Alan Teorisi

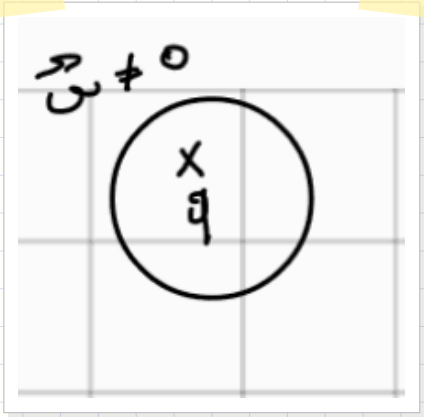
Ders 15: Lorentz kuvveti, magnetik indüksiyon, akım yoğunluğu

Orijinal not: Ders15.pdf

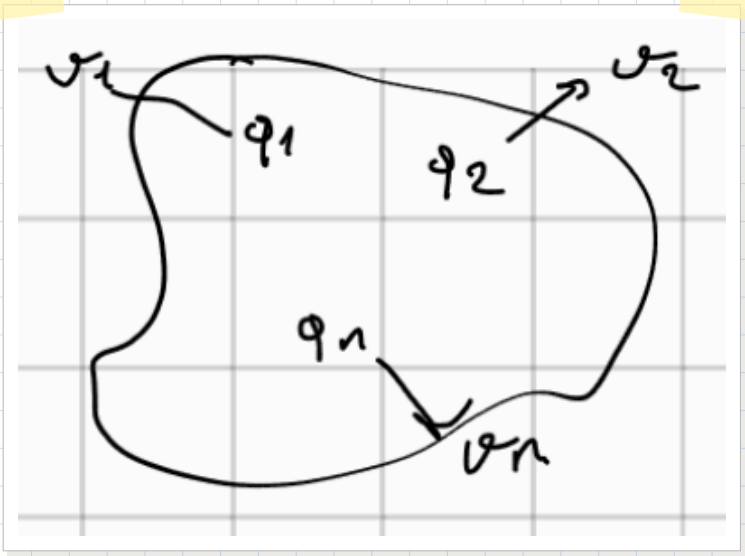
UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

NOTICE *This document was transcribed from handwritten lecture notes with the help of Claude (Anthropic). It is meant as a supplementary resource and may contain errors or omissions. Always check against the original notes and official course material.*

orj. s. 1



orijinal çizim, s. 1

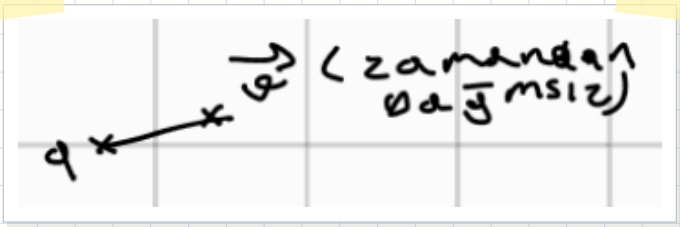


orijinal çizim, s. 1

q_i: $i = 1,2,\ldots,n$

$\vec{E}$ q_i'lerin yarattığı alansa, ? yüklerde q'ya göre hareket halinde ise o zaman gözlenen $\vec{F}$ kuvveti $q\vec{E}$'den farklı olur ve bu fark q'ya ve q'nun $\vec{v}$'sine dik olacak şekilde ortaya çıkan magnetik indüksiyon vektörü adı verilir ve bu hareketli yükler tarafından yaratılıyor.

$$\vec{F} = q \cdot \vec{E}$$



orijinal çizim, s. 1

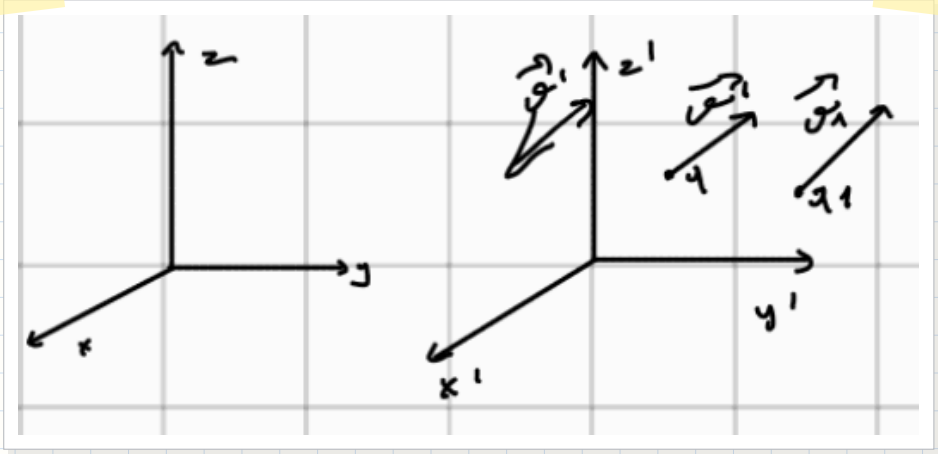
$$\vec{F} - q\vec{E} = q\vec{v} \times \vec{B}$$

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B} \quad \leftarrow \text{Lorentz kuvveti}$$

$$= q(\vec{E} + \vec{v} \times \vec{B}) \qquad \vec{B}\,?$$

$\vec{E}$'yi yaratan kaynaklar durgun yükler

$\vec{B}$'yi " " hareketli yükler



orijinal çizim, s. 1

"iki ayrı gözlemci"

$$\vec{v} = \vec{v}_1$$
$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$
$$\vec{F}'_1 = q_1(\vec{E}' + \vec{v}' \times \vec{B}')$$

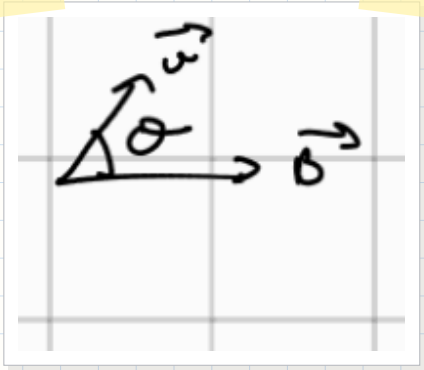
(Son satırda $\vec{v}' \times \vec{B}'$ terimi çizilmiş.)

q_i : $\vec{v}_i = 0$ $\vec{B} = 0$

$\vec{v}_i \neq 0$ $\vec{B} \neq 0$ (t'den bağımsız)

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B}) = q\vec{E} + q\vec{v} \times \underbrace{\vec{B}}_{\substack{\text{Tesla} \\ \text{Weber/m}^2}}$$

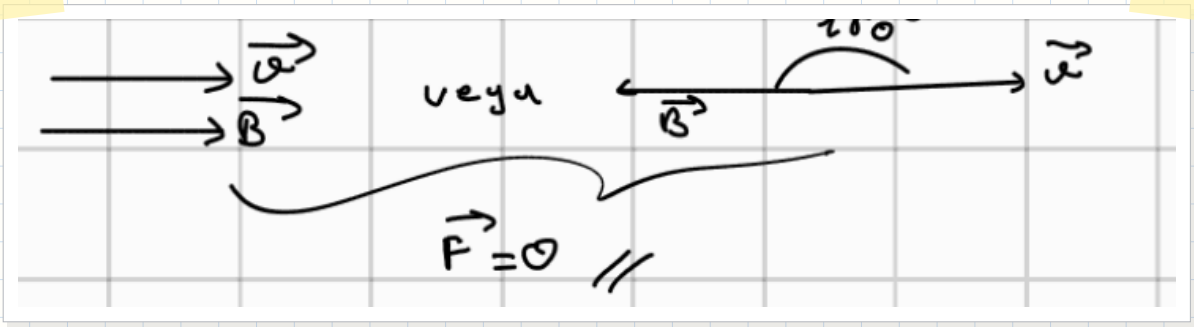
$\vec{F} = q\vec{v} \times \vec{B}$ $\vec{B} = 1\,\mathrm{T}$



orijinal çizim, s. 1

$|\vec{F}| = |q|\,|\vec{v}|\,|\vec{B}| \cdot \sin\theta$

$\vec{v} \parallel \vec{B}$



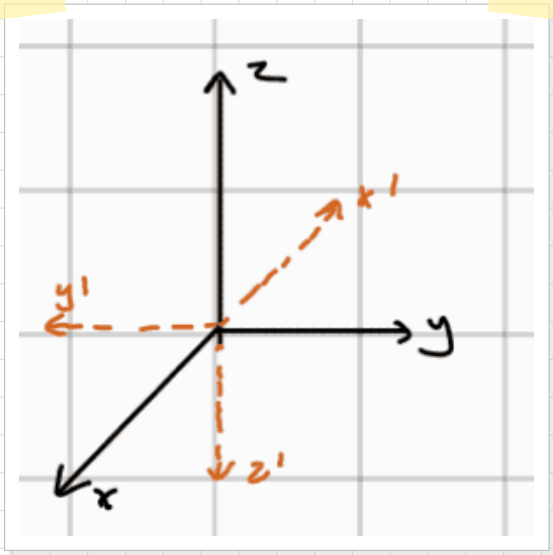
orijinal çizim, s. 1

$\vec{F} = 0$

$\vec{F} = q(\vec{v} \times \vec{B} + \vec{E})$

$-\vec{F} = q(-\vec{v} \times \vec{B}' - \vec{E}')$

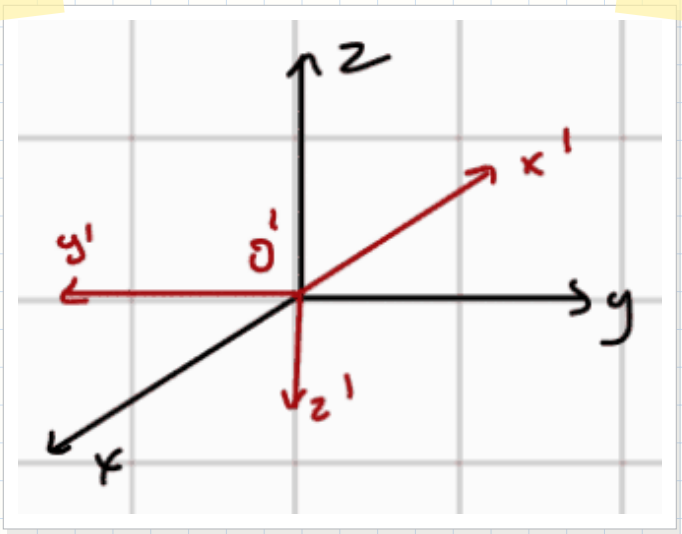
$\Downarrow \quad \vec{B}$



orijinal çizim, s. 1

$\vec{B}' \neq -\vec{B}$
$\vec{E}' = -\vec{E}$ ✓
$\vec{v}' = -\vec{v}$ ✓
$\vec{F}' = -\vec{F}$ ✓

orj. s. 2 Pr 2 $\vec{a}(x, y, z)$ $\vec{a}(x', y', z')$



orijinal çizim, s. 2

$$\vec{a}'(x',y',z') = -\vec{a}$$

$$\vec{B} = \operatorname{rot}\vec{a} = \left(\frac{\partial}{\partial x}\vec{e}_x + \frac{\partial}{\partial y}\vec{e}_y + \frac{\partial}{\partial z}\vec{e}_z\right) \times \vec{a}$$

$$\vec{B}' = \operatorname{rot}\vec{a}' = \left(\frac{\partial}{\partial x'}\vec{e}_{x'} + \frac{\partial}{\partial y'}\vec{e}_{y'} + \frac{\partial}{\partial z'}\vec{e}_{z'}\right) \times \vec{a}'$$

$$= \left(-\frac{\partial}{\partial x}\vec{e}_x - \frac{\partial}{\partial y}\vec{e}_y - \frac{\partial}{\partial z}\vec{e}_z\right) \times (-\vec{a})$$

$$= \operatorname{rot}\vec{a} = \vec{B}$$

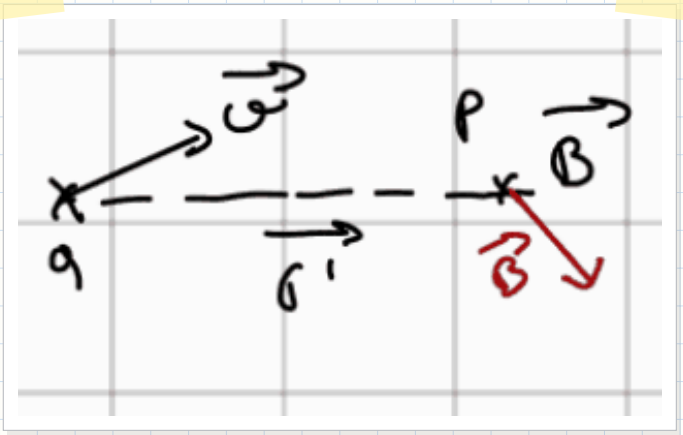
a kutupsal ise rot a eksenel vektördür.



orijinal çizim, s. 2

$$dq = \rho\, dv$$

$$d\vec{B} = dq\,\frac{\vec{v} \times \vec{r}'}{r'^3}$$



orijinal çizim, s. 2

$$\vec{B} \perp \vec{r}' \qquad \vec{B} \perp \vec{v} \qquad |\vec{B}| \sim \frac{1}{r'^2}\, q\, |\vec{v}|$$

$$\vec{B} = q \cdot \frac{\vec{v} \times \vec{r}'}{r'^3} \qquad \vec{a} \times \vec{b} = \vec{c} \text{ ise } \vec{c} \perp \vec{a},\ \vec{c} \perp \vec{b}$$

$$|\vec{B}| = |q|\,|\vec{v}| \cdot \frac{1}{r'^2} \cdot \sin\theta$$

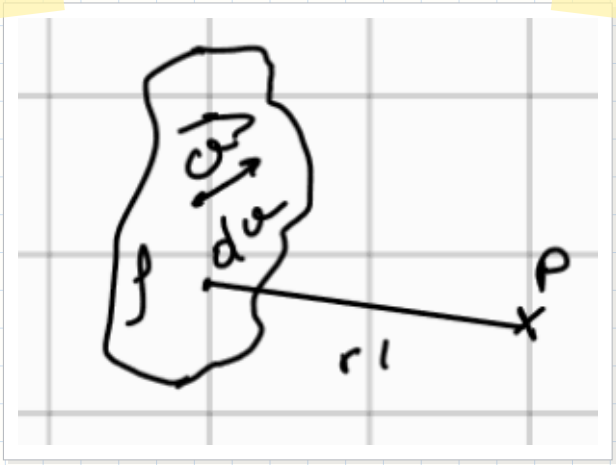
yük yoğunluğu ρ ile dağılmışsa

$$dq = \rho\, dV$$

$$d\vec{B} = dq\, \frac{\vec{v} \times \vec{r}'}{r'^3}$$

$$= \rho\, \vec{v} \times \frac{\vec{r}'}{r'^3}\, dV$$

$$\vec{B} = \int_V d\vec{B} = \int_V \rho\, \vec{v} \times \frac{\vec{r}'}{r'^3}\, dV$$



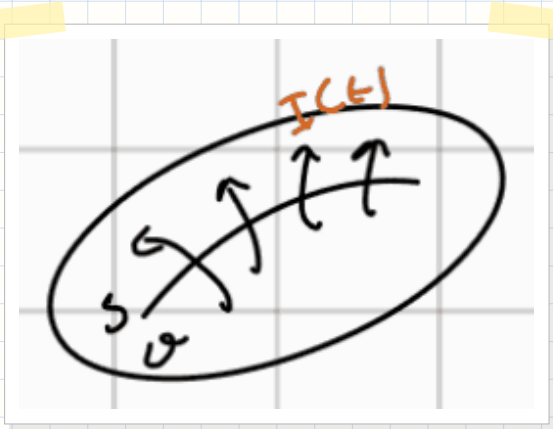
orijinal çizim, s. 2

$$\underbrace{\rho}_{C/m^3} \cdot \underbrace{\vec{v}}_{m/s} \equiv \underbrace{\vec{J}}_{\text{hacimsel akım yoğunluğu}} \qquad (A/m^2) \qquad A = C/s$$

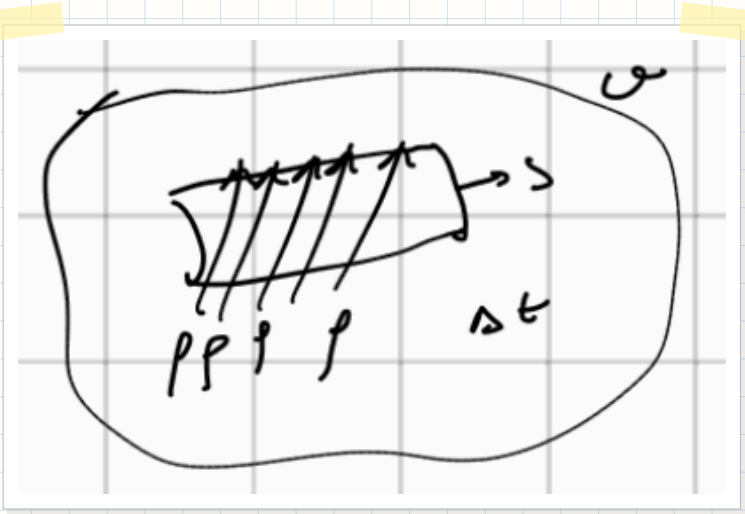
$$\vec{B} = \frac{\mu_0}{4\pi} \int \vec{J} \times \frac{\vec{r}'}{r'^3}\, dv \qquad \vec{J} \parallel \vec{v} \qquad \vec{B} \perp \vec{r}',\ \vec{B} \perp \vec{J}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int \frac{\rho\, \vec{r}'}{r'^3}\, dv$$

orj. s. 3



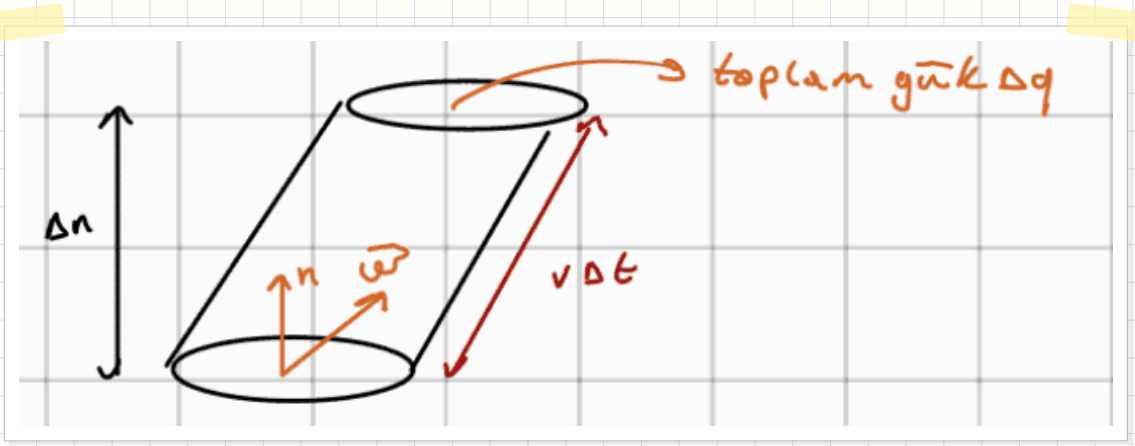
orijinal çizim, s. 3



orijinal çizim, s. 3

$t_0,\ t_0 + \Delta t$

$\lim_{\Delta t \to 0} \frac{\Delta q}{\Delta t} \equiv I_S(t)$ (S'den geçen elektrik akımının tanımı)

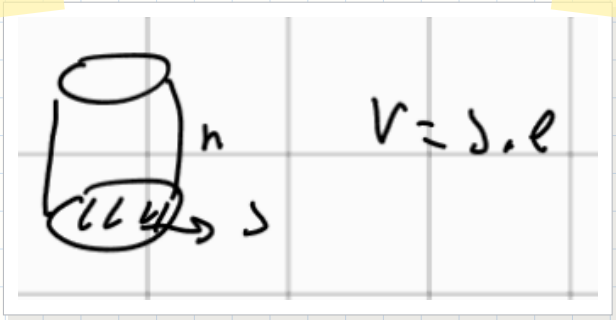


orijinal çizim, s. 3

$\vec{J} = \rho\vec{v}$

$$I_{\Delta S} = \frac{\vec{v} \cdot \vec{n}\, \Delta t\, \Delta S\, \rho}{\Delta t} = \vec{J} \cdot \vec{n}\, \Delta S$$

$$dq = \rho\, dV$$
$$\Delta q = \rho \cdot \underbrace{\vec{v}\, \Delta t \cdot \vec{n}\, \Delta S}_{dV}$$



orijinal çizim, s. 3

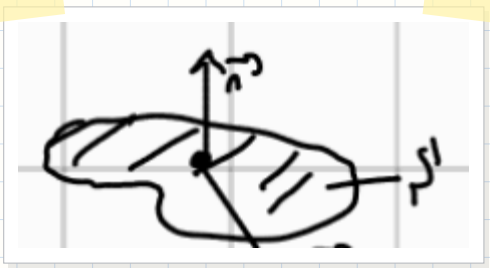


orijinal çizim, s. 3

$$\vec{n} \cdot \underbrace{\vec{h}'}_{\vec{v} \cdot \Delta t} = |\vec{n}|\, |\vec{h}'| \cdot \cos\theta = h' \cos\theta$$

$$\lim_{t \to 0} \frac{\Delta q}{\Delta t} \equiv I_S(t)$$

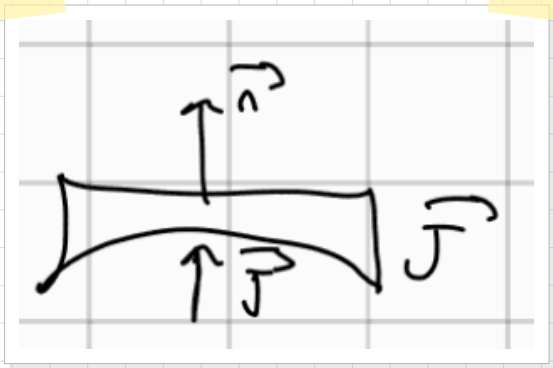
$$dI = \vec{J} \cdot d\vec{S}$$



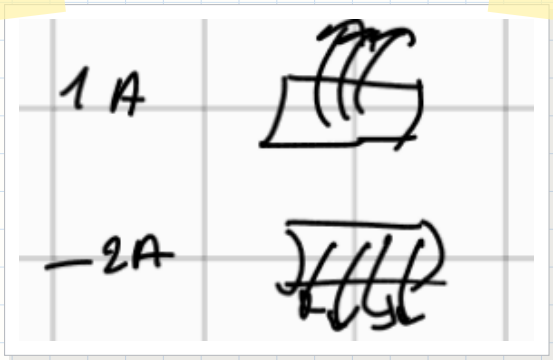
orijinal çizim, s. 3

✓ $$I = \int_S dI = \int_S \vec{J} \cdot d\vec{S} = \int_S \vec{J} \cdot \vec{n}\, dS \qquad d\vec{S} = dS \cdot \vec{n}$$

akım skalerdir



orijinal çizim, s. 3



orijinal çizim, s. 3

$J\,[A/m^2]$

hacim içinden geçen
Akım diye bir şey yoktur
yüzey içinden geçen akım vardır

3.2.1

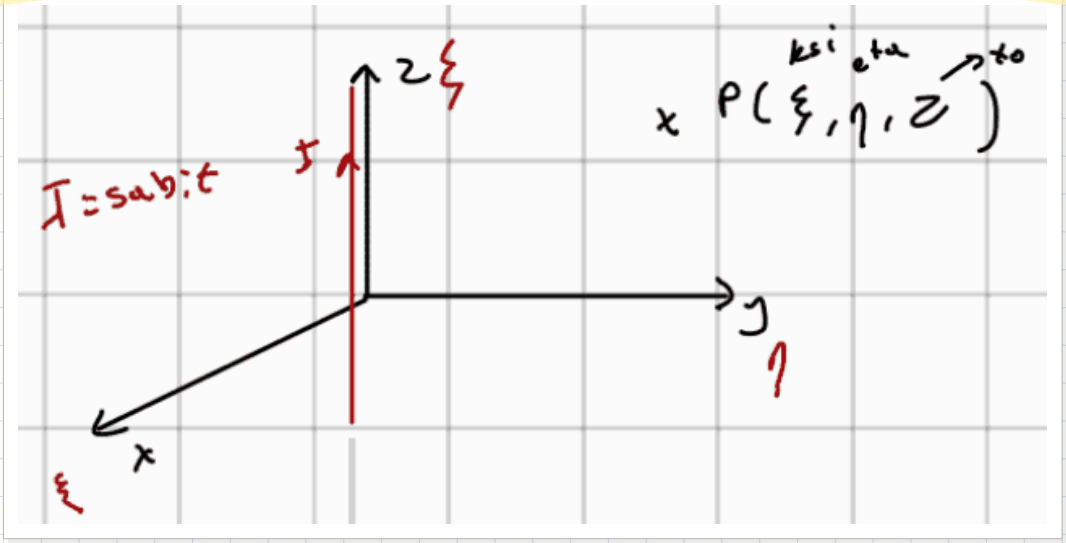
$$H = \frac{1}{4\pi}\int_{-\infty}^{\infty}\left(\mathbf{e}_z \times \frac{\vec{r}'}{r'}\right)\frac{d\xi}{r'^2} = \frac{1}{2\pi\rho}\mathbf{e}_\varphi$$

$$\vec{B} = \mu_0\vec{H} \quad \text{(boşlukta)}$$

orj. s. 4

$$[\vec{H}] = A/m \qquad \mu_0 = 4\pi\cdot 10^{-7}\ H/m$$

$$[\vec{B}] = \underbrace{Wb}_{\text{A.Henry}}/m^2 \equiv T$$



orijinal çizim, s. 4

$$r' = |\vec{r}'| = \sqrt{(x-\xi)^2 + (y-\eta)^2 + (z-\zeta)^2}$$

$$\vec{r}' = (x-$$

$$\vec{J} = I\,\delta(\xi)\,\delta(\eta)\,\vec{e}_z$$

$$\vec{B} = \mu_0 \vec{H} \;\Rightarrow\; \vec{H} = \frac{1}{\mu_0}\vec{B}$$

$$= \frac{1}{4\pi}\iiint I\,\delta(\xi)\,\delta(\eta)\,\vec{e}_z \times \frac{(x-\xi)\vec{e}_x + (y-\eta)\vec{e}_y + (z-\zeta)\vec{e}_z}{\left[(x-\xi)^2 + (y-\eta)^2 + (z-\zeta)^2\right]^{3/2}}\, d\xi\, d\eta\, d\zeta$$

$$\int_{-\infty}^{\infty} \delta(\xi)\, f(\xi)\, d\xi = f(0)$$

$$\Rightarrow\; \vec{H} = \frac{I}{4\pi}\int_{\zeta=-\infty}^{\infty} \frac{x\,\vec{e}_y - y\,\vec{e}_x}{\left[x^2 + y^2 + (z-\zeta)^2\right]^{3/2}}\, d\zeta$$

$$\vec{H} = \frac{I}{4\pi}(x\vec{e}_y - y\vec{e}_x)\int_{-\infty}^{+\infty} \frac{d\zeta}{\left(\sqrt{\rho^2 + (z-\zeta)^2}\right)^3}$$

$$\vec{H} = \frac{I\,(x\vec{e}_y - y\vec{e}_x)}{4\pi}\int_{\psi=+\pi/2}^{-\pi/2} \frac{-\rho\,(1+\tan^2\psi)\,d\psi}{(\rho^2 + \rho^2\tan^2\psi)^{3/2}}$$

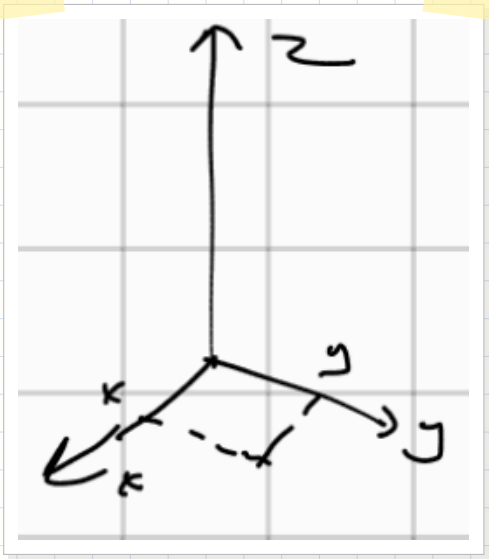
$$= \frac{I\rho\,(x\vec{e}_y - y\vec{e}_x)}{4\pi\rho^3}\int_{-\pi/2}^{\pi/2} \frac{d\psi}{\sqrt{1+\tan^2\psi}}$$

$$= \frac{I}{4\pi\rho^2}\underbrace{(\rho\cos\phi\,\vec{e}_y - \rho\sin\phi\,\vec{e}_x)}_{\vec{e}_\phi}\int_{-\pi/2}^{\pi/2}\cos\psi\, d\psi$$

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

$$= \frac{I}{4\pi\rho}\vec{e}_\phi \cdot \sin\psi\Big|_{-\pi/2}^{\pi/2}$$
$$= \frac{I}{2\pi\rho}\vec{e}_\phi$$

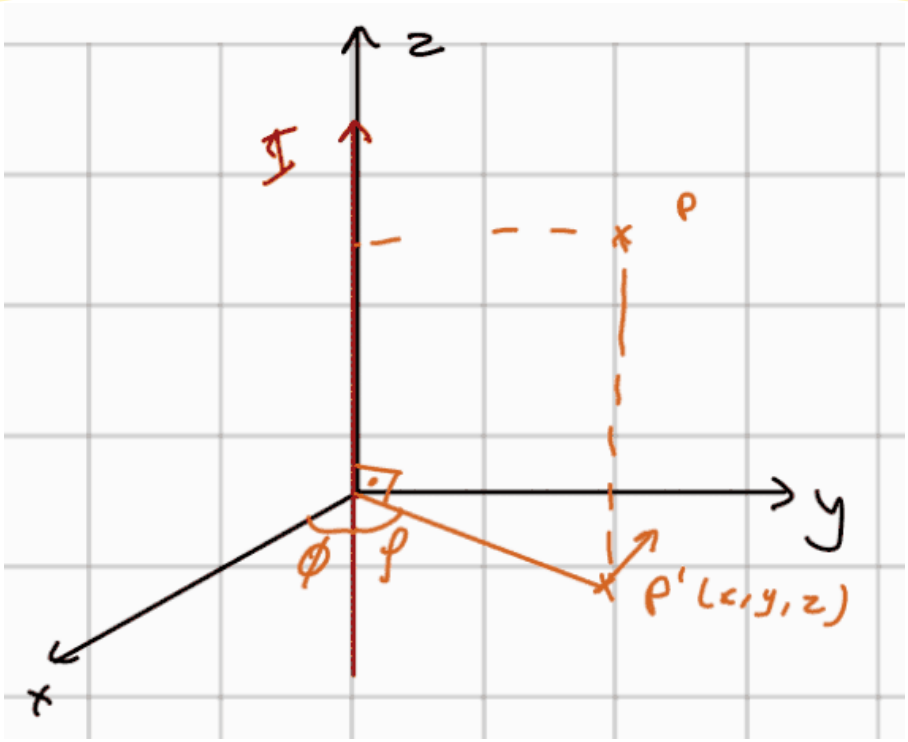
$$\rho = \sqrt{x^2 + y^2}$$



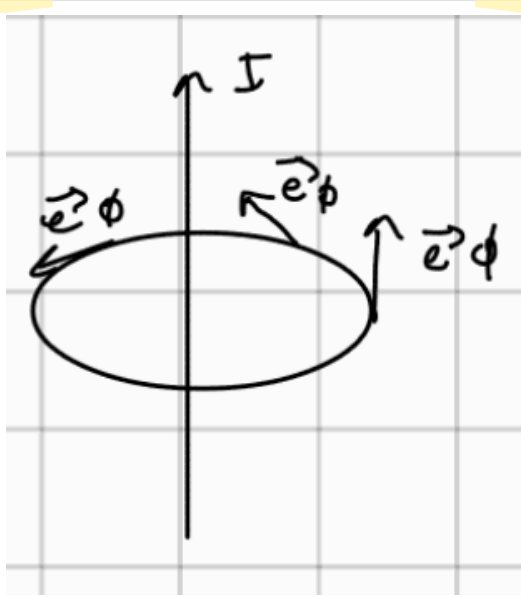
orijinal çizim, s. 4

$$\tan\psi = \frac{z - \zeta}{\rho}$$
$$\rho\,(1 + \tan^2\psi)\,d\psi = -d\zeta$$
$$d\zeta = -\rho\,(1 + \tan^2\psi)\,d\psi$$

orj. s. 5



orijinal çizim, s. 5



orijinal çizim, s. 5

$$\vec{e}_\phi = \cos\phi\,\vec{e}_y - \sin\phi\,\vec{e}_x$$

$$V \longleftrightarrow \vec{A}$$
$$\rho \longleftrightarrow \vec{J}$$
$$\varepsilon_0 \longleftrightarrow \frac{1}{\mu_0}$$

$$\Delta V = -\rho/\varepsilon_0$$
$$\Delta\vec{A} = -\mu_0\vec{J}$$

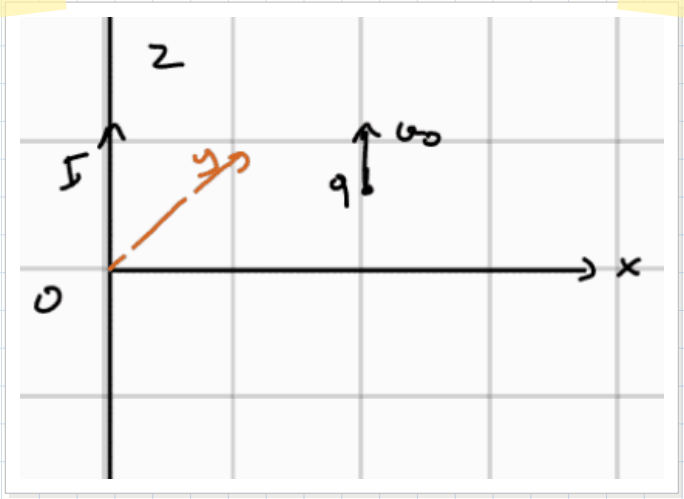
$$\begin{cases} \operatorname{rot}\vec{E} = 0 \\ \operatorname{div}\vec{B} = 0 \end{cases}$$

$$\Delta A = -\mu_0 J$$

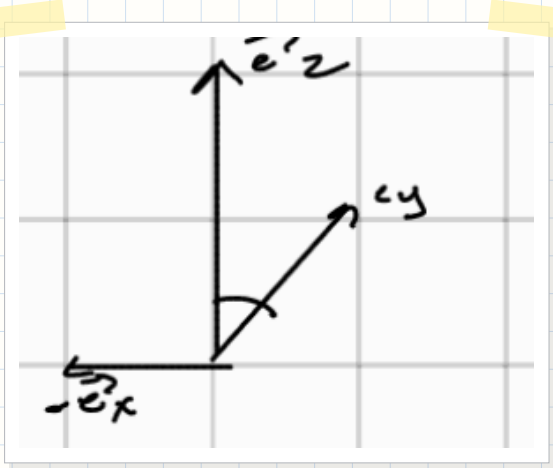
$$\boxed{\vec{H} = \frac{1}{\mu_0}\operatorname{rot}\vec{A}}$$

$\operatorname{div} A = 0$ rot ? okunamadı

Pr 3



orijinal çizim, s. 5



orijinal çizim, s. 5

$$\vec{B} = \frac{\mu_0}{2\pi}\frac{I}{\rho}\vec{e}_\phi$$

$$\vec{B}_q = \frac{\mu_0 I}{2\pi a}\vec{e}_y$$

$$\vec{F}_q = q\vec{v}_0 \times \vec{B}_q$$

$$= qv_0\,\vec{e}_z \times \frac{\mu_0 I}{2\pi a}\vec{e}_y$$

$$\vec{F}_q = -\frac{\mu_0 q v_0 I}{2\pi a}\vec{e}_x$$

$$\vec{F}_I = -\frac{\mu_0 q v_0 I}{2\pi a}\vec{e}_x$$

$$\vec{F}_{I1} = +\frac{\mu_0 q v_0 I_1}{2\pi (b-a)}\vec{e}_x$$

$$\vec{F}_q = \vec{F}_I + \vec{F}_{I1}$$

$$= \frac{\mu_0 q v_0}{2\pi}\vec{e}_x\left(\frac{I_1}{b-a} - \frac{I}{a}\right)$$

$$\vec{F}_q = 0 \implies \frac{I_1}{b-a} - \frac{I}{a} = 0$$

$$\boxed{I_1 = \frac{I(b-a)}{a}}$$

orj. s. 6

Pr 10

$$\vec{F} = \underbrace{I_2\vec{l}}_{q\vec{v}} \times \underbrace{\vec{B}_T}_{\frac{\mu_0}{2\pi}\vec{e}_x\left(\frac{I_3}{b}-\frac{I_1}{a}\right)}$$

$$\vec{B}_1 = \frac{\mu_0 I_1}{2\pi a}(-\vec{e}_x)$$

$$\vec{B}_3 = \frac{\mu_0 I_3}{2\pi b}\vec{e}_x$$

$$\vec{F} = (I_2 l\,\vec{e}_z) \times \left(\frac{\mu_0}{2\pi}\vec{e}_x\left(\frac{I_3}{b} - \frac{I_1}{a}\right)\right)$$

$$= \frac{I_2 l\,\mu_0}{2\pi}\left(\frac{I_3}{b} - \frac{I_1}{a}\right)\vec{e}_y$$

$\vec{F} = 0$ için $\quad \frac{I_3}{b} = \frac{I_1}{a}$

$q\vec{v}\,dt \times \vec{B}$

$\vec{J} \times \vec{B}$

$\|$

$I \cdot \vec{l}$

$$\vec{F} = \int_V (\vec{J} \times \vec{B})\,dv$$

Sene başından geldiğimiz yere kadar 9:30 3 soru ?Ağu 25:

Birtane bundan
Pr dikkate edin
Kalan problemler
3. ödevi ?Aslıhan