Fizika 2i

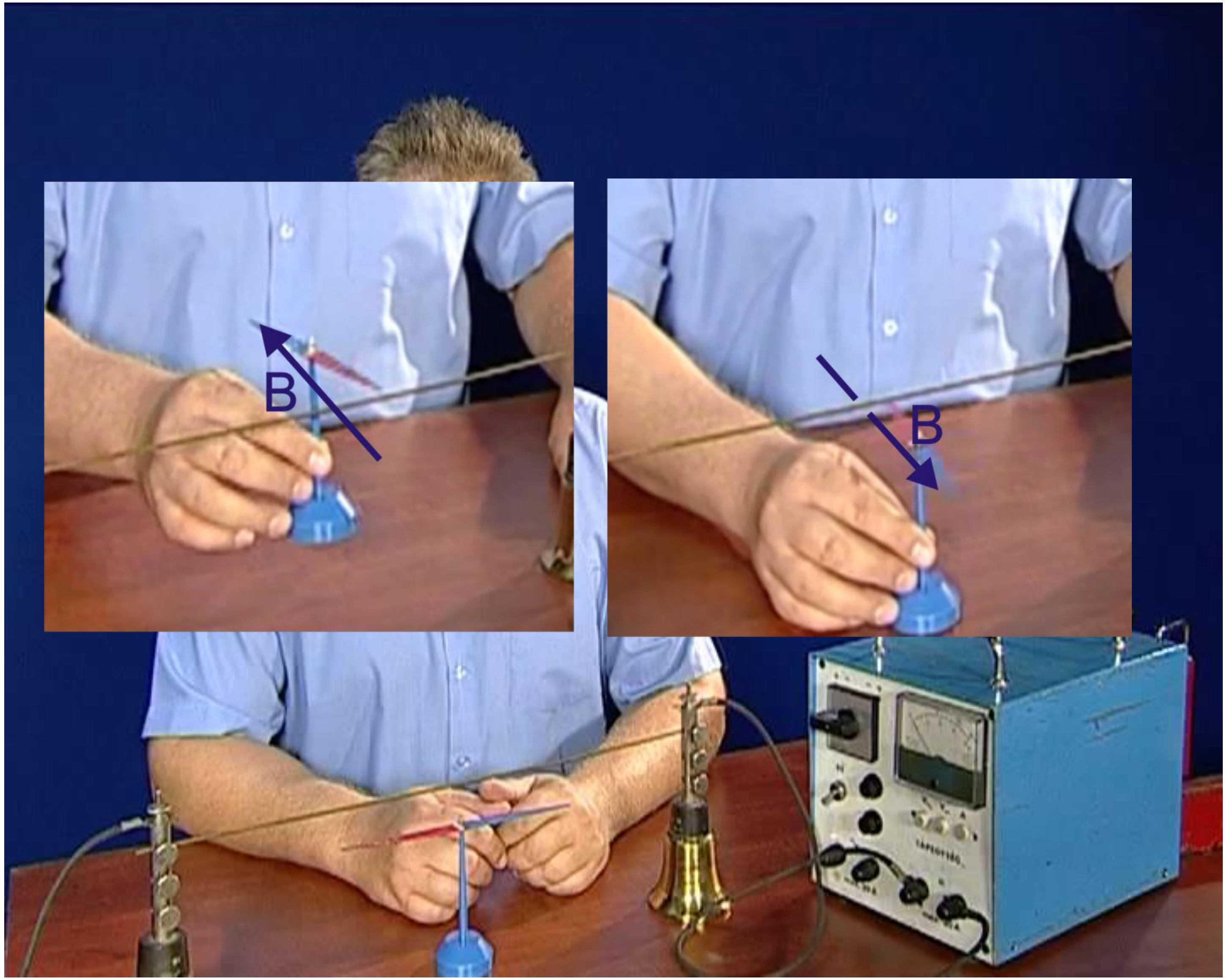
Mozgó töltések és áramok mágneses tere

7. előadás

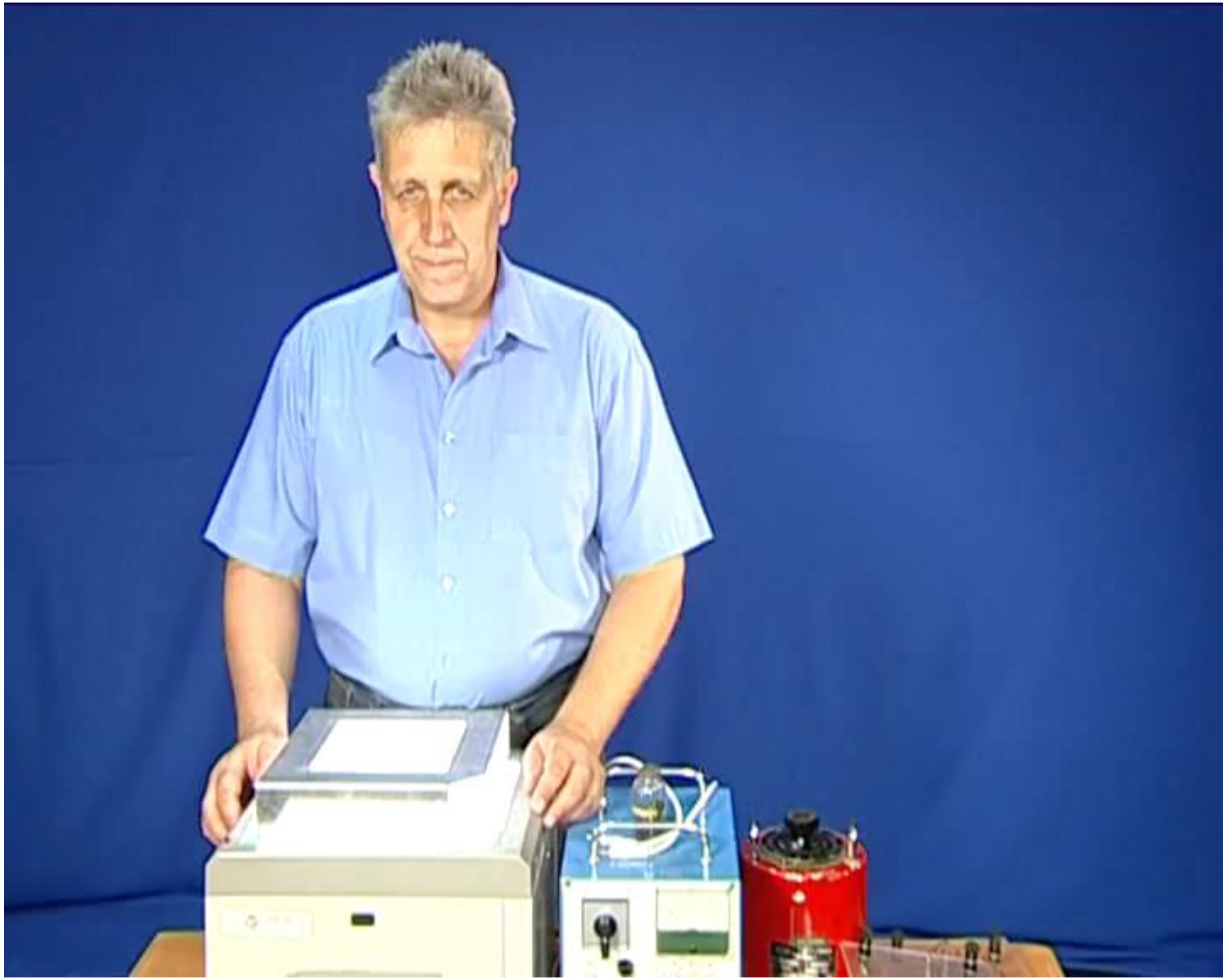
Az Ørsted kísérlet (1820)

Hans Christian Ørsted

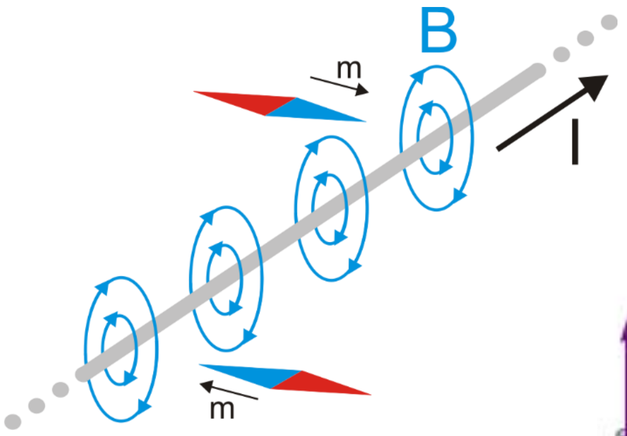
1777 – 1851

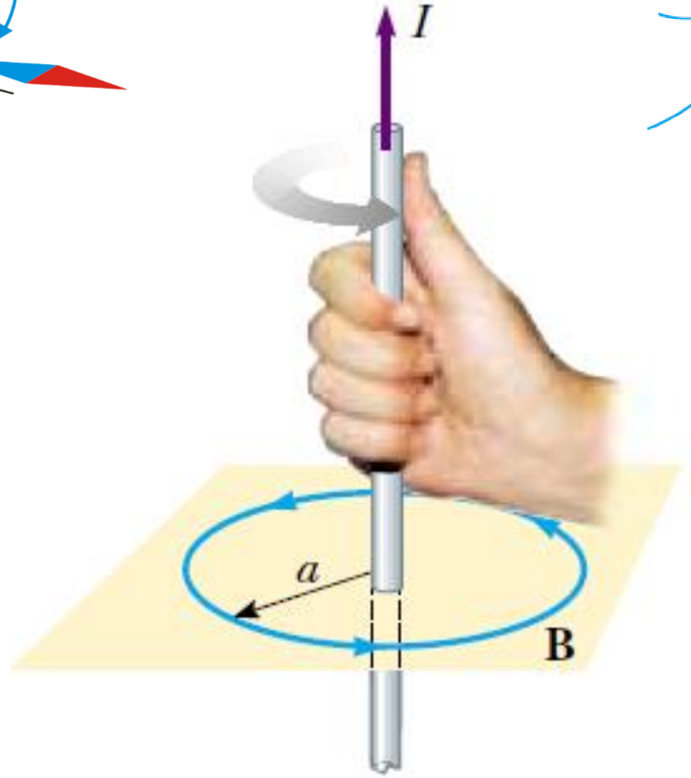


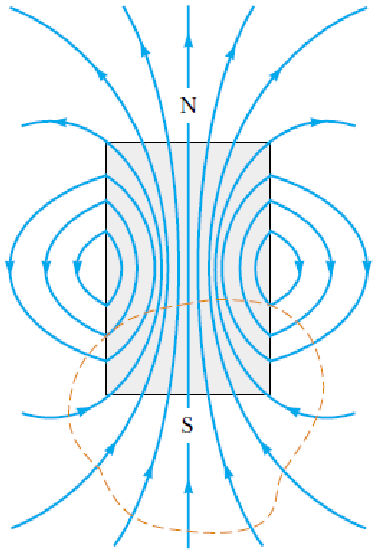
Mágneses erővonalak



Megfigyelések, eredmények





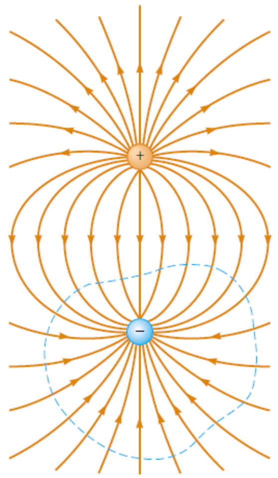


Összegzés:

- a mágneses indukcióvonalak zártak,
  a mágneses tér forrásmentes,

$$\oint \bar{B} d\bar{A} = 0$$

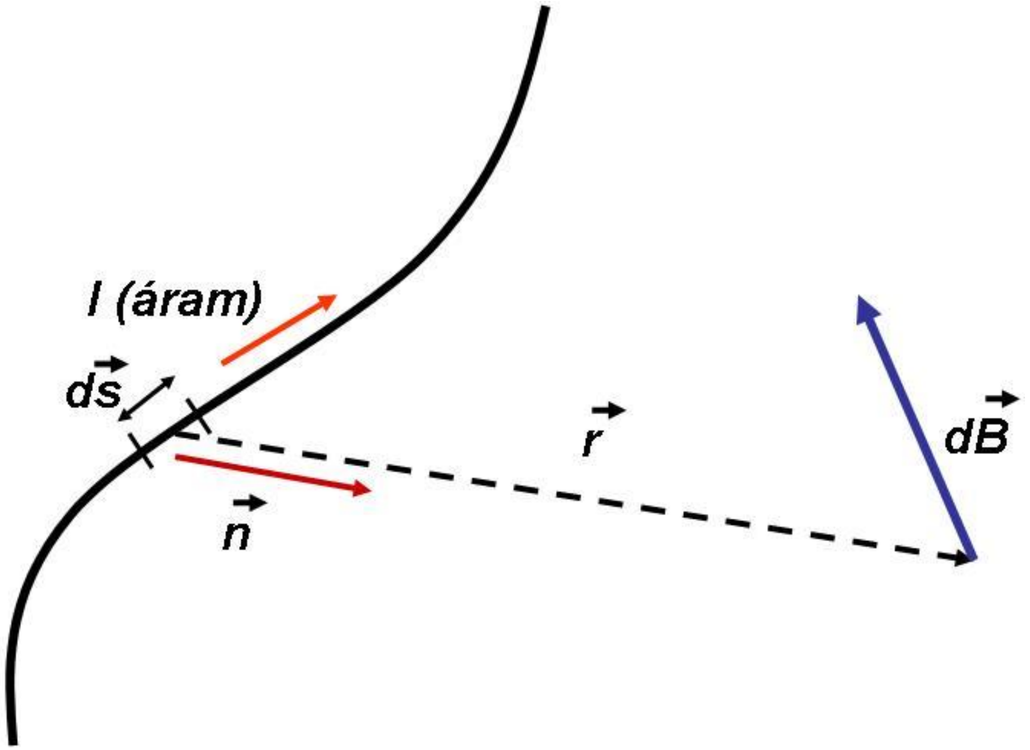
  a B mező örvényes,
- B nagysága távolodva a vezetőtől csökken,
- irány meghatározása a jobbkéz szabállyal



Elektrosztatika

$$\oint_A \vec{E} d\vec{A} = \frac{Q_ö}{\varepsilon_o}$$

A Biot-Savart törvény



Jean-Baptiste Biot
(1774–1862)

Félix Savart
(1791–1841)

$$d\vec{B} = \frac{\mu_o}{4\pi} I \frac{d\vec{s} \times \vec{n}}{r^2}$$

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

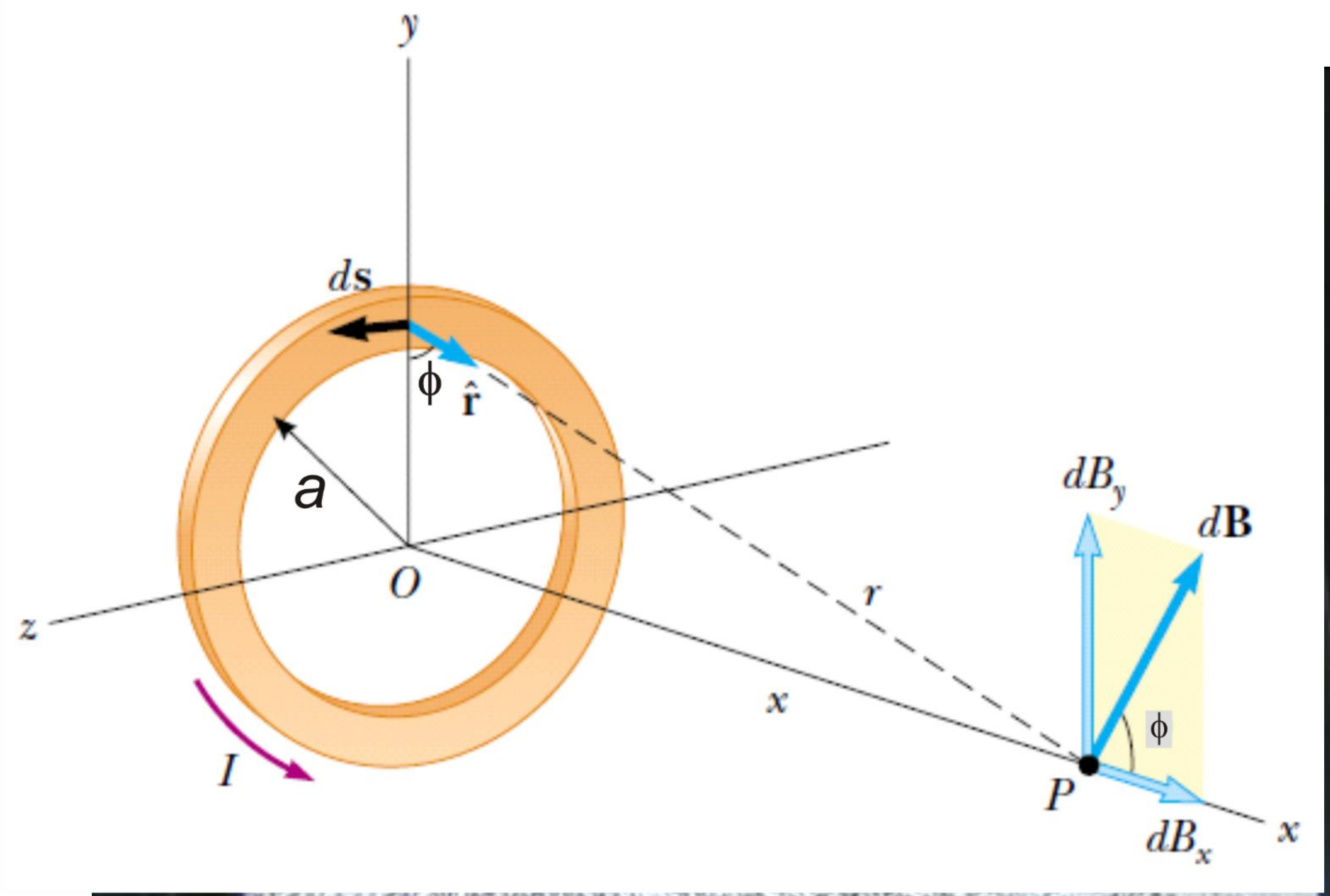
a vákuum mágneses permeabilitása

- ***d*B** merőleges ***ds***-re és **r** –re
- ***d*B** nagysága fordítottan arányos r^2-tel
- ***d*B** nagysága arányos I-vel és **ds** hosszával
- ***d*B** nagysága arányos ***ds*** és **r** közötti szög szinuszával

Tetszőleges alakú vezetőre: szuperpozíció

$$\overline{B} = \sum \Delta\overline{B}$$

Körvezető mágneses tere

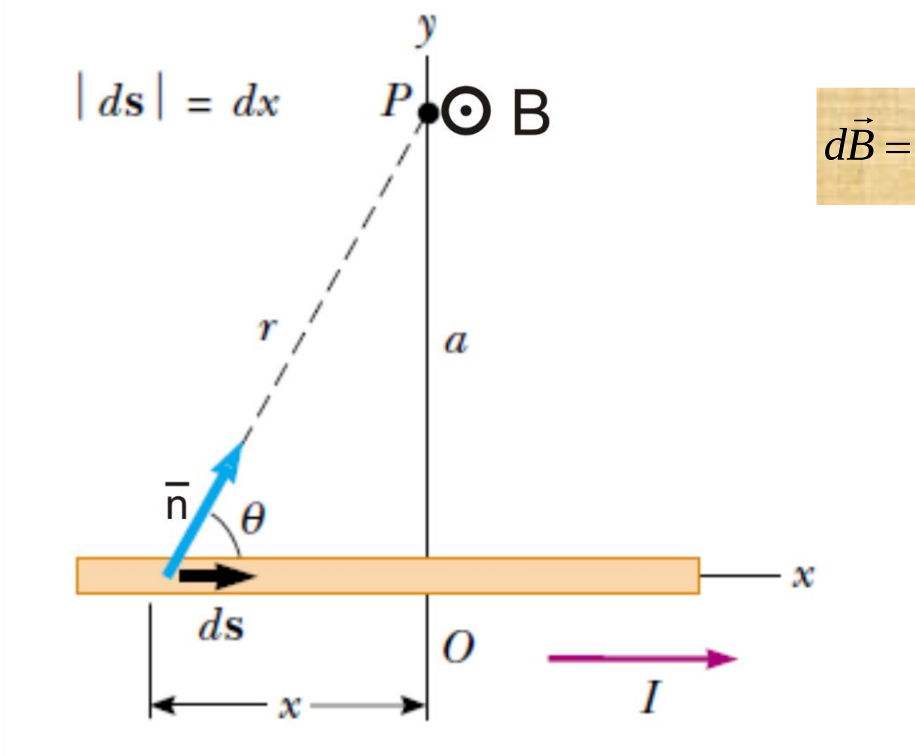


$$dB = \frac{\mu_o}{4\pi} I \frac{ds}{r^2} = \frac{\mu_o}{4\pi} I \frac{ds}{a^2 + x^2}$$

$$dB_x = \frac{\mu_o}{4\pi} I \frac{ds}{a^2 + x^2} \sin\phi = \frac{\mu_o}{4\pi} I \frac{ds}{a^2 + x^2} \frac{a}{\sqrt{a^2 + x^2}} = \frac{\mu_o}{4\pi} I \frac{ds}{\left(a^2 + x^2\right)^{3/2}} \cdot a$$

$$B(x) = \frac{\mu_o}{2} \frac{Ia^2}{\left(a^2 + x^2\right)^{3/2}}$$ illetve $$\vec{B} = \frac{\mu_o}{2\pi} \frac{\vec{\mu}}{\left(a^2 + x^2\right)^{3/2}}$$

Egyenes vezető mágneses tere



$$d\vec{B} = \frac{\mu_o}{4\pi} I \frac{d\vec{s} \times \vec{n}}{r^2}$$

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

$$x = -\frac{a}{\tan\theta}$$

$$r = \frac{a}{\sin\theta}$$

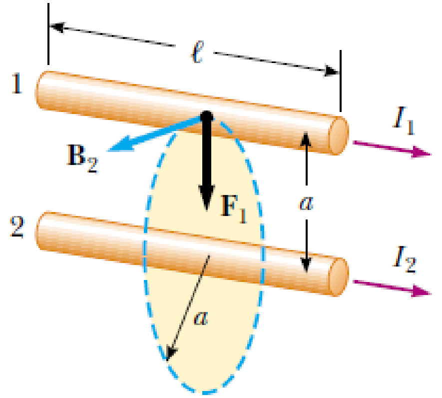
$$dx = a \frac{1}{\sin^2\theta} d\theta$$

$$dB = \frac{\mu_0}{4\pi} I \frac{a}{\sin^2\theta} d\vartheta \frac{\sin^2\theta}{a^2} \sin\theta = \frac{\mu_0}{4\pi a} I \sin\theta \, d\vartheta$$

$$B = \frac{\mu_0 I}{4\pi a} \int_{\theta_1}^{\theta_2} \sin\theta \, d\theta = \boxed{\frac{\mu_0 I}{4\pi a} (\cos\theta_1 - \cos\theta_2)}$$

$$B = \boxed{\frac{\mu_0 I}{2\pi a}}$$

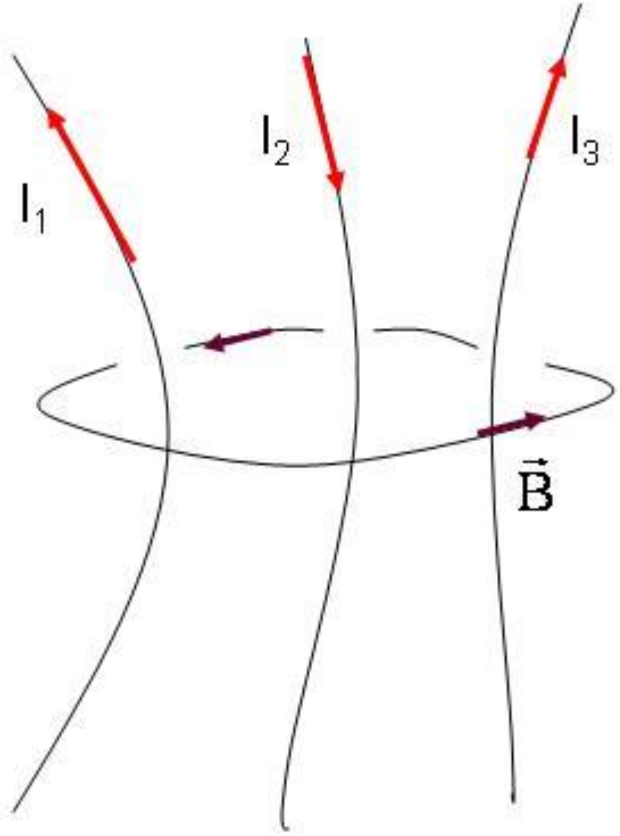
Példa: árammal átjárt vezetők között ható erő



$$F_1 = I_1 \ell B_2 = I_1 \ell \left(\frac{\mu_0 I_2}{2\pi a} \right) = \frac{\mu_0 I_1 I_2}{2\pi a} \ell$$

$$\boxed{\frac{F_B}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi a}}$$

Ampère – törvény I.

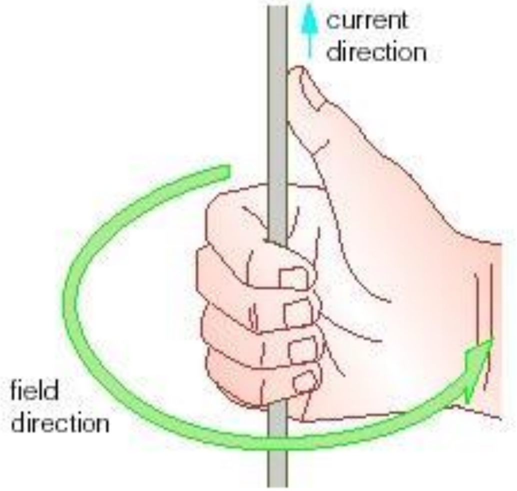


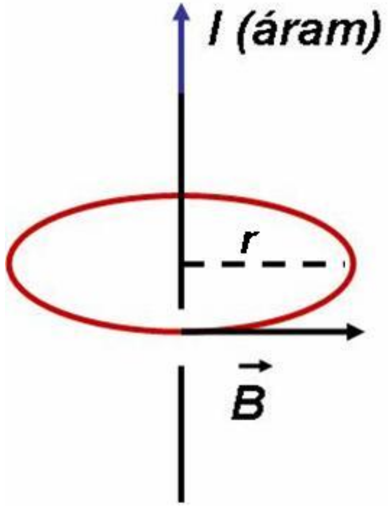
$\Sigma I = I_1 - I_2 + I_3$

$$\oint_S \vec{B} d\vec{s} = \mu_o \sum_j \mathrm{I}_j$$

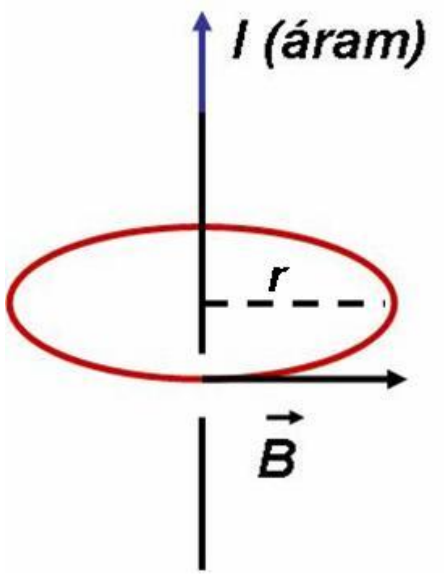
André-Marie Ampère
1775 – 1836

jobbkéz-szabály:





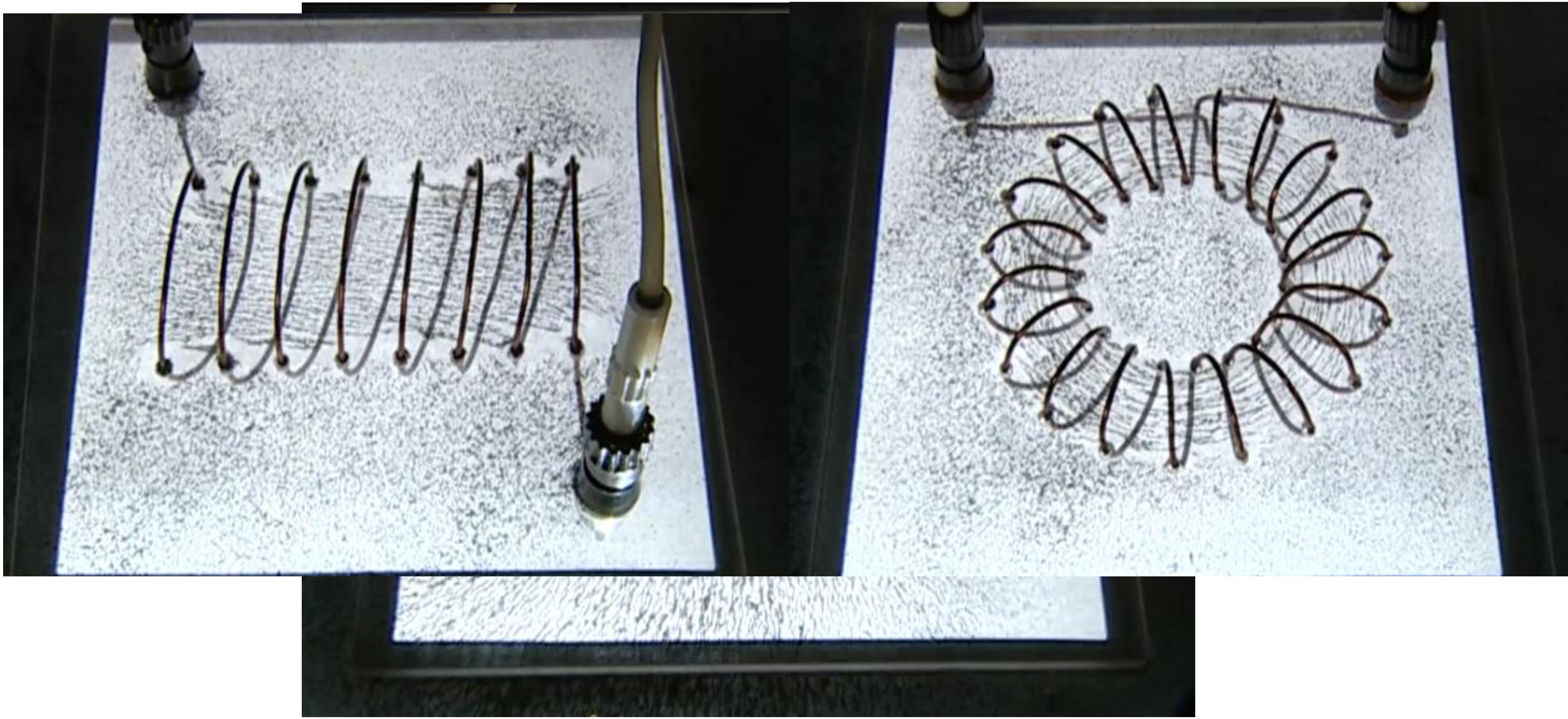
Ampère – törvény II.



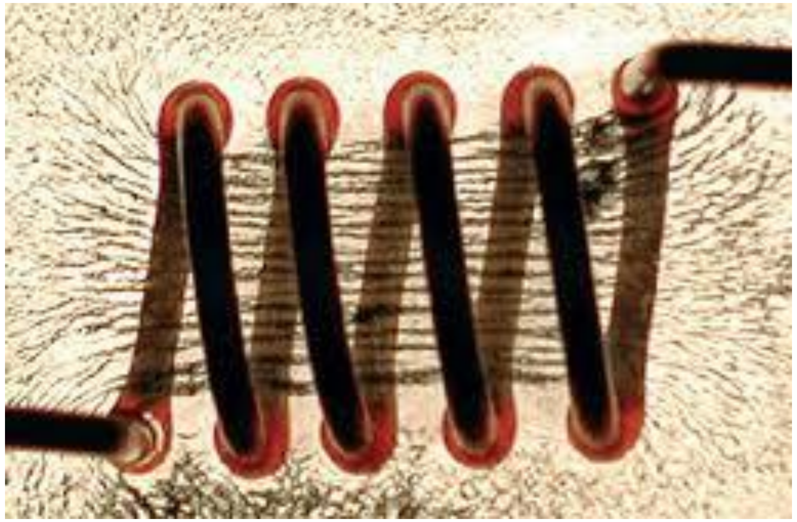
$$\oint_s \vec{B}d\vec{s} = \mu_o \sum_j \mathrm{I_j} \longrightarrow \oint_s \vec{B}d\vec{s} = 2r\pi B \quad \text{ill.} \quad \mu_o \sum_j \mathrm{I_j} = \mu_o \mathrm{I}$$

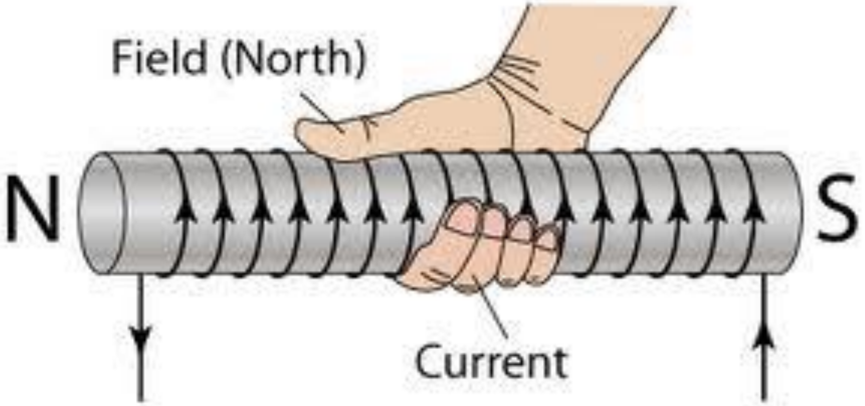
$$2r\pi B = \mu_o \mathrm{I} \qquad \text{azaz} \qquad B = \frac{\mu_o \mathrm{I}}{2r\pi}$$

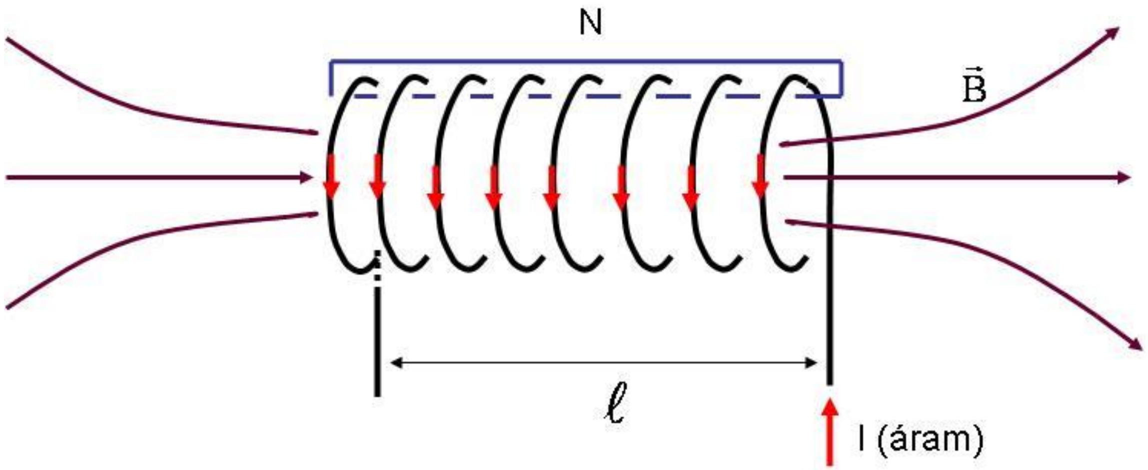
Kísérlet



Ampère – törvény III.





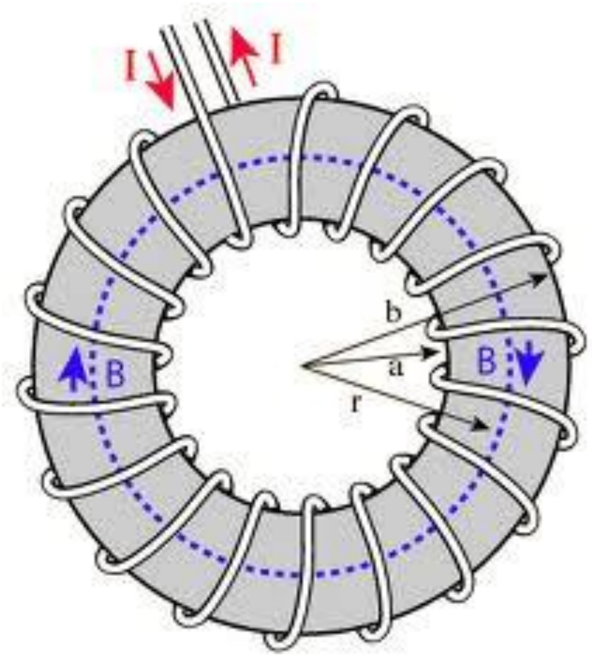


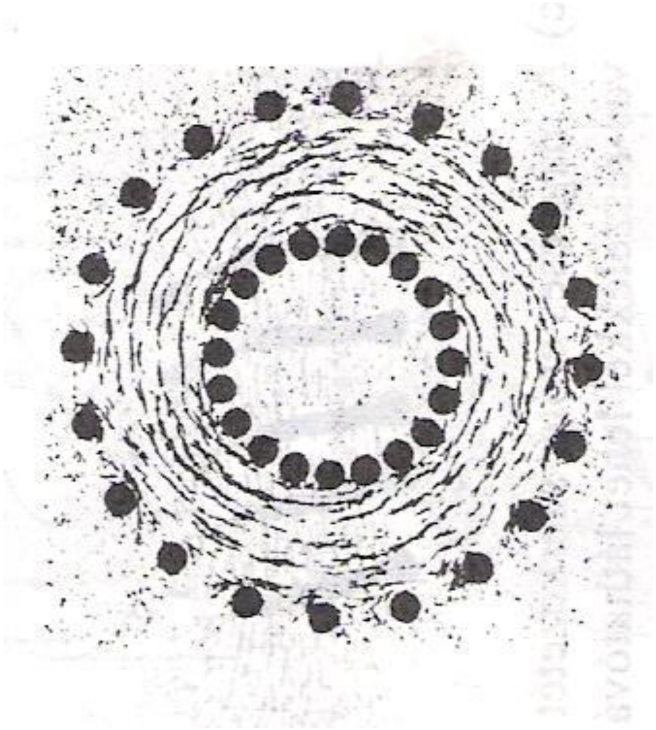
$$\oint_s \vec{B}d\vec{s} = \mu_o \sum_j \mathrm{I}_j$$

$$\downarrow$$

$$B = \frac{\mu_o N I}{\ell}$$

Ampère – törvény IV.





$$B = \frac{\mu_o N I}{2 r \pi}$$