpha)\right] +$$

$$+ \vec{a_\alpha}\,\frac{1}{r}\left[\frac{\partial}{\partial r}(r \cdot A_\theta) - \frac{\partial A_r}{\partial \theta}\right]$$

$$\vec{A}(\vec{r}) = \frac{\mu}{4\pi}\int_V \frac{\vec{J}(\vec{r'}) \cdot dV}{|\vec{r} - \vec{r'}|} \qquad \vec{A}(\vec{r}) = \frac{\mu}{4\pi}\int_S \frac{k(\vec{r'}) \cdot dS}{|\vec{r} - \vec{r'}|}$$

$$\vec{A}(\vec{r}) = \frac{\mu I}{4\pi}\int_l \frac{dl}{|\vec{r} - \vec{r'}|}$$

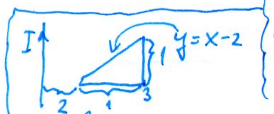
...KTIVITET I MEĐUINDUKTIVITET

$$L = \frac{\Phi}{I} \qquad \Psi = N \cdot \Phi \qquad L = \frac{N \cdot \Phi}{I}$$

$$M = k\sqrt{L_1 \cdot L_2}$$

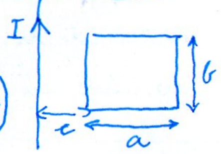
$$M = k_1 \cdot k_2$$

$$M = k_2 \cdot N_1 \cdot \frac{L_2}{N_2}$$



$$\Phi = \int_2^3 B y\,dx = \ldots$$

$$\Phi = \frac{\mu_0 I b}{2\pi}\ln\left(\frac{c+a}{c}\right)$$



$$\Phi = \int \frac{\mu_0 I}{2\pi x}\,dS$$

$$W = \frac{1}{2}\sum_{i=1}^{n} I_i \cdot \Phi_i \qquad W = \frac{1}{2}\int_V \vec{B}\,\vec{H}\,dV$$

Mag. energija strujnog kruga

$$W = \frac{1}{2} I \cdot \Phi = \frac{1}{2} L \cdot I^2 = \frac{1}{2L}\Phi^2$$

Mag. energija dva strujna kruga

$$\Phi_1 = L_1 I_1 \pm M I_2 \qquad \Phi_2 = L_2 I_2 \pm M I_1$$

+ - mag. Φ se podudaraju

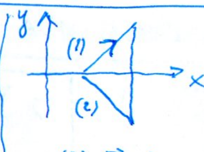
- - ne podudaraju

$$W = \frac{1}{2}L_1 I_1^2 + \frac{1}{2}L_2 I_2^2 \pm M I_1 I_2$$

$$W = \frac{1}{2}\frac{\Phi_{11}^2}{L_1} + \frac{1}{2}\frac{\Phi_{22}^2}{L_2} \pm \frac{\Phi_{12} \cdot \Phi_{21}}{M}$$

SILA NA VODIČ PROTJECAN STRUJOM

$$\vec{F} = \int_l I(d\vec{l} \times \vec{B}) \qquad \vec{F} = \int_V (\vec{J} \times \vec{B})\,dV$$



$$(2)\; d\vec{l} = (-\vec{a_x}dx - \vec{a_y}dy)$$

$$y'(x) \ldots dy = \ldots dx$$

$$W = \int \vec{F}\,d\vec{s} \rightarrow \text{pomicanje vodiča po putu}$$

$$F_{1,2} = \mu_0 \mu_r \frac{I_1 \cdot I_2 \cdot l}{2\pi r}$$

l – duljina vodiča, r – udaljenost između vodiča

$$\vec{F_x} = \vec{a_x} I_1 I_2 \frac{\partial M}{\partial x} \qquad \vec{F_y} = \vec{a_y} I_1 I_2 \frac{\partial M}{\partial y}$$

FARADAY-ev ZAKON

$$\boxed{e = \oint_c \vec{E}_{ind} \cdot d\vec{l} = -\frac{d\Phi}{dt} = -\frac{d}{dt}\iint_S \vec{B}\,\vec{n}\,dS}$$

1) Ako petlja miruje

$$\oint \vec{E}\,d\vec{l} = -\iint_S \frac{\partial \vec{B}}{\partial t}\,\vec{n}\,dS$$

2) ako se petlja kreće

$$\oint \vec{E}\,d\vec{l} = \oint (\vec{v} \times \vec{B})\,d\vec{l}$$

3) ako dva djeluju

$$\oint \vec{E}\,d\vec{l} = -\iint_S \frac{\partial \vec{B}}{\partial t}\,\vec{n}\,dS + \oint_c (\vec{v} \times \vec{B})\,d\vec{l}$$

$$\boxed{\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}}$$

$$\boxed{e = -L\frac{di}{dt} = -M\frac{di}{dt}}$$

$\nabla\cdot\vec B = 0 \Rightarrow \oint_S \vec B\,\vec n\, dS = 0$

$\nabla\cdot\vec D = \rho_s \Rightarrow \oint_S \vec D\,\vec n\, dS = \iiint_V \rho_s\, dV$

gustoća el. naboja

$\nabla\times\vec E = -\frac{\partial \vec B}{\partial t} \Rightarrow \oint_c \vec E\, d\vec l = -\frac{d}{dt}\iint_S \vec B\,\vec n\, dS$

$\boxed{\vec D = \varepsilon\vec E \quad \vec B = \mu\vec H \quad \vec J = \kappa\vec E}$

$\boxed{\vec N = \vec E\times\vec H}$ -> Poyntingov vektor

$\boxed{P = \oint_S (\vec E\times\vec H)\,\vec n\, dS = \oint_S \vec N\,\vec n\, dS}$

$w_M = \frac{1}{2}\mu|\vec H|^2$
gustoća en. pohranjene u mag. polju

$w_E = \frac{1}{2}\vec E\cdot\vec D$
GUSTOĆA POHRANJENE ENER. U ELEKTRIČNOM POLJU

$\boxed{\vec E = -\nabla\varphi}$

...SKI PROMJENJIVA POLJA I FAZORI

$= -j\omega\underline{\vec B}$

$= \underline{\vec J} + j\omega\underline{\vec D}$

$= \underline{\rho_s}$

$= 0$

$\nabla\underline J = -j\omega\underline\rho$
JED. KONTINUITETA

$W_{m,SR} = \frac{\mu}{4}\iiint |\underline{\vec H}|^2 dV$
SR. ENERGIJA MAG. POLJA

$\vec N_{SR} = \frac{1}{T}\int_0^T (\vec E\times\vec N)\,dt$

$W_{e,SR} = \frac{\varepsilon}{4}\iiint_V |\underline{\vec E}|^2 dV$
SR. ENER. ELEKTR. POLJA

$P_{g,SR} = \frac{1}{2\kappa}\iiint_V |\underline{\vec J}|^2 dV$
SREDNJI GUBITCI

$\boxed{\vec N_{SR} = \frac{1}{2}|\vec N|}$

$\oint_S \underline{\vec N}\,\vec n\, dS = -P_{g,sr} + 2j\omega(W_{e,SR} - W_{m,SR})$

...ONA SR. SNAGA SINUSNOG POLJA KOJA U JEDINICI ...ENA PROTEČE PLOHOM S

...OVI U SREDSTVIMA BEZ GUBITAKA

BRZINA PROSTIRANJA VALA

...m $v = 3\cdot 10^8$ m/s

$H_y^+ = \frac{E_x^+}{Z} \quad H_y^- = \frac{-E_x^-}{Z}$

$\lambda = \frac{2\pi}{\omega\sqrt{\mu\varepsilon}}$

$\vec p^{\,+} = \frac{(E_x^+)^2}{Z}\vec a_z$

$\vec p^{\,-} = -\frac{(E_x^-)^2}{Z}\vec a_z$

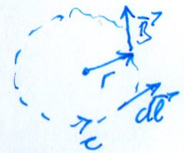
$\boxed{v_f = \lambda\cdot f}$

VALNI OTPOR SREDSTVA BEZ GUBITAKA

$\beta = \omega\sqrt{\mu\varepsilon}$ -> FAZNA

$\mu_0 = \mu$

struja na Amperovoj dubočina membrani Amperovom membranom



$\vec B d\vec l = B\,dl$

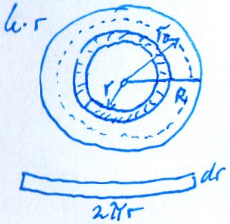
$\mu_0 J\cdot\pi r^2 = B\oint_c dl$

$\mu_0 J\pi r^2 = B\, 2\pi r$

$\boxed{B = \frac{\mu_0 J r}{2}}$

Amperov zakon primjer 2

$J = k\cdot r$



$dI_{prsten} = J\, dA$

$J = \frac{dI}{dA}$

$dI_{prsten} = (kr)(2\pi r\, dr)$

$I_{\text{prsten Amperove membrane}} = \int_0^{r_0} k\, 2\pi r^2 dr = 2\pi k\frac{r_0^3}{3}$

$\mu_0 I_{AM} = \oint$ ...

$\mu_0 2\pi k\frac{r_0^3}{3} =$ ...

$B = \frac{\mu_0 k \ldots}{3}$

$\boxed{\vec E = \frac{\omega\mu}{\beta^2}(\vec H\times\vec\beta)}$

$\cos(\omega t - \vec\beta\vec r + \varphi)$
opći zapis

$v = \frac{1}{\sqrt{\mu\ldots}}$

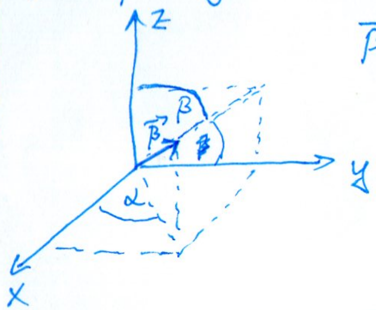
$\boxed{Z = Z_0\sqrt{\frac{\mu_r}{\varepsilon_r}}}$

$\boxed{\vec\beta\cdot\vec E = 0}$

$\boxed{\vec E\perp\vec\beta \quad \vec H\perp\vec\beta}$

$Z = \frac{E}{H}$ val...

KADA $\vec\beta$ dolazi ovako



$\vec\beta = \beta(\sin\beta\cos\alpha\,\vec a_x + \sin\alpha\sin\beta\,\vec a_y + \cos\beta\ldots$

$\beta = \omega\sqrt{\mu\varepsilon}$

Bobrović str. 254.

$\vec M = \frac{(\mu_r - 1)}{\mu_0\mu_r}\vec B$
VEKTOR MAGNETIZACIJE

$\vec J = \nabla\times\vec M$
GUSTOĆA STRUJE MAGNETIZACIJE

$\vec K_A = \vec M\times\vec n_s$
AMPEROVA PLOŠNA STRUJA

$e^{i\theta} = \ldots$