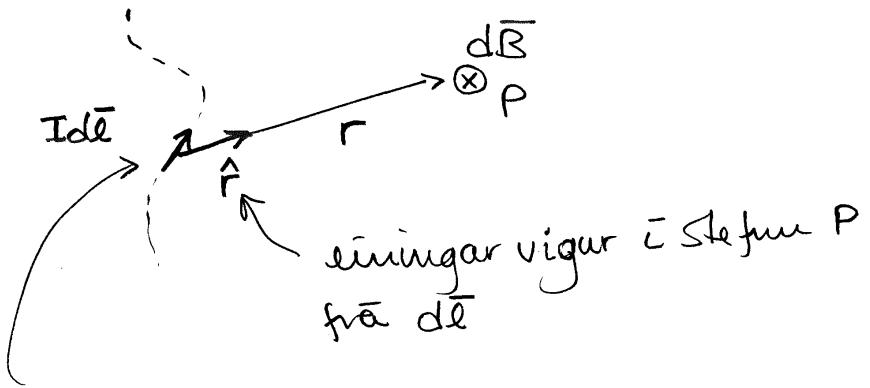
28. Uppspretta segulsviðs

Tilraunir sýna að á leiðara í segulsviði verkar kraftur

$$d\bar{F} = I\, d\bar{\ell} \times \bar{B}$$

eins sýna þær að straumur um leiðara veldur segulsviði utan hans

Lögmál Biot og Savarts

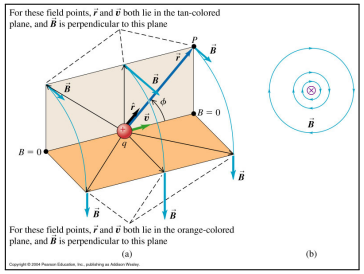


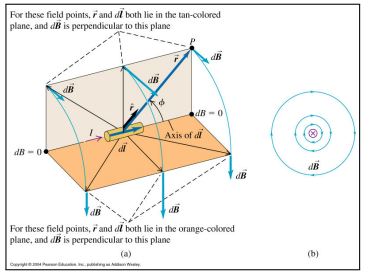
einingar vigur í stefnu P frá $d\bar{\ell}$

straumstyrki í leiðara

$$d\bar{B} = \frac{\mu_0}{4\pi} \frac{I\, d\bar{\ell} \times \hat{r}}{r^2}$$

(hægri handar regla, puttar í $d\bar{\ell} \cdot I$ hinn í segulsviðsst.)





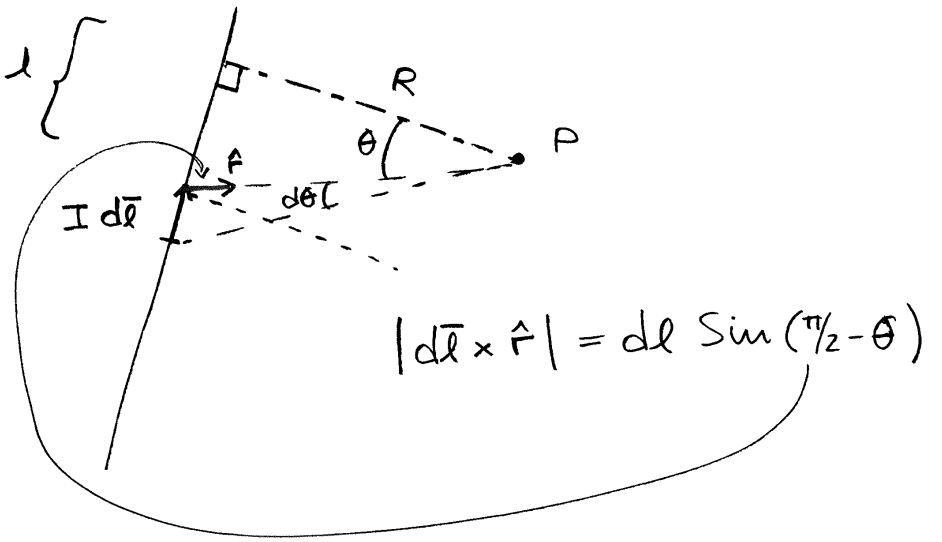
Fyrir heila straumlykkju gildir að $\vec{B}$ í punkti P er

$$\vec{B} = \frac{\mu_0 I}{4\pi} \oint \frac{d\vec{l} \times \hat{r}}{r^2}$$

- μ_0: segulsvörunar stuðull

$$\mu_0 = 4\pi \cdot 10^{-7} \frac{Tm}{A}$$

Fyrir langan beinan leiðara



$$|d\bar{l} \times \hat{r}| = dl \sin(\pi/2 - \theta) = dl \cos\theta$$

$$\left.\begin{array}{l} r\sin\theta = l \\ r\cos\theta = R \end{array}\right\} \rightarrow \tan\theta = \frac{l}{R}$$

$$l = R\tan\theta \rightarrow dl = R\,d(\tan\theta)$$

$$= \frac{R d\theta}{\cos^2\theta}$$

Heildið verður þá

$$B = \frac{\mu_0 I}{4\pi} \int \frac{dl \cos\theta}{r^2}$$

$$= \frac{\mu_0 I}{4\pi} \int \frac{R d\theta}{\cos^2\theta} \cdot \frac{\cos\theta}{R^2} \cdot \cos^2\theta$$

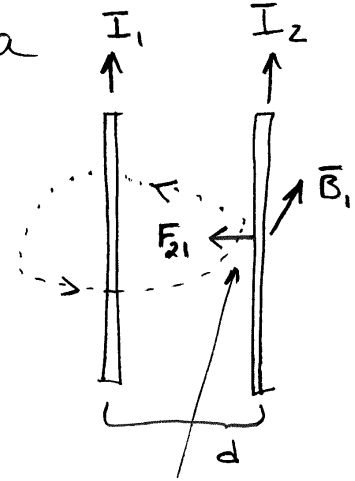
$$r^2 = \frac{R^2}{\cos^2\theta}$$

$$= \frac{\mu_0 I}{4\pi R} \int_{-\pi/2}^{\pi/2} \cos\theta \cdot d\theta = \frac{\mu_0 I}{2\pi R}$$

Athugum kraft milli tveggja leiðara

samsíða

Annar leiðarinn myndar segulsvið sem veldur krafti á hinn leiðarann



stefnan sést þá

$d\bar{F} = I\,d\bar{l} \times \bar{B}$

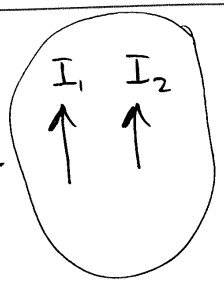
$$|\bar{F}_{21}| = F_{21} = I_2 l_2 B_1$$

$$= I_2 l_2 \frac{\mu_0 I_1}{2\pi d}$$

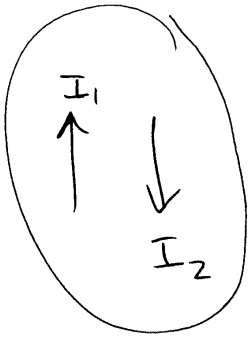
$$\rightarrow \frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$$

er kraftur á lengdareiningu hvors leiðara gegn hins.

Straumar víxlverkast

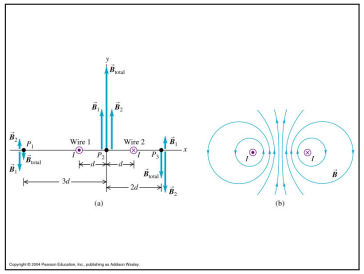
Sams. 

aðdráttarkraftur

andsamsíða 

fráhrinding

{ Í báðri stiftin mínntar B milli víranna ef þeir geta hreyft. }



Lögmál Ampères

Ampère sýndi að fyrir <u>jafnstraum</u> I um leiðara gildir almennt

$$\oint \bar{B} \cdot d\bar{\ell} = \mu_0 I$$

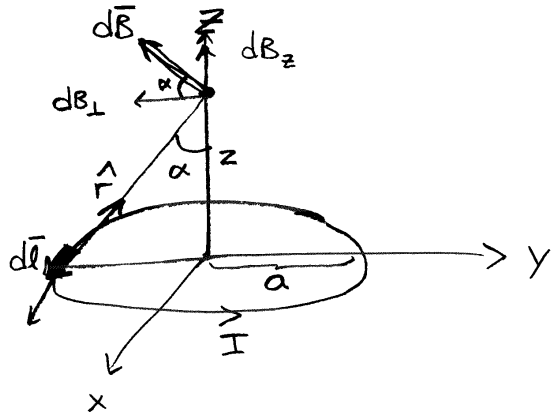
Línuheildi um veg sem umlykur leiðaran með I

{ Bera saman við Gauß-regla }

Ampère lögmálið má leiða út frá lögmáli Biot og Savarts

Dæmi

Hringlykkja með straum I, finnum B á samhverfuásnum ⊥ á hringinn, ($\hat{z}$-ás).



speglunar samhverfa um $\bar{0}$ → $dB_\perp$ strykast út fyrir hvern punkt

$$d\bar{B} = \frac{\mu_0}{4\pi} \frac{I\, d\bar{\ell} \times \hat{r}}{r^2}$$

$$d\bar{\ell} \perp \hat{r} \rightarrow |d\bar{\ell} \times \hat{r}| = d\ell$$

$$dB_z = dB \sin\alpha = \left(\frac{\mu_0 I\, d\ell}{4\pi r^2}\right)\left(\frac{a}{r}\right)$$

$$B_z = \int dB_z = \frac{\mu_0 I a}{4\pi r^3} \int_0^{2\pi a} dl$$

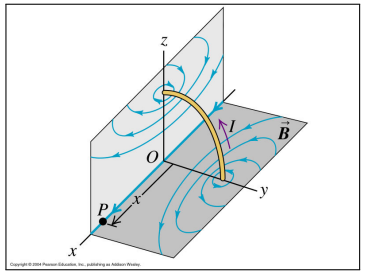
$$= \frac{\mu_0 I a}{4\pi r^3} 2\pi a \quad \text{og} \quad r^2 = a^2 + z^2$$

$$\rightarrow \boxed{B_z = \frac{\mu_0 I a^2}{2(a^2+z^2)^{3/2}}}$$

fjarsvið fyrir sagultvípól er

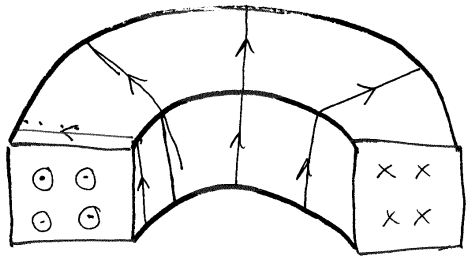
$$\lim_{z \to \infty} B_z = \frac{\mu_0 I a^2}{2 z^3}$$

samstaðar dofnun sviðs og fyrir raftvípól



Dæmi

Segulsvið kleinuhrings spólu



þverstæður

Notum lögmál Ampères

$$\oint \bar{B} \cdot d\bar{l} = \mu_0 I$$

Samhverfa → sviðslínur eru hringir

→ veljum heildisveg sem hringi því sviðið er fasti á þeim.

fyrir utan kleinuhring

$$\oint \bar{B} \cdot d\bar{l} = \mu_0 (NI) = 0 \,, \; I = 0$$

$$\| $$

$$B \oint dl = B(2\pi r) \quad \rightarrow B = 0 \text{ ef } r \neq 0$$

innan hrings

$$\oint \bar{B} \cdot d\bar{l} = B \oint dl = \mu_0 (NI)$$

$$\|$$

$$B\, 2\pi r$$

$$\rightarrow \boxed{B = \frac{\mu_0 NI}{2\pi r}}$$

sviðið er ekki eins hátt inni í kleinuhring

svidid innan beinnar langrar spólu er einsleitt

$$B = \mu_0 \frac{N}{l} I$$