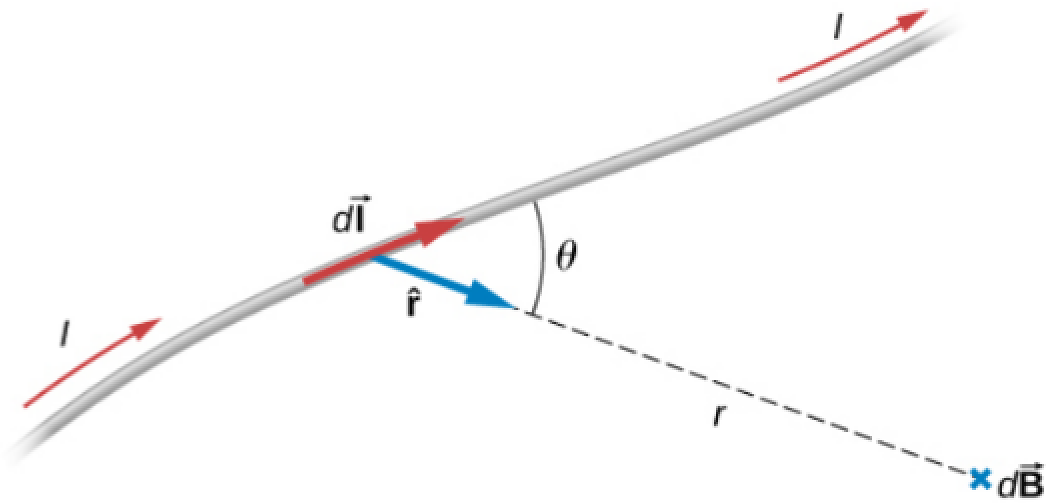
Uppsprettur segulsviðs

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

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

$$dB = \frac{\mu_0}{4\pi}\frac{I\,dl \sin\theta}{r^2}$$



A current element $Id\vec{\mathbf{l}}$ produces a magnetic field at point P given by the Biot-Savart law.

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Biot-Savart law

The magnetic field $\vec{\mathbf{B}}$ due to an element $d\vec{\mathbf{l}}$ of a current-carrying wire is given by

$$\vec{\mathbf{B}} = \frac{\mu_0}{4\pi}\int_{\text{wire}}\frac{I\,d\vec{\mathbf{l}} \times \hat{\mathbf{r}}}{r^2}. \qquad 12.4$$

Segulsvið þunns beins leiðara

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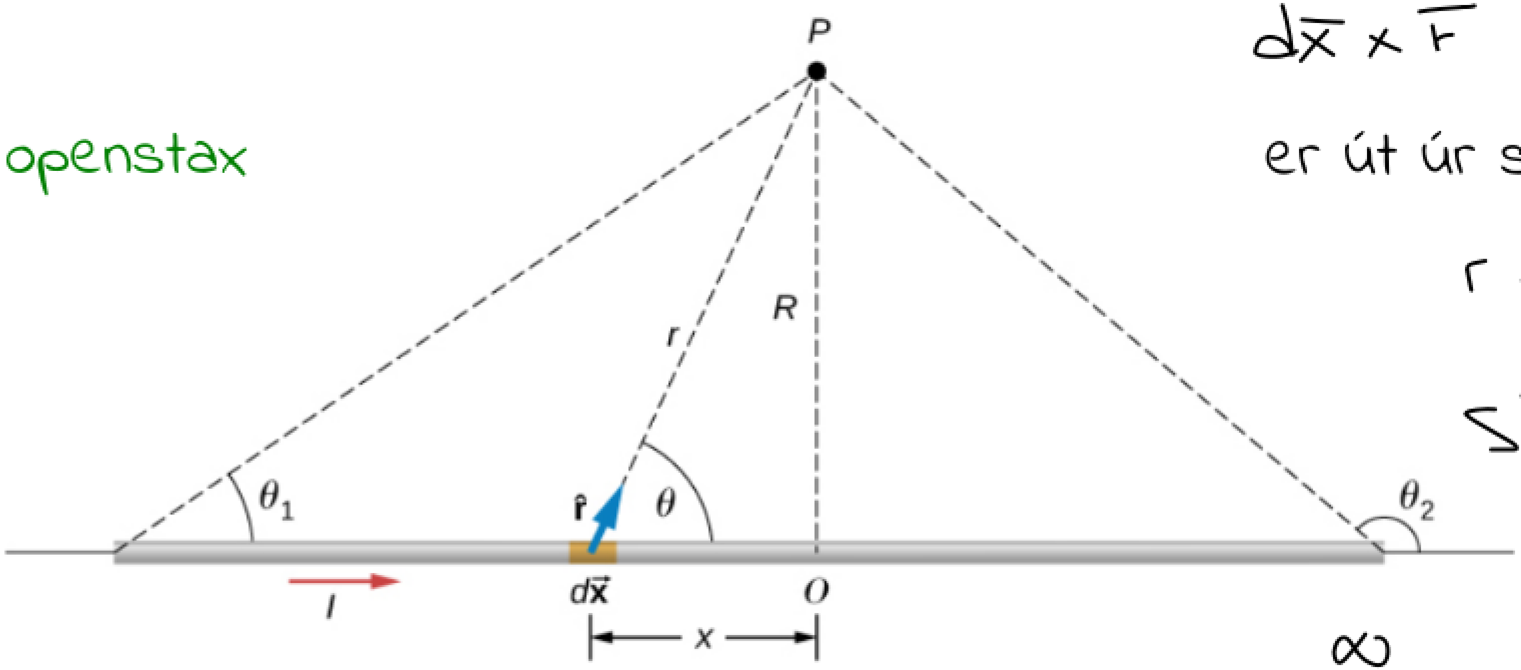


$d\bar{x} \times \bar{r}$

er út úr síðunni fyrir P

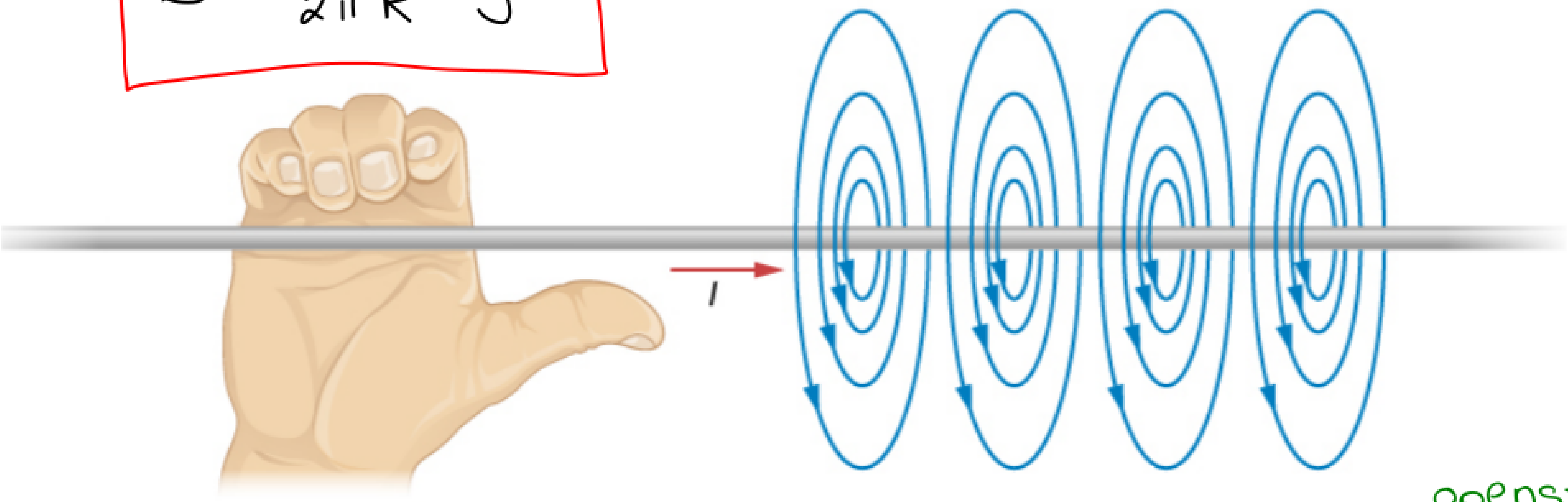
$$r = \sqrt{x^2 + R^2}$$

$$\sin\theta = \frac{R}{\sqrt{x^2 + R^2}}$$

$$\underline{B} = \frac{\mu_0 I}{4\pi} \int_{-\infty}^{\infty} \frac{\sin\theta \, dx}{r^2} = \frac{\mu_0 I}{4\pi} \int_{-\infty}^{\infty} \frac{R\,dx}{[x^2 + R^2]^{3/2}}$$

$$= \frac{\mu_0 I}{2\pi} \int_0^{\infty} \frac{R\,dx}{[x^2 + R^2]^{3/2}} = \frac{\mu_0 I}{2\pi R} \left\{ \frac{x}{(x^2 + R^2)^{1/2}} \Big|_0^{\infty} \right\} = \underline{\frac{\mu_0 I}{2\pi R}}$$

$$\boxed{\overline{B} = \frac{\mu_0 I}{2\pi R}\hat{\varphi}}$$



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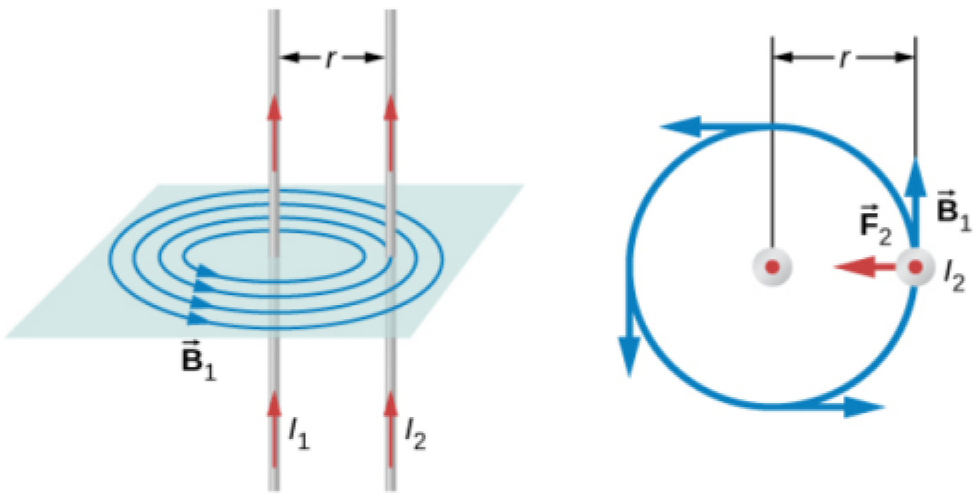
Segulkrafturinn milli tveggja samhliða leiðara

Á leiðara 2 verkar

$$F_2 = I_2 l B_1 = \frac{\mu_0 l I_1 I_2}{2\pi r}$$

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

$$B_1 = \frac{\mu_0 I_1}{2\pi r}$$



Tengsl við orku

Segulsviðið á samhverfuás lykkju

$$dB = \frac{\mu_0}{4\pi} \frac{I\,dl}{r^2} \sin\left(\frac{\pi}{2}\right)$$

$$= \frac{\mu_0}{4\pi} \frac{I\,dl}{y^2+R^2}$$

$$\bar{B} = \hat{j} \oint dB \cos\theta$$

$$= \hat{j} \frac{\mu_0 I}{4\pi} \oint \frac{\cos\theta \, dl}{y^2+R^2}$$

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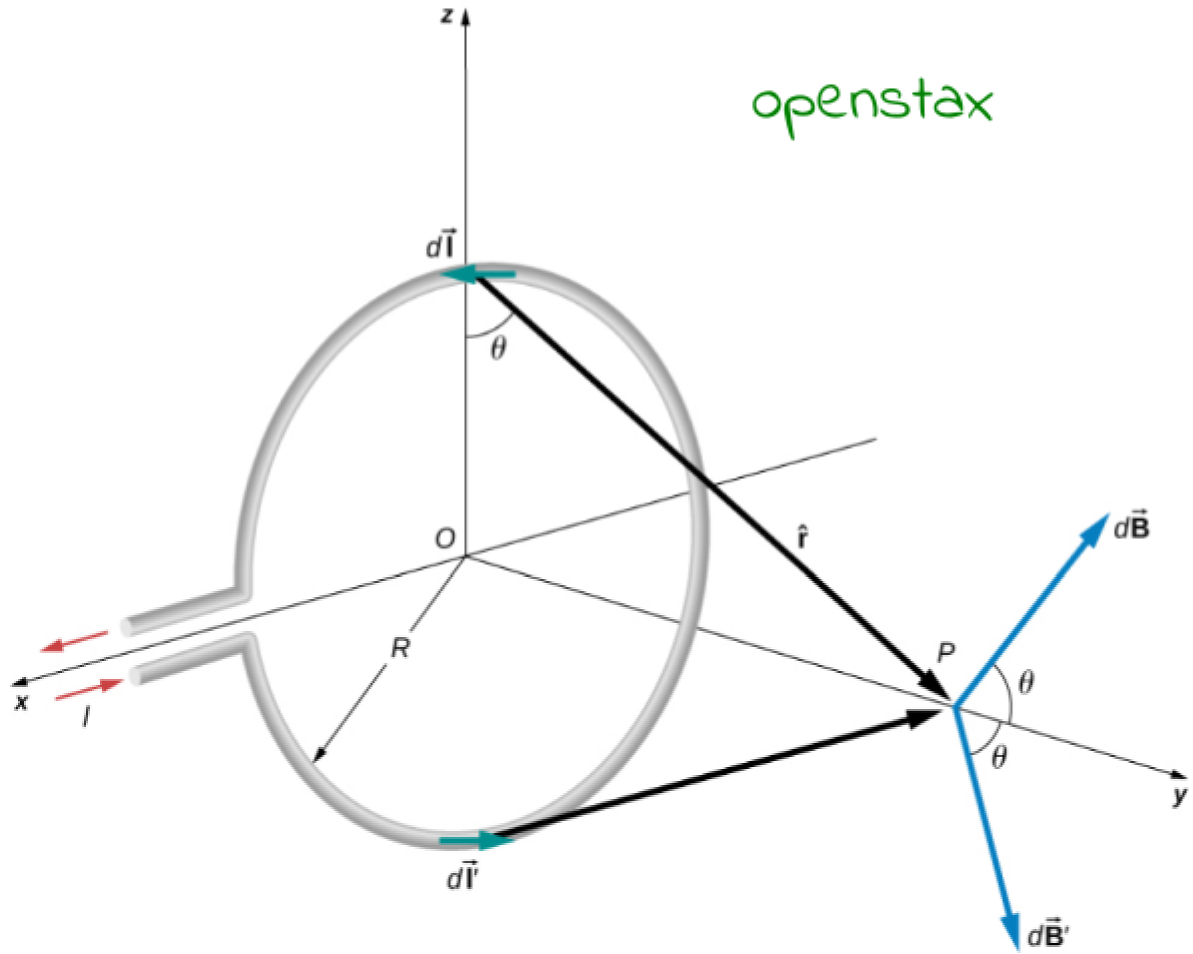

Figure 12.11 Determining the magnetic field at point P along the axis of a current-carrying loop of wire.

$$\cos\theta = \frac{R}{\sqrt{y^2+R^2}}$$

$$\rightarrow \quad \bar{B} = \hat{j} \frac{\mu_0 I R}{4\pi (y^2+R^2)^{3/2}} \oint dl = \frac{\mu_0 I R^2}{2(y^2+R^2)^{3/2}} \hat{j}$$

því $\oint dl = 2\pi R$

Notum $\bar{\mu} = I A \hat{n} = I \pi R^2 \hat{j}$ hér

Í miðju lykkjunnar, $y = 0$

$$\boxed{\bar{B} = \frac{\mu_0 I}{2R} \hat{j}}$$

og langt frá lykkjunni, $y >> R$, fæst

$$\boxed{\bar{B} = \frac{\mu_0 \bar{\mu}}{2\pi R^3}}$$

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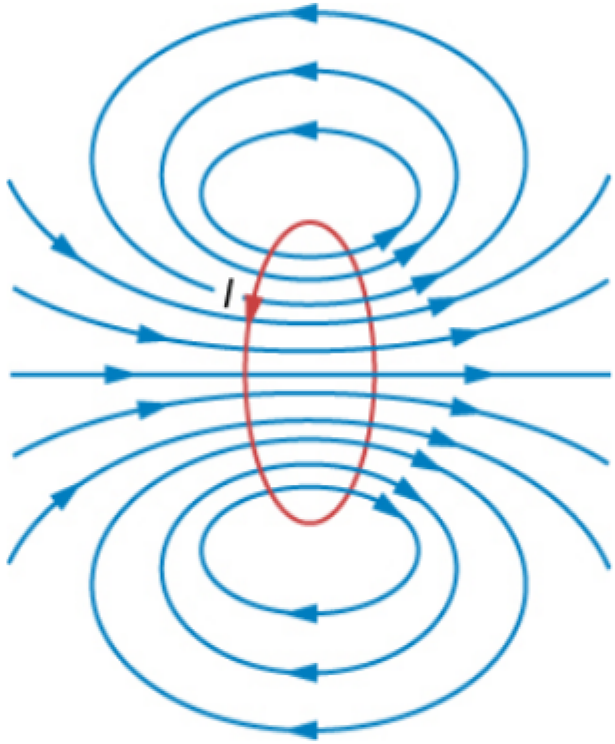

sem er svið segultvískauts

Lögmál Amperes

Segulsviðið B er ekki geymið vigursvið

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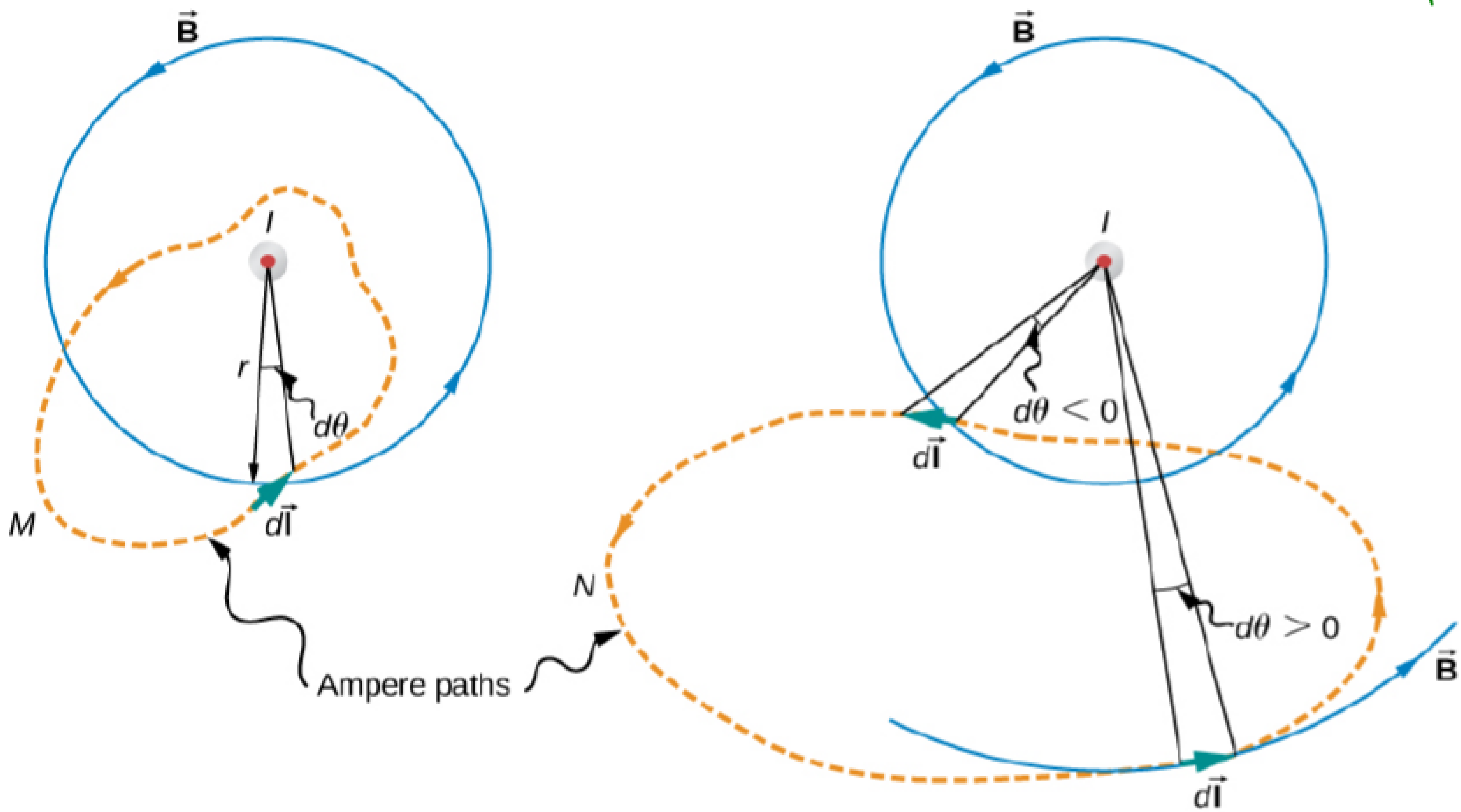


Hægt er að sýna að $\oint_N \bar{B} \cdot d\bar{l} = 0$, en $\oint_M \bar{B} \cdot d\bar{l} = \mu_0 I$

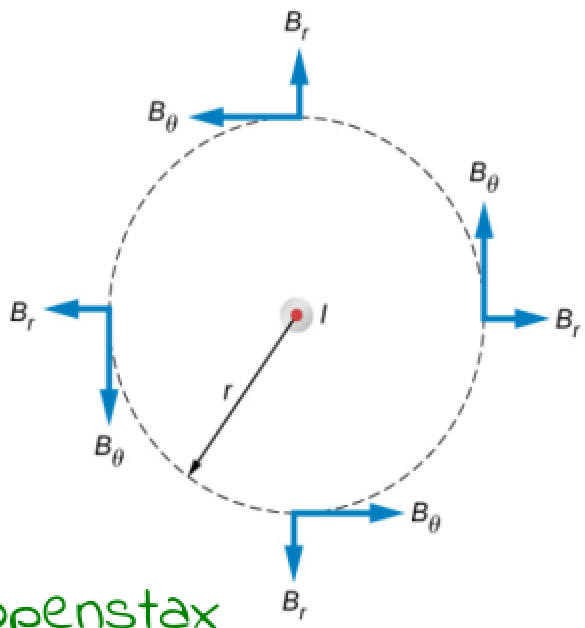
Ampère's law

Over an arbitrary closed path,

$$\boxed{\oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} = \mu_0 I} \qquad 12.23$$

where I is the total current passing through any open surface S whose perimeter is the path of integration. Only currents inside the path of integration need be considered.

Beinn langur vír



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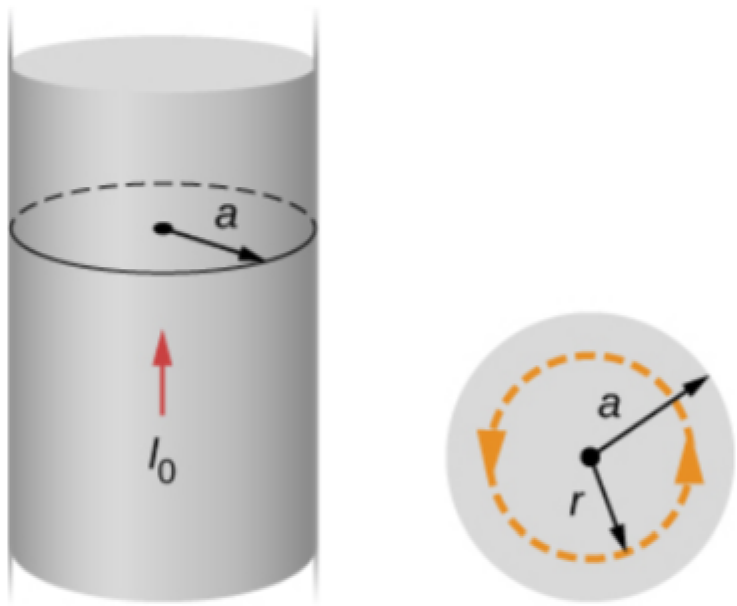
$$\oint \bar{B} \cdot d\bar{l} = \oint \bar{B}_\theta \cdot d\bar{l}$$

$$= 2\pi r B = \mu_0 I$$

$$\rightarrow \boxed{\bar{B} = \frac{\mu_0 I}{2\pi r} \hat{\theta}}$$

Ex. 12.7, þykkur leiðari með fast straumþykkni



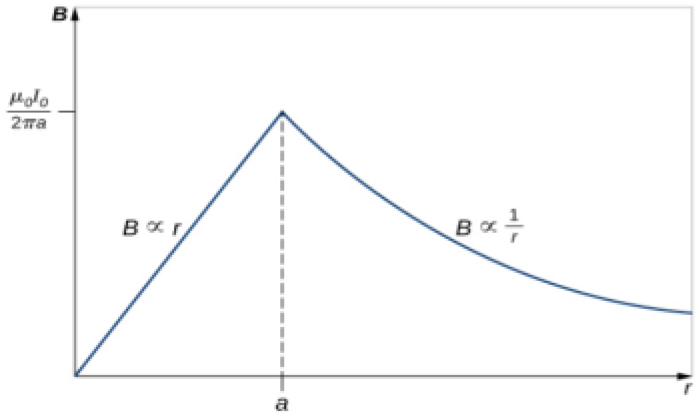
Utan vírs

$$\oint \bar{B} \cdot d\bar{l} = \oint B\,dl = B\,2\pi r = \mu_0 I$$

$$\rightarrow \bar{B} = \frac{\mu_0 I_0}{2\pi r}\hat{\theta}, \quad r > a$$

Innan vírs

$$I_{enc} = \frac{r^2}{a^2} I_0 \rightarrow \bar{B} = \frac{\mu_0 I_0}{2\pi}\frac{r}{a^2}\hat{\theta} \quad r \leq a$$



Variation of the magnetic field produced by a current I_0 in a long, straight wire of radius a.

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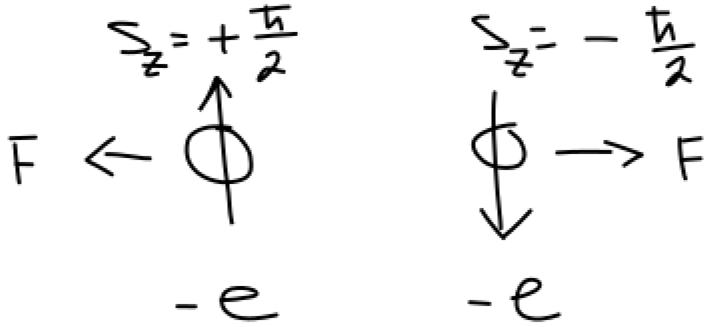
Seguleiginleikar efnis

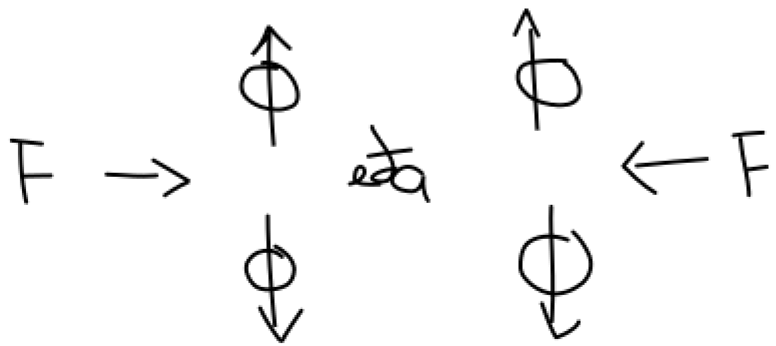
Allt efni er veikt andseglandi (diamagnetic), líka við!
Sígild eðlisfræði nægir ekki til að skýra seguleiginleika efnis (heldur ekki andseglun)

Rafeindir bera segultvískautsvægi í hlutfalli við spuna þeirra og hverfiþunga á hvelum atóma. Atóm geta því haft segulvægi, sérstaklega um mitt lotukerfið vegna skiptakrafts rafeinda í efri hvelum

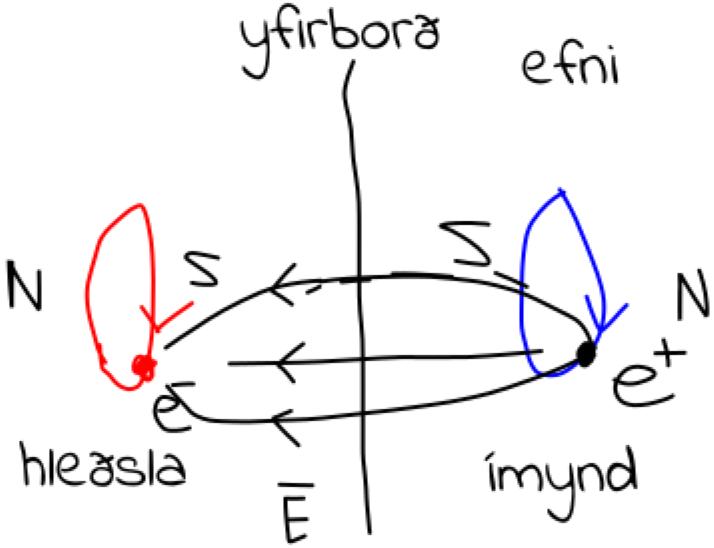
Seglun er til í mörgum flokkum, við minnumst á andseglun (diamagnetism), meðseglun (paramagnetism), járnseglun (ferromagnetism) og andjárnseglun (antiferromagnetism)

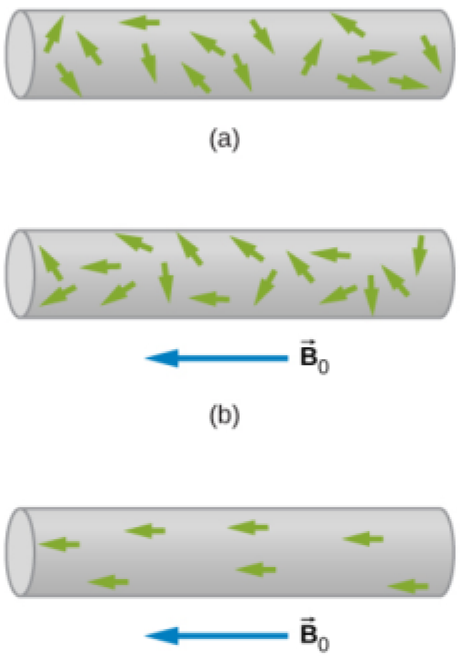
Fráhrindikraftur Coulombs og skiptakraftur - aðdráttarkraftur

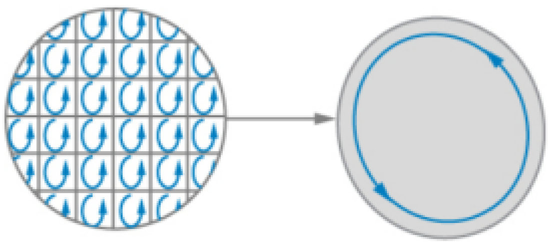




Andseglun, einfölduð sígild skýring







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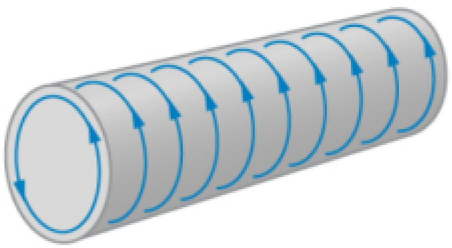

Meðseglun

Ytrasvið raðar upp tvískautum en of veikur skiptakraftur nær ekki að viðhalda uppröðun eftir að ytra sviðið hverfur

Heildarsvið B, ytrasvið B_0, innra svið B_m - svörun við B_0

$$\bar{B} = \bar{B}_0 + \bar{B}_m$$

$$\bar{B} = \chi \bar{B}_0$$

segulviðtak

$$\bar{B} = (1+\chi)\bar{B}_0$$

fyrir einfalda línulega andseglun eða meðseglun fæst að

$$\mu = (1 + \chi)\mu_0$$

χ getur haft annaðhvort formerkið og í flóknari efnum er viðtakið ekki fasti, en flókið fall af B og T

Paramagnetic Materials	χ	Diamagnetic Materials	χ
Aluminum	2.2×10^{-5}	Bismuth	-1.7×10^{-5}
Calcium	1.4×10^{-5}	Carbon (diamond)	-2.2×10^{-5}
Chromium	3.1×10^{-4}	Copper	-9.7×10^{-6}
Magnesium	1.2×10^{-5}	Lead	-1.8×10^{-5}
Oxygen gas (1 atm)	1.8×10^{-6}	Mercury	-2.8×10^{-5}
Oxygen liquid (90 K)	3.5×10^{-3}	Hydrogen gas (1 atm)	-2.2×10^{-9}
Tungsten	6.8×10^{-5}	Nitrogen gas (1 atm)	-6.7×10^{-9}
Air (1 atm)	3.6×10^{-7}	Water	-9.1×10^{-6}

Table 12.2 Magnetic Susceptibilities *Note: Unless otherwise specified, values given are for room temperature.

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Járnseglun

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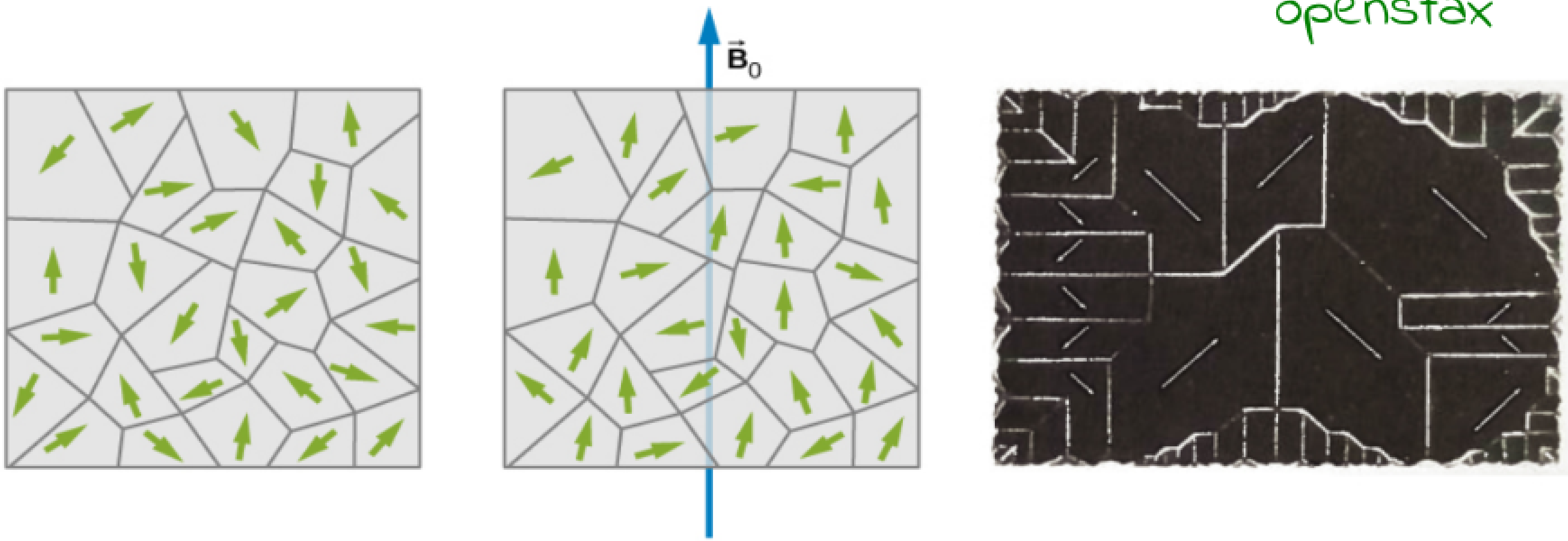
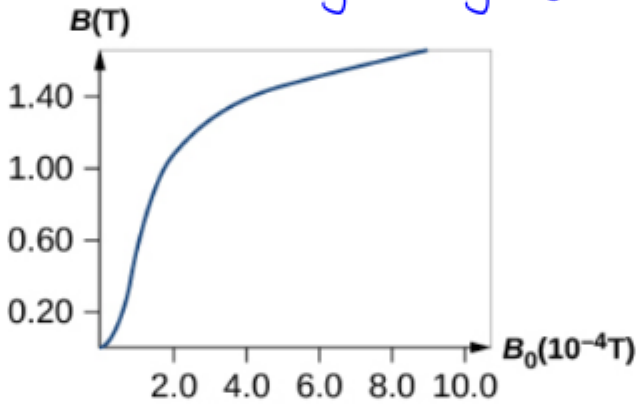


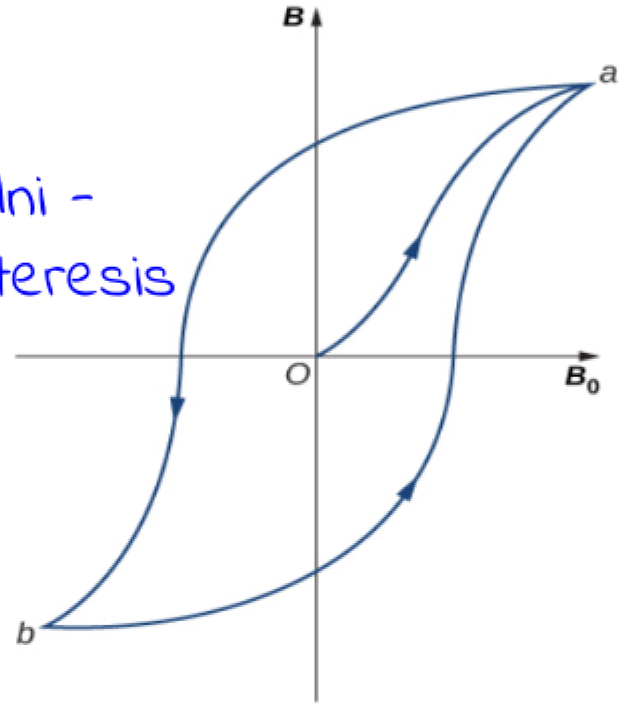
Sterkur skiptakraftur raðar segultvískautum (spunum..) í óðul (domains)

flókin tengsl B og B_0



The magnetic field B in annealed iron as a function of the applied field B_0.

Heldni - hysteresis



Samanburður segulsvið spólu og síseguls

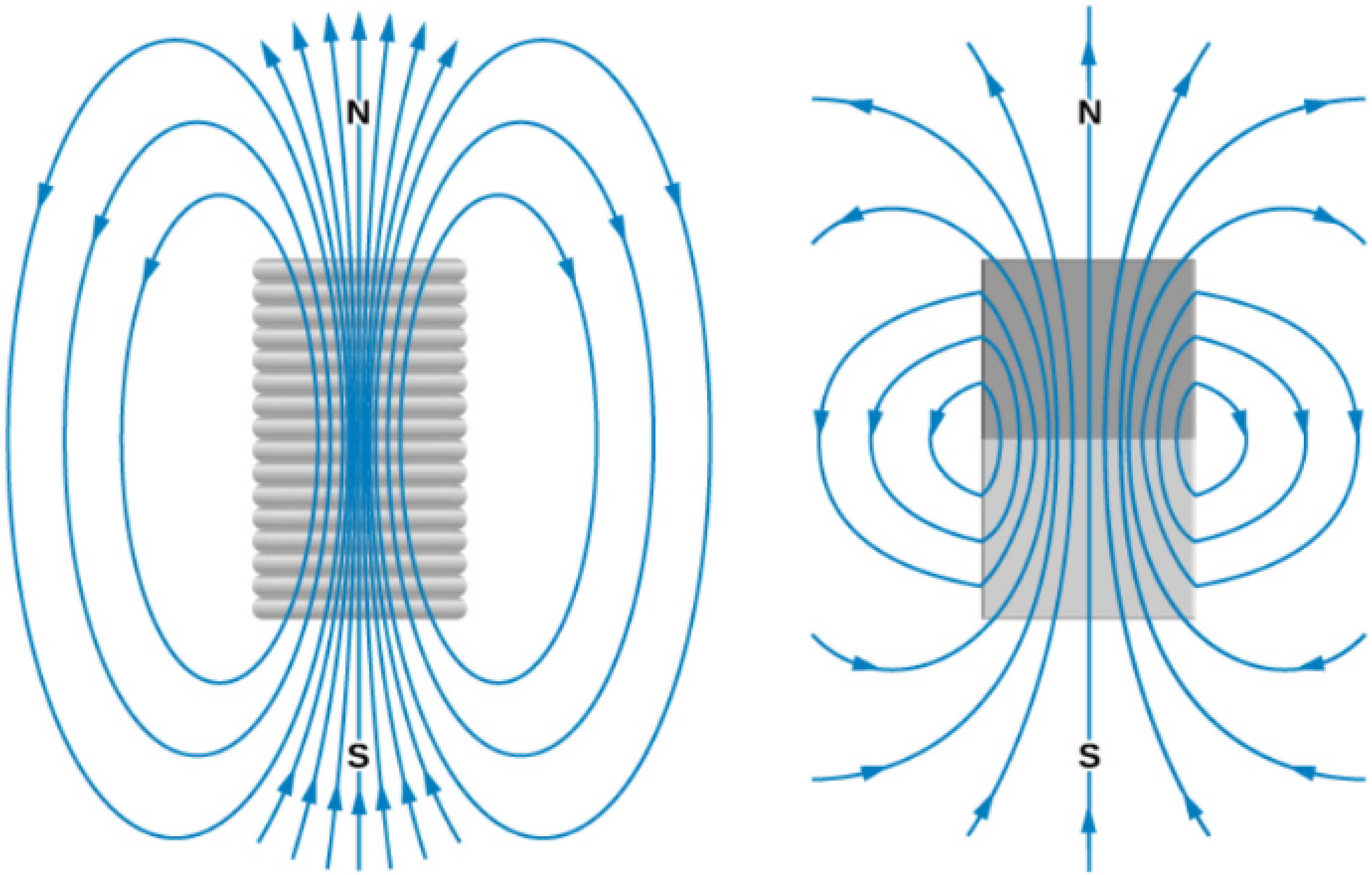


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Figure 12.27 Comparison of the magnetic fields of a finite solenoid and a bar magnet.

Segulsviðslínurnar enda og byrja hvergi -- segultvískaut

Spurningar - samanburður

Höfum lögmál Coulombs og fyrir þyngdarkraftinn

$$|\bar{F}_e| = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2}$$

$$|\bar{F}_g| = G\frac{|m_1 m_2|}{r^2}$$

Sama lögmál, um báða kraftana gildir lögmál Gauß --->

Hvar er segulþáttur þyngdarsviðsins?

Til gamans: Hve langt nær samanburður á þyngdarfræði og rafsegulfræði?

Maxwell

$$\bar\nabla \cdot \bar E = \frac{\rho}{\epsilon_0}$$

$$\bar\nabla \cdot \bar B = 0$$

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

$$\bar\nabla \times \bar H = \bar J + \frac{\partial}{\partial t}\bar D$$

$$\bar D = \epsilon \bar E$$

$$\bar H = \frac{1}{\mu}\bar B$$

$$\bar F_e = q(\bar E + \bar v \times \bar B)$$

Almennu sviðsjöfnur Einsteins -> gerðar línulegar

$$\bar F_g = m(\bar g + 4\bar v \times \bar b)$$

$$\bar\nabla \cdot \bar g = -4\pi G \rho$$

$$\bar\nabla \cdot \bar b = 0$$

$$\bar\nabla \times \bar g = -\frac{\partial}{\partial t}\bar b$$

$$\bar\nabla \times \bar b = -\frac{4\pi G}{c^2}\bar J_g + \frac{1}{c^2}\frac{\partial}{\partial t}\bar g$$

segulhluti þyngdarsviðs

GPS

þyngdarbylgjur?

En við höldum okkur við stöðufræðina