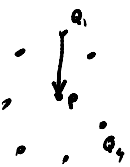
MAGNETISK FELT

Elektrisk felt $\vec{F} = \frac{Q_1 Q_2}{4\pi\epsilon_0} \frac{\hat{R}}{R^2}$

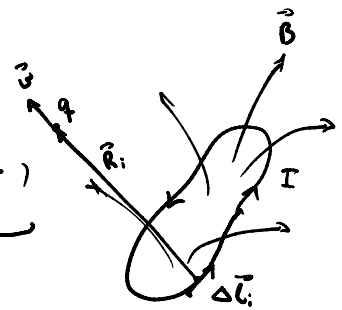
$= Q\vec{E}$ → felt: $\vec{E}(\vec{r})$ $\quad \sum \frac{Q_i}{4\pi\epsilon_0} \frac{\hat{R}_i}{R_i^2}$



Ladninger i bevegelse

$\vec{F} = q\vec{v} \times \underbrace{\left(\sum_i \frac{\mu_0}{4\pi} \frac{I\Delta\vec{l}_i \times \hat{R}_i}{R_i^2} \right)}_{\vec{B}(\vec{r})}$

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

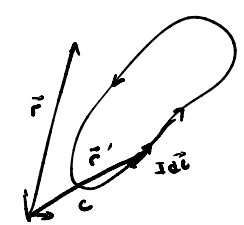


$\vec{R}_i$ fra et element $I\Delta\vec{l}_i$ til obs. punkt

Biot-Savarts lov

$$\vec{B}(\vec{r}) = \sum_i \frac{\mu_0}{4\pi} \frac{I\Delta\vec{l}_i \times \hat{R}_i}{R_i^2}$$

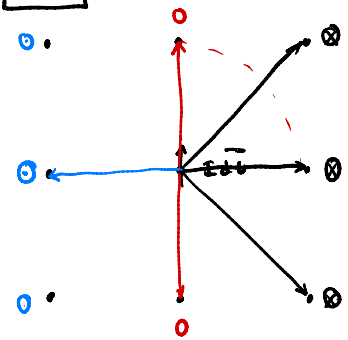
$$= \oint_C \frac{\mu_0}{4\pi} \frac{I\,d\vec{l} \times \hat{R}}{R^2}$$



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

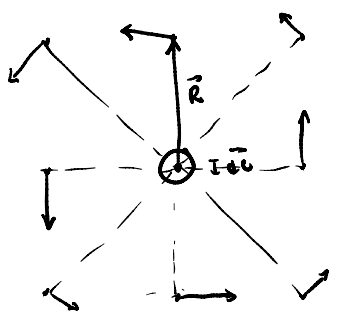
TEST

TEST



a) $\vec{B}$ b) $\vec{B}$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{\ell} \times \hat{R}}{R^2}$$



a) $\vec{R}$, b) $d\vec{B}$

TEST

a) $\vec{R}(\varphi) = -(a\cos\varphi, a\sin\varphi, 0)$

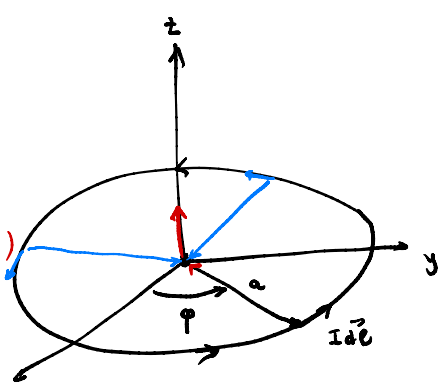
(b) $d\vec{\ell}(\varphi)$

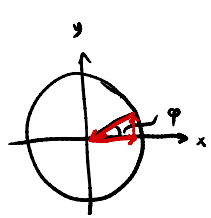
c) $d\vec{B}$ retning $\parallel \hat{z}$

d) $d\vec{B}$ størrelse

$$\frac{\mu_0}{4\pi} \frac{I d\vec{\ell} \times \hat{R}}{R^2} \quad \begin{matrix} d\ell\,\hat{\varphi} \times \\ R^2 = a^2 \end{matrix}$$

$$= d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\ell\, \hat{\varphi}}{a^2}$$





$$\vec{B} = \int d\vec{B} = \oint_C \frac{\mu_0}{4\pi} \frac{I\, d\vec{l} \times \hat{z}}{a^2} = \frac{\mu_0}{4\pi} \frac{I \hat{z}}{a^2} \overbrace{\oint_C dl}^{2\pi a} = \frac{\mu_0}{2\cancel{4}\cancel{\pi}} \frac{I}{a} \cancel{2\pi a} \hat{z}$$

$$\vec{B}(\vec{0}) = \frac{1}{2a} \mu_0 I \hat{z}$$

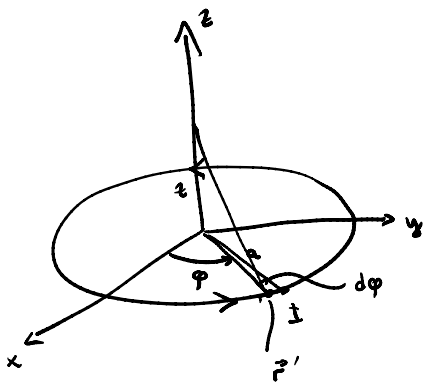
a) Koordinat-metoden

$\vec{R} = \ldots (\quad)$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{l} \times \vec{R}}{R^3}$$

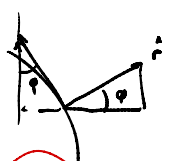
$\vec{r}' = (a\cos\varphi, a\sin\varphi, 0)$

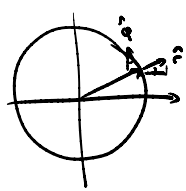
$d\vec{l} = a\, d\varphi\ \hat{\varphi}$



$\hat{r} = (\cos\varphi, \sin\varphi, 0)$

$\hat{\varphi} = (-\sin\varphi, \cos\varphi, 0)$





$\vec{R} = \vec{r} - \vec{r}' = (0,0,z) - (a\cos\varphi, a\sin\varphi, 0)$

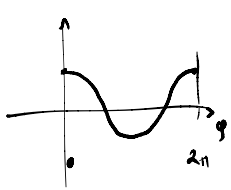
$\vec{R} = (-a\cos\varphi, -a\sin\varphi, z)$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{l} \times \vec{R}}{R^3} = \frac{\mu_0}{4\pi} \frac{I a\, d\varphi\, \hat{\varphi} \times \hat{R}}{R^3}$$

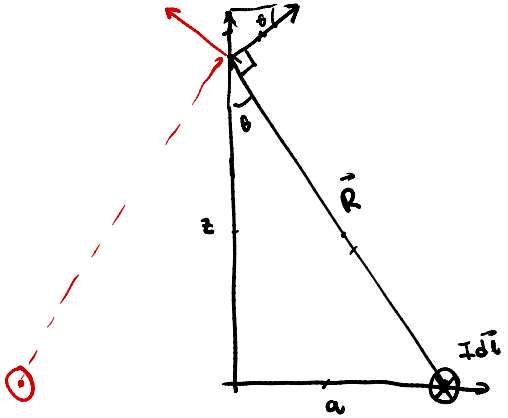
$$\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ -\sin\varphi & \cos\varphi & 0 \\ -a\cos\varphi & -a\sin\varphi & z \end{vmatrix} = (z\cos\varphi, -z\sin\varphi, \overbrace{a\sin^2\varphi + a\cos^2\varphi}^{a})$$

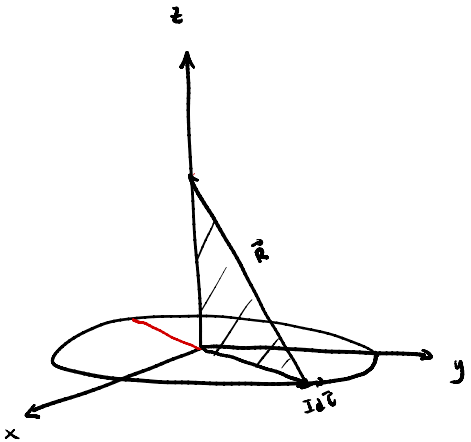
$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I a\, d\varphi\, (z\cos\varphi, -z\sin\varphi, a)}{(a^2 + z^2)^{3/2}}$$

$$\vec{B} = \int d\vec{B} = \int_0^{2\pi} \frac{I a\, d\varphi\, (z\cos\varphi, -z\sin\varphi, a)}{(a^2 + z^2)^{3/2}}$$



$$\vec{B} = \frac{\mu_0}{4\pi} \frac{I a 2\pi a}{(a^2 + z^2)^{3/2}} \hat{z} = \vec{B}(0,0,z)$$





$d\vec{B} \longrightarrow dB_z$

$$\frac{dB_z}{dB} = \frac{a}{R} \qquad dB_z = dB\,\frac{a}{R}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\,\frac{I\,d\vec{l}\times\vec{R}}{R^3} = \frac{\mu_0}{4\pi}\,\frac{I\,dl\,R}{R^3}$$

$$dB_z = \frac{\mu_0}{4\pi}\,\frac{I\,dl\,\ell\,a}{R^3\,R}$$

$$B_z = \oint dB_z = \frac{\mu_0}{4\pi}\,\frac{I\,a}{R^3}\,\overbrace{\oint dl}^{2\pi a} = \frac{\mu_0}{4\pi}\,\frac{I\,a\,2\pi a}{R^3} = \frac{\mu_0}{4\pi}\,\frac{I\,2\pi a^2}{(a^2+z^2)^{3/2}}$$

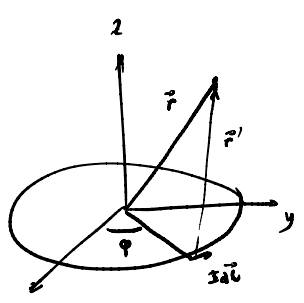
Numerisch

$$d\vec{B} = \frac{\mu_0}{4\pi}\,\frac{I\,d\vec{l}_i\times\vec{R}_i}{R_i^3}$$

$$\vec{R}_i = \vec{r} - \vec{r}_i\,,$$

$$d\vec{l}_i = a\,d\varphi\,(-\sin\varphi, \cos\varphi, 0)$$

$$\vec{R}_i = \vec{r} - \vec{r}_i$$




```
for i in range (N): phi = i/N * 2*π
        ri =        (a * cos(phi), a * sin(phi), 0)
        dli = a * dphi * (-sin(phi), cos(phi), 0)
```

$$R_i = r - r_i$$

$$dB_i = K * I * (dL_i \times R_i) / |R_i|^3$$