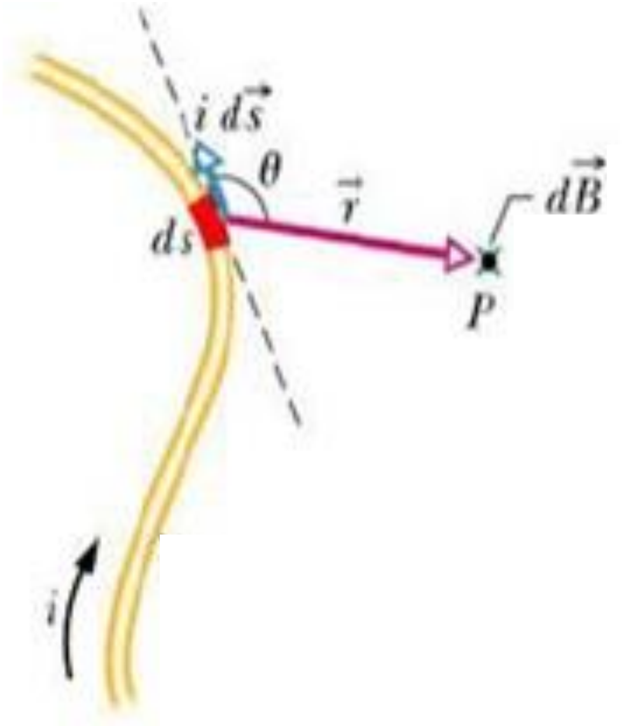
Campo Magnetostático

Profa. Hilde Harb Buzzá

Campo produzido por uma Corrente

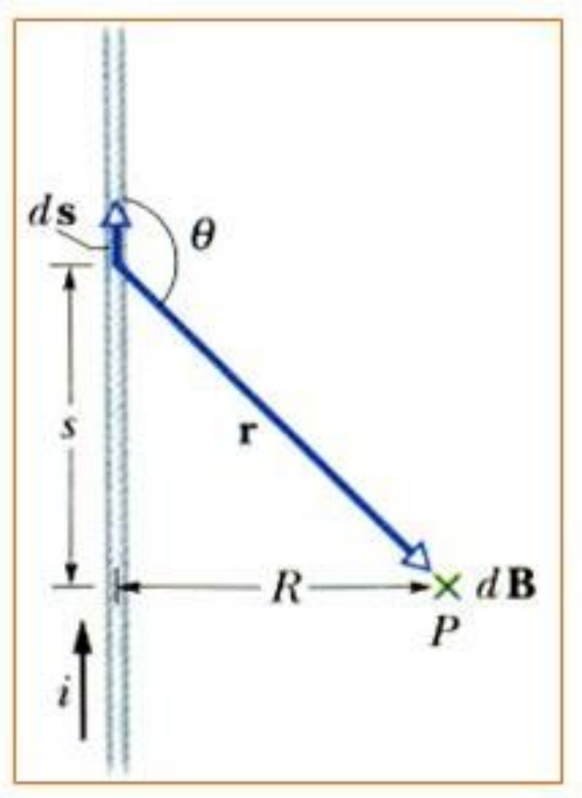


$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{id\vec{s} \times \hat{r}}{r^2}$$

Lei de Biot-Savart

Campo produzido por uma Corrente

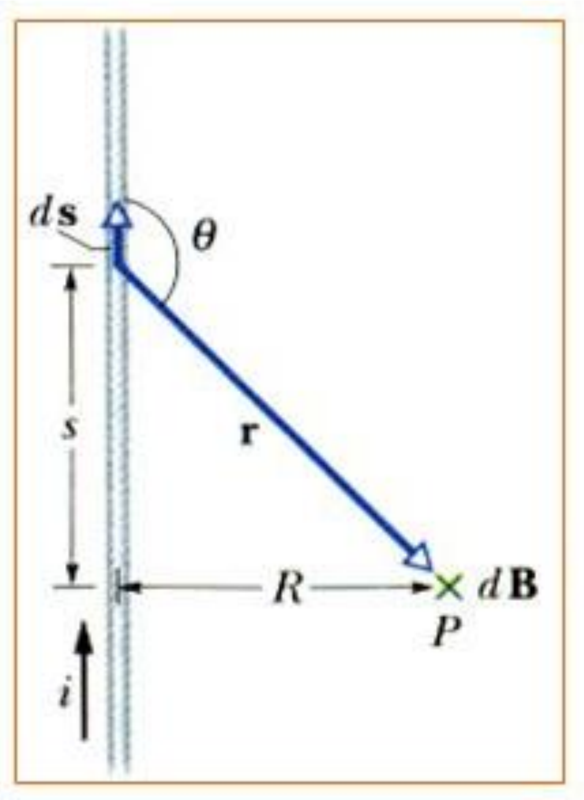
Em um fio longo, retilíneo



https://slideplayer.com.br/slide/5651503/

Campo produzido por uma Corrente

Em um fio longo, retilíneo



$$dB = \frac{\mu_0}{4\pi}\frac{ids.sen\theta}{r^2}$$

Lei de Biot-Savart

$$B = \int_{-\infty}^{+\infty} dB = 2\int_0^{+\infty} \frac{\mu_0}{4\pi}\frac{ids.sen\theta}{r^2}$$

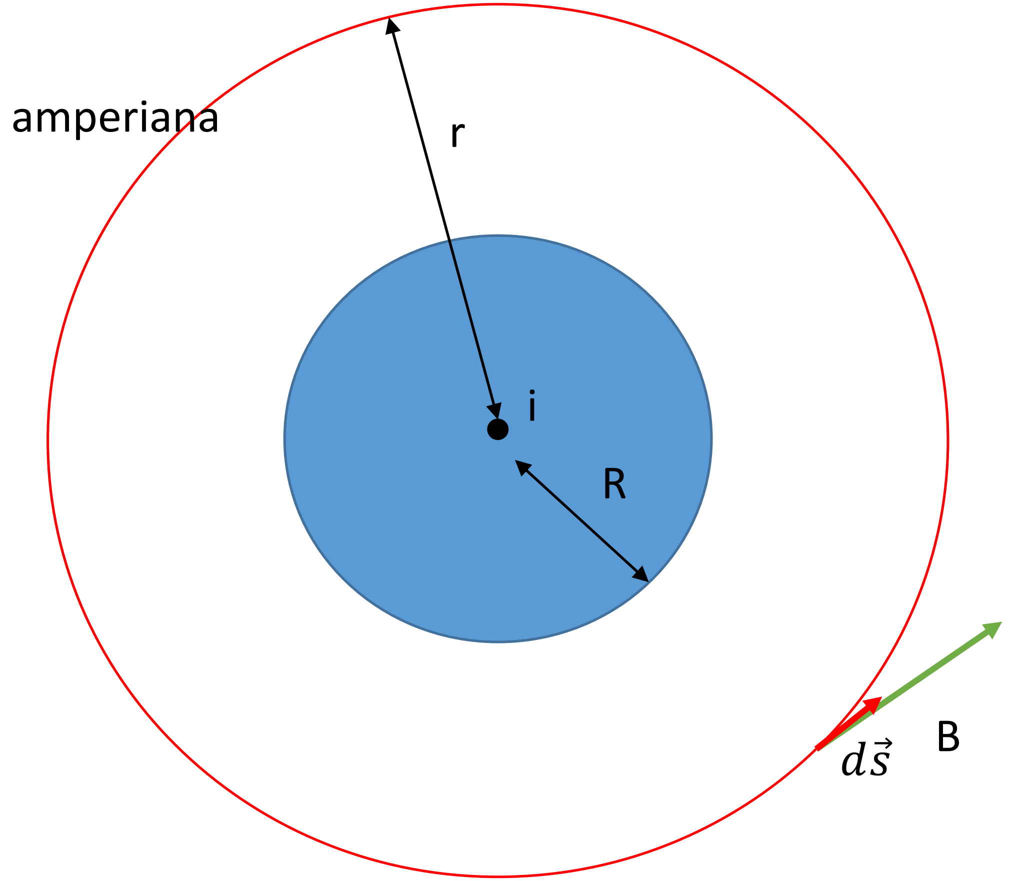
$$B = 2\frac{i\mu_0}{4\pi}\int_0^{\infty} \frac{sen\theta.ds}{r^2}$$

$$B = 2\frac{i\mu_0}{4\pi R} = \frac{i\mu_0}{2\pi R}$$

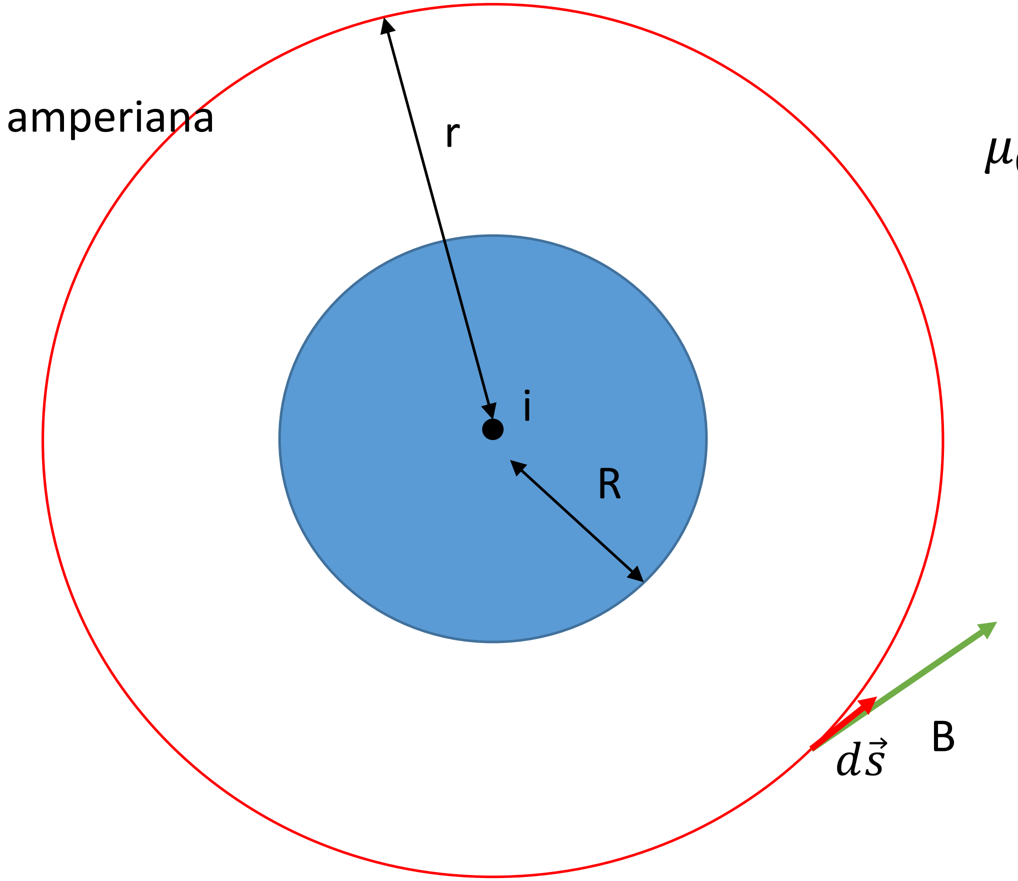
https://slideplayer.com.br/slide/5651503/

Aplicando a Lei de Ampère

$$\mu_0 i_{env} = \oint \vec{B} d\vec{s}$$



Aplicando a Lei de Ampère



$$\mu_0 i_{env} = \oint \vec{B} d\vec{s}$$

$$\mu_0 i_{env} = \oint B cos\theta ds$$

$$\mu_0 i_{env} = \oint B ds$$

$$\mu_0 i_{env} = B \oint ds$$

$$\mu_0 i_{env} = B 2\pi r$$

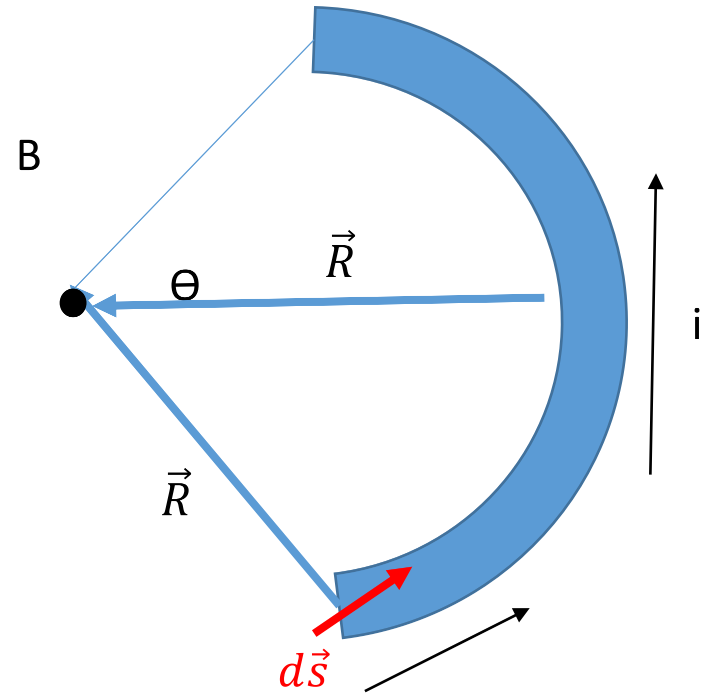
$$\boldsymbol{B = \frac{\mu_0 i}{2\pi r}}$$

Medida do campo magnético de um fio retilíneo

Animação!

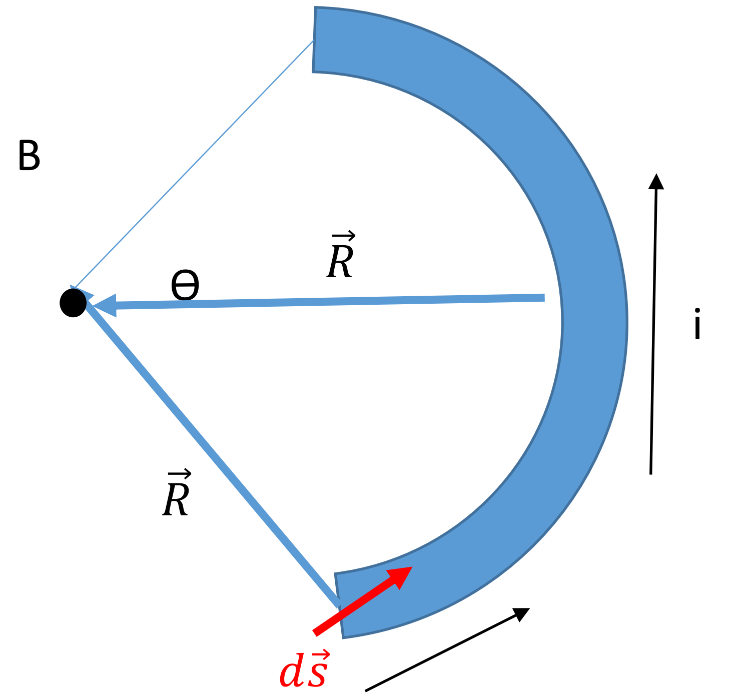
Campo produzido por uma Corrente

Em um arco de circunferência



Campo produzido por uma Corrente

Em um arco de circunferência



$$dB = \frac{\mu_0}{4\pi}\frac{ids.sen\theta}{r^2}$$

$$dB = \frac{\mu_0}{4\pi}\frac{ids.sen90}{r^2}$$

$$dB = \frac{\mu_0}{4\pi}\frac{ids}{R^2}$$

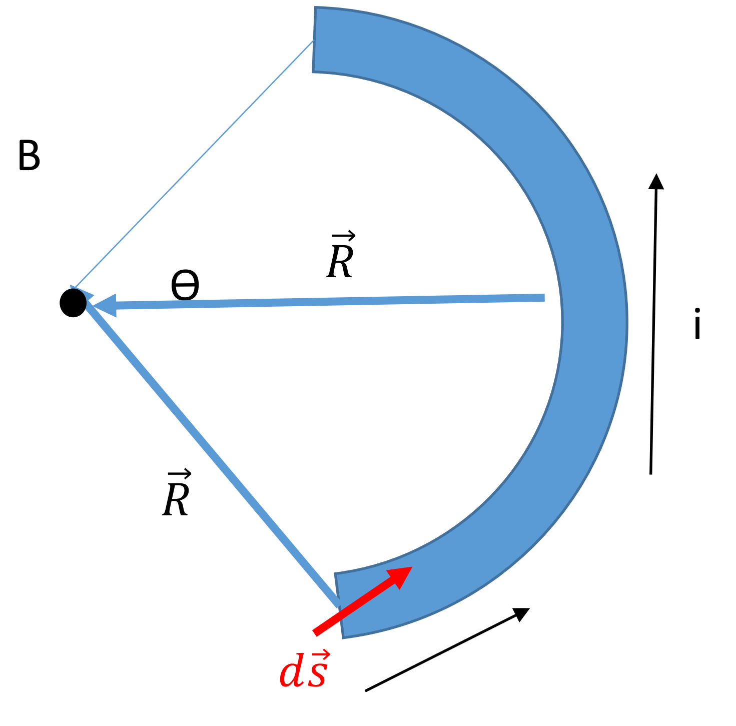
$$\boldsymbol{B = \frac{\mu_0 i}{4\pi R}\theta}$$

↑

$$B = \int B = \int \frac{\mu_0}{4\pi}\frac{ids}{R^2} = \frac{\mu_0 i}{4\pi R^2}\int ds = \frac{\mu_0 i}{4\pi R^2}\int_0^\theta R d\theta$$

Campo produzido por uma Corrente

Em um arco de circunferência



$$dB = \frac{\mu_0}{4\pi}\frac{ids.sen\theta}{r^2}$$

$$dB = \frac{\mu_0}{4\pi}\frac{ids.sen90}{r^2}$$

$$dB = \frac{\mu_0}{4\pi}\frac{ids}{R^2}$$

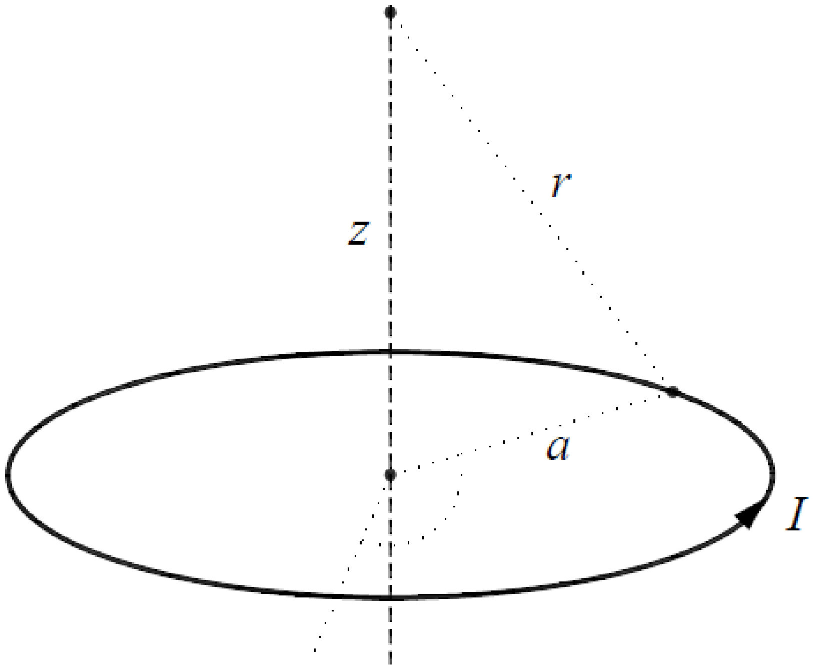
$$\boldsymbol{B = \frac{\mu_0 i}{2R}}$$

↑

$$B = \int B = \int \frac{\mu_0}{4\pi}\frac{ids}{R^2} = \frac{\mu_0 i}{4\pi R^2}\int ds = \frac{\mu_0 i}{4\pi R^2}\int_0^{2\pi} Rd\theta$$

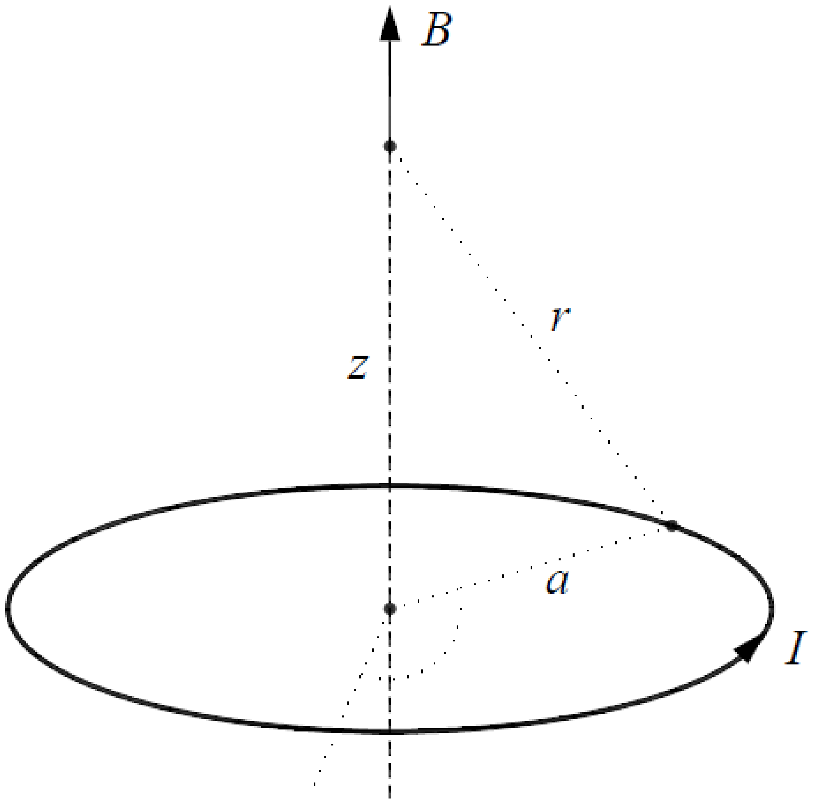
Campo produzido na Espira

Campo produzido na Espira



$$dB = \frac{\mu_0}{4\pi} \frac{ids.sen\theta}{r^2}$$

Campo produzido na Espira



$$dB = \frac{\mu_0}{4\pi}\frac{ids.sen\theta}{r^2}$$

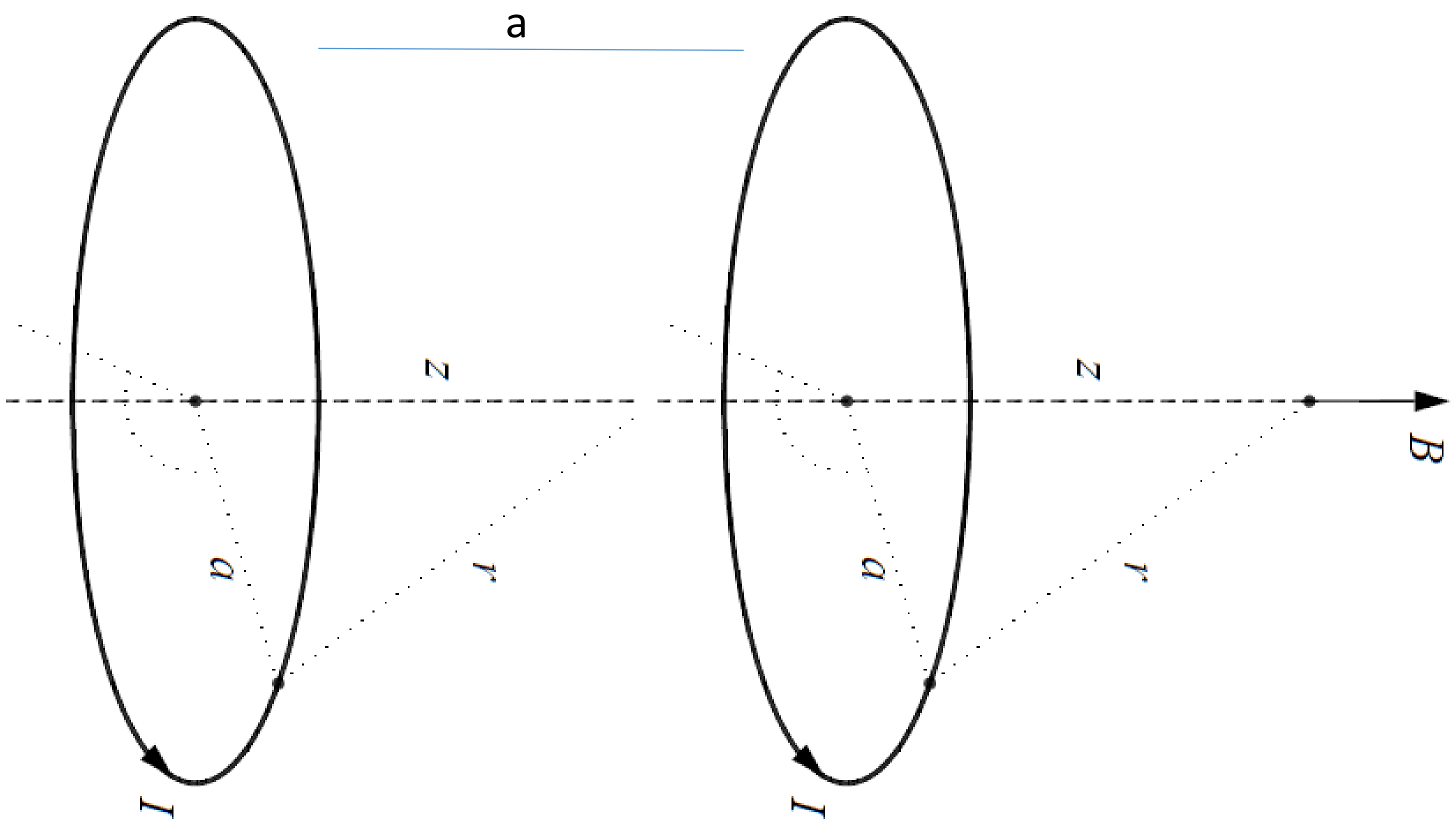
$$\vec{B}(z) = \frac{i\mu_0}{2}\frac{a^2}{(z^2 + a^2)^{3/2}}\hat{z}$$

Medida do campo magnético de uma bobina circular

Phet Simulador

Bobina Helmholtz

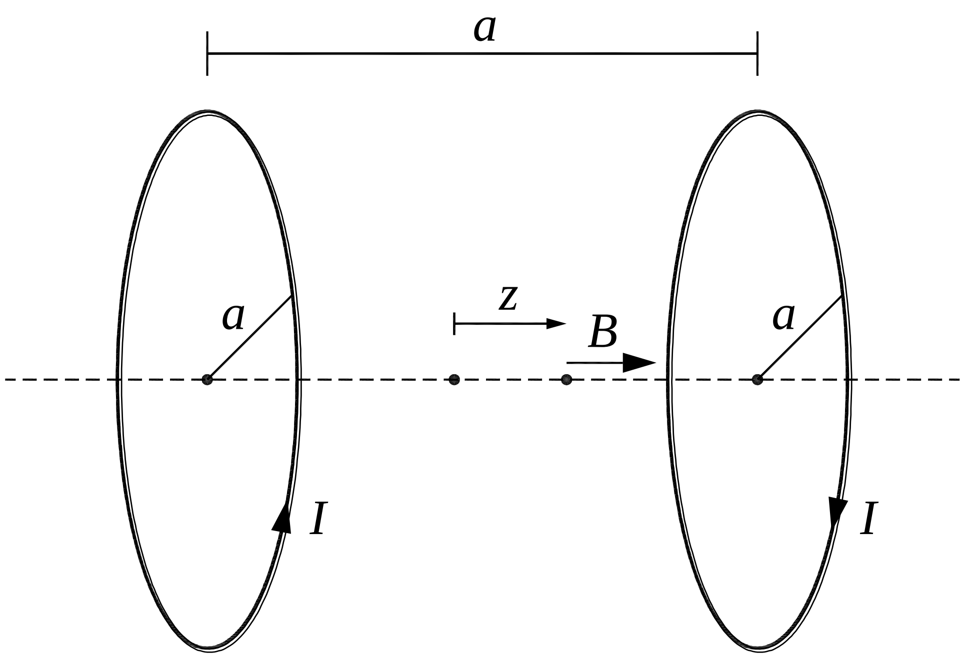
Bobina Helmholtz



Bobina Helmholtz

1 bobina:

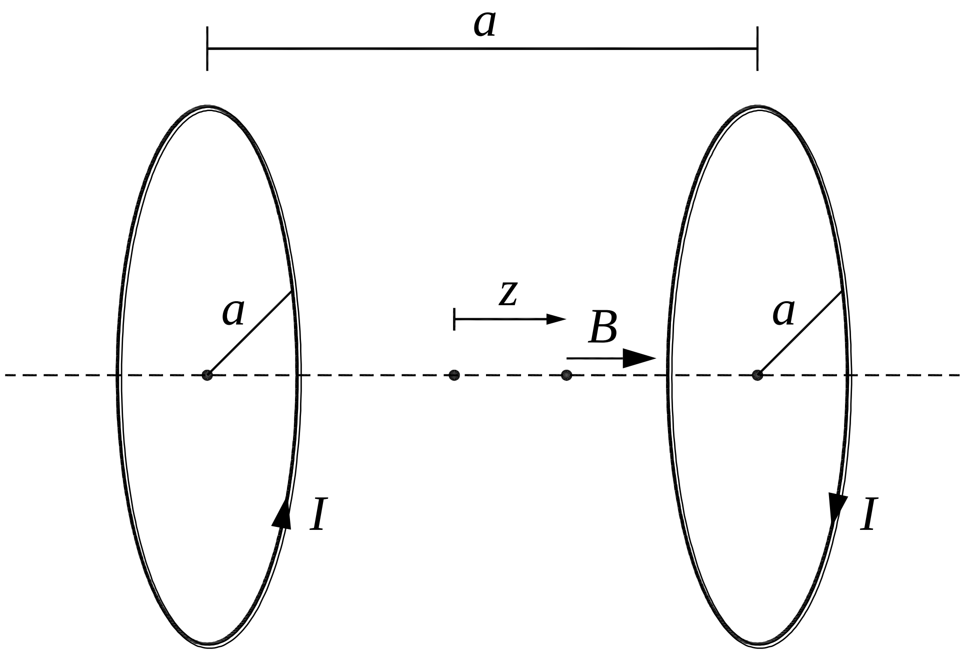
$$\vec{B}(z) = \frac{i\mu_0}{2}\frac{a^2}{(z^2 + a^2)^{3/2}}\hat{z}$$



Bobina Helmholtz

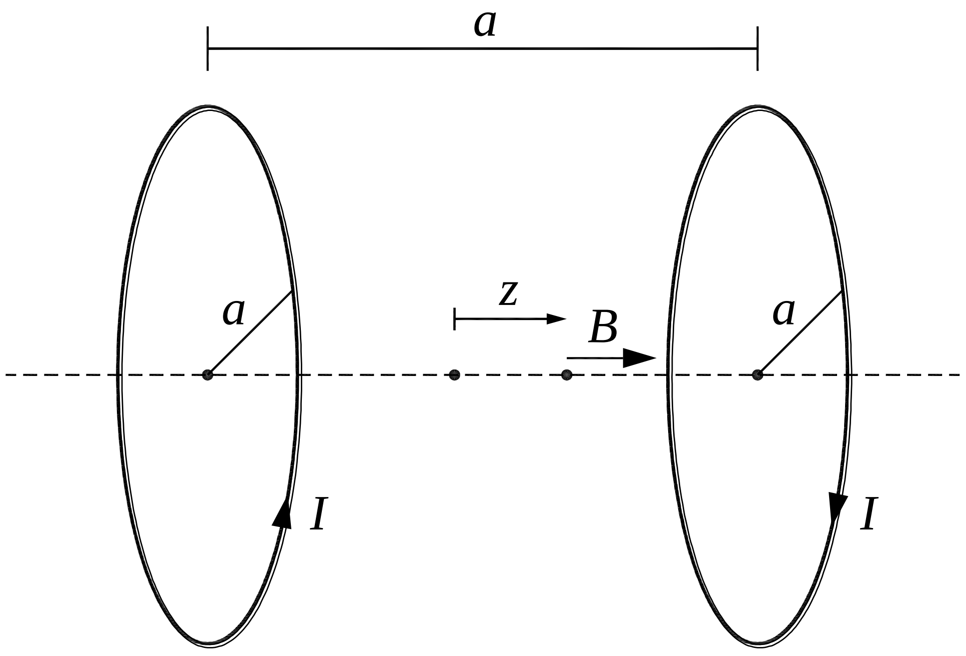
1 bobina:

$$\vec{B}(z) = \frac{i\mu_0}{2}\frac{a^2}{(z^2 + a^2)^{3/2}}\hat{z}$$



$$\overrightarrow{B_1}(z) = \frac{i\mu_0}{2}\frac{a^2}{\left((z - \frac{a}{2})^2 + a^2\right)^{3/2}}\hat{z}$$

Bobina Helmholtz



1 bobina:

$$\vec{B}(z) = \frac{i\mu_0}{2}\frac{a^2}{(z^2+a^2)^{3/2}}\hat{z}$$

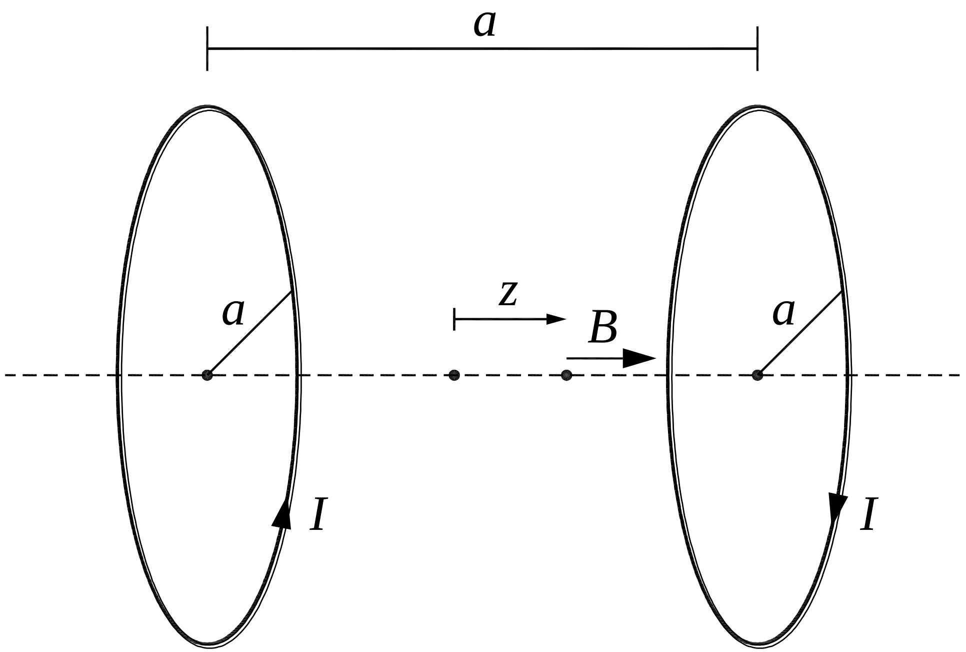
$$\overrightarrow{B_1}(z) = \frac{i\mu_0}{2}\frac{a^2}{\left((z-\frac{a}{2})^2+a^2\right)^{3/2}}\hat{z}$$

$$\overrightarrow{B_2}(z) = \frac{i\mu_0}{2}\frac{a^2}{\left((z+\frac{a}{2})^2+a^2\right)^{3/2}}\hat{z}$$

Bobina Helmholtz

1 bobina:

$$\vec{B}(z) = \frac{i\mu_0}{2}\frac{a^2}{(z^2 + a^2)^{3/2}}\hat{z}$$

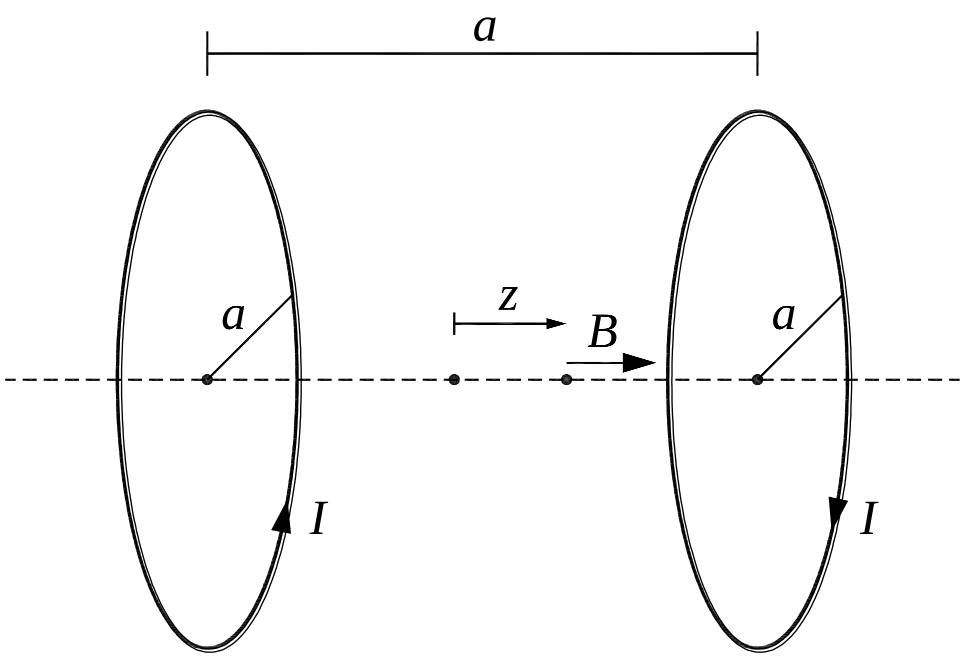


$$\vec{B}(z) = \overrightarrow{B_1}(z) + \overrightarrow{B_2}(z)$$

$$\overrightarrow{B_1}(z) = \frac{i\mu_0}{2}\frac{a^2}{\left((z - \frac{a}{2})^2 + a^2\right)^{3/2}}\hat{z}$$

$$\overrightarrow{B_2}(z) = \frac{i\mu_0}{2}\frac{a^2}{\left((z + \frac{a}{2})^2 + a^2\right)^{3/2}}\hat{z}$$

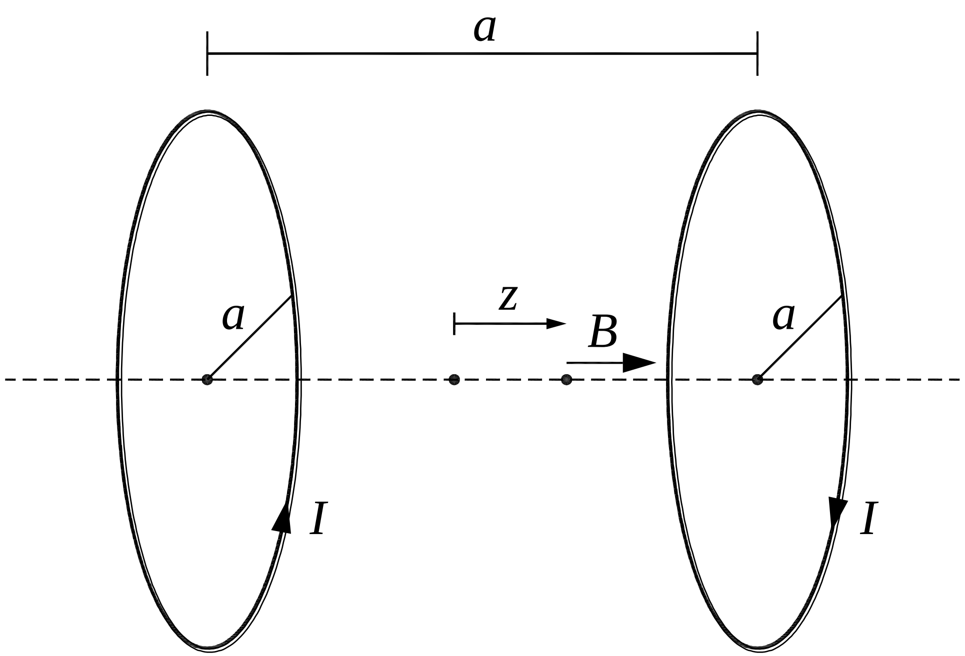
Bobina Helmholtz



$$\vec{B}(z) = \overrightarrow{B_1}(z) + \overrightarrow{B_2}(z)$$

$$\vec{B}(z) = \frac{\mu_o I a^2}{2}\left(\frac{1}{((z-a/2)^2+a^2)^{3/2}} - \frac{1}{((z+a/2)^2+a^2)^{3/2}}\right)\hat{z}$$

Bobina Helmholtz



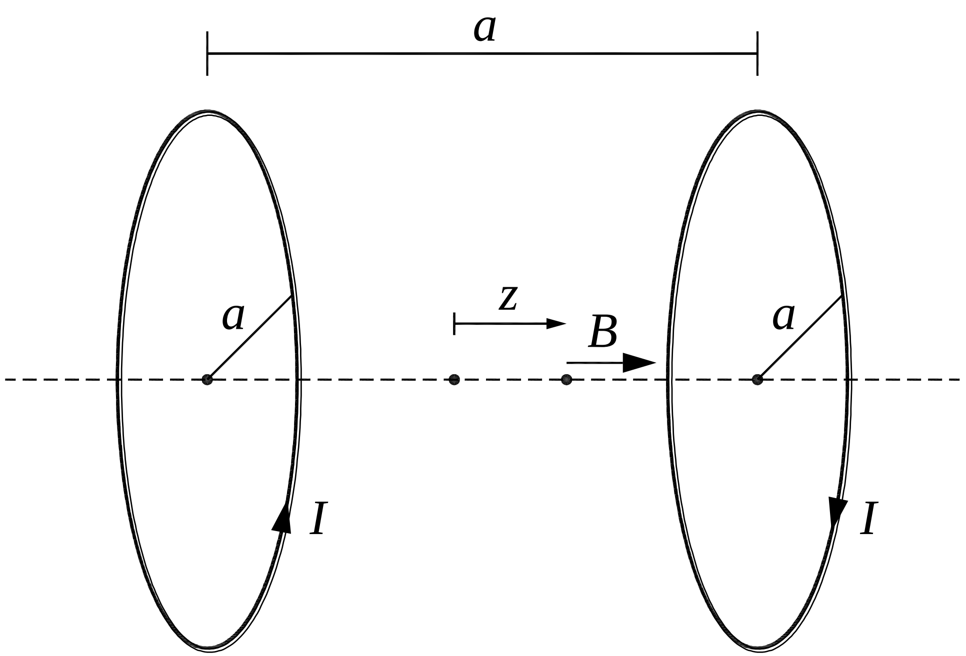
$$\vec{B}(z) = \overrightarrow{B_1}(z) + \overrightarrow{B_2}(z)$$

$$\vec{B}(z) = \frac{\mu_o I a^2}{2}\left(\frac{1}{((z-a/2)^2 + a^2)^{3/2}} - \frac{1}{((z+a/2)^2 + a^2)^{3/2}}\right)\hat{z}$$

Para z=0:

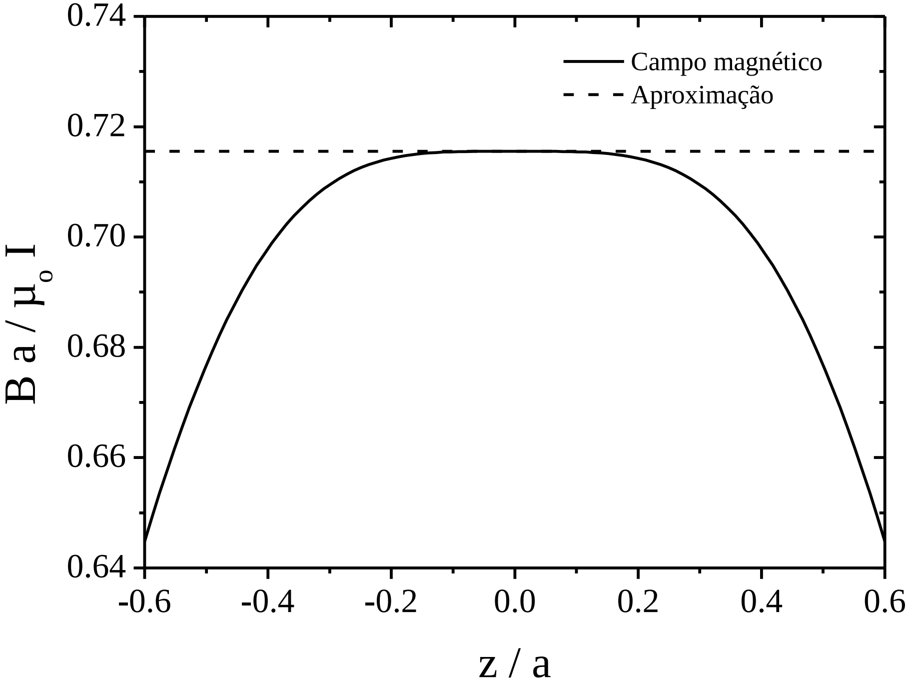
$$\vec{B}_{ap} = \frac{8}{5^{3/2}}.\frac{\mu_o I}{a}\hat{z} \approx 0,715.\frac{\mu_o I}{a}\hat{z}$$

Bobina Helmholtz

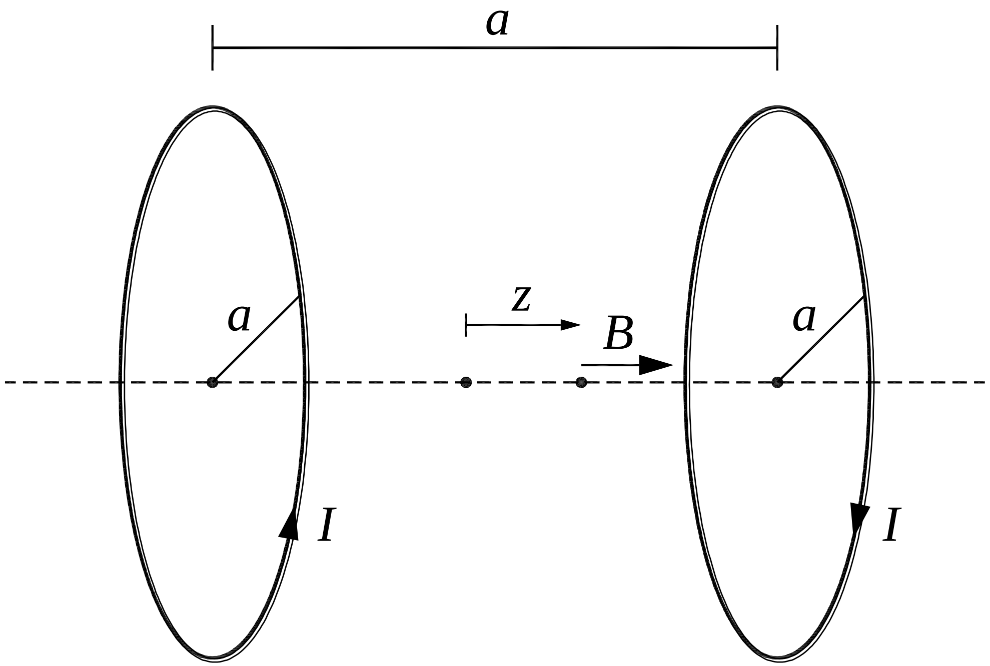


$$\vec{B}(z) = \vec{B_1}(z) + \vec{B_2}(z)$$

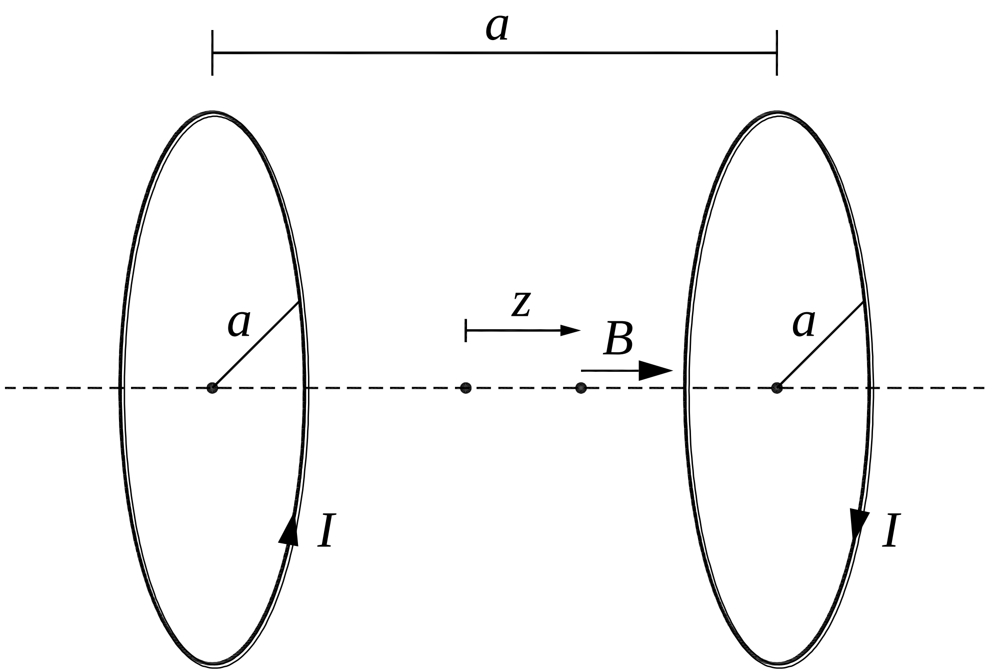
$$\vec{B}(z) = \frac{\mu_o I a^2}{2}\left(\frac{1}{((z-a/2)^2+a^2)^{3/2}} - \frac{1}{((z+a/2)^2+a^2)^{3/2}}\right)\hat{z}$$



Bobina Anti-Helmholtz

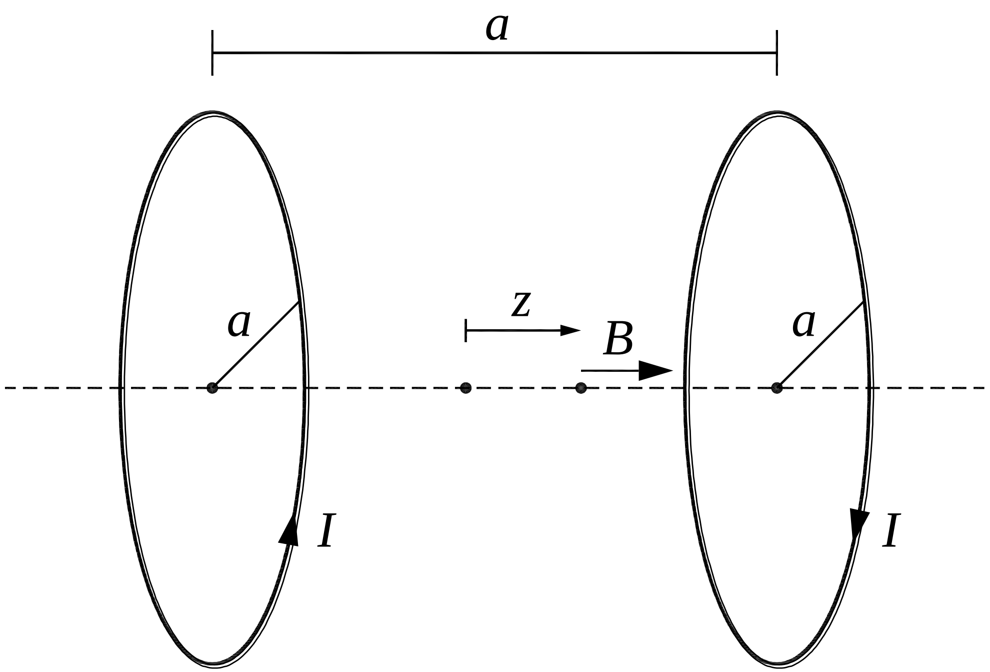


Bobina Anti-Helmholtz



$$\vec{B}(z) = \frac{\mu_o I a^2}{2}\left(\frac{1}{((z-a/2)^2+a^2)^{3/2}} - \frac{1}{((z+a/2)^2+a^2)^{3/2}}\right)\hat{z}$$

Bobina Anti-Helmholtz

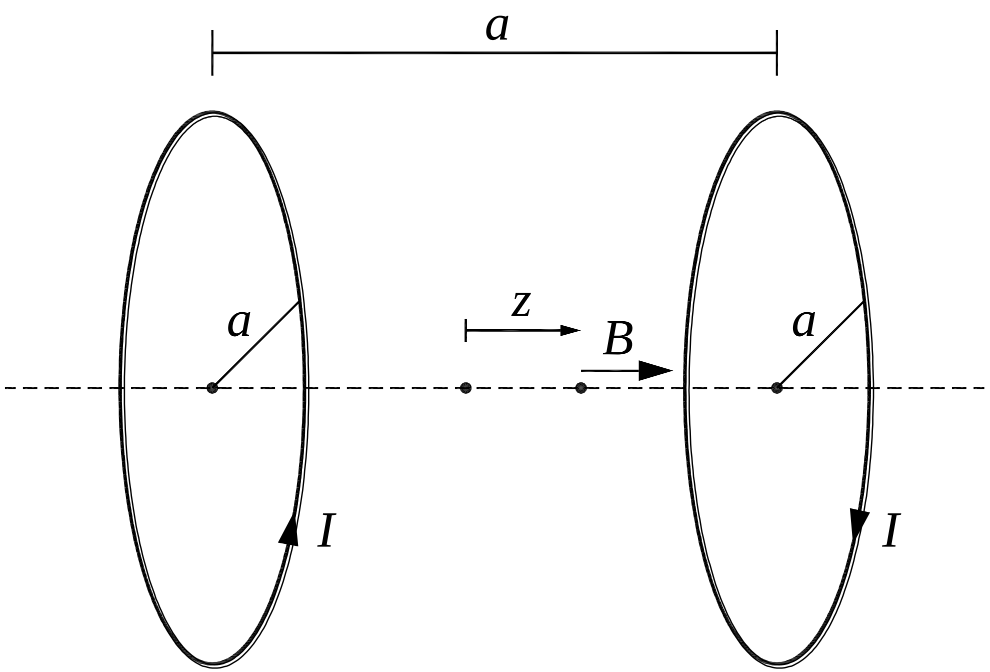


$$\vec{B}(z) = \frac{\mu_o I a^2}{2}\left(\frac{1}{((z-a/2)^2+a^2)^{3/2}} - \frac{1}{((z+a/2)^2+a^2)^{3/2}}\right)\hat{z}$$

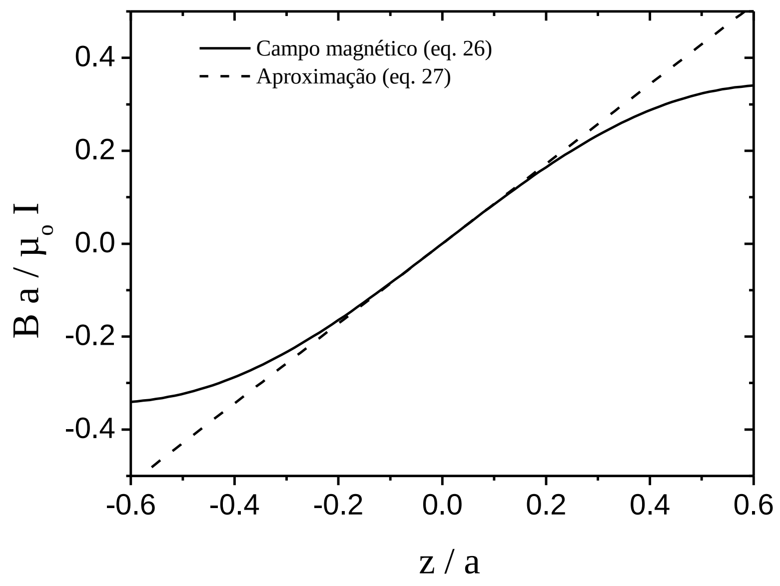
Para z=0:

$$\vec{B}_{ap}(z) = \frac{48}{5^{5/2}}.\frac{\mu_o I}{a^2}z.\hat{z} \approx 0{,}859.\frac{\mu_o I}{a^2}z.\hat{z}$$

Bobina Anti-Helmholtz

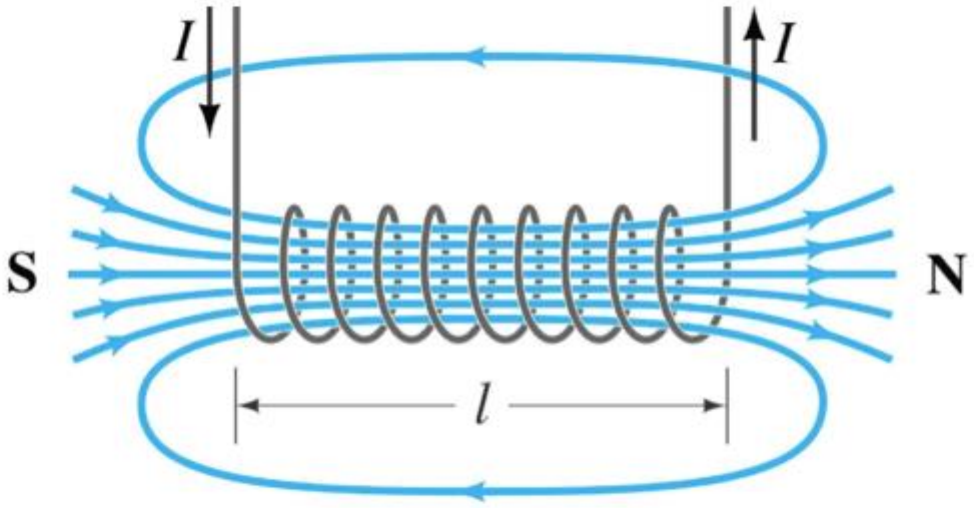


$$\vec{B}(z) = \frac{\mu_o I a^2}{2}\left(\frac{1}{((z-a/2)^2+a^2)^{3/2}} - \frac{1}{((z+a/2)^2+a^2)^{3/2}}\right)\hat{z}$$



Campo no Solenóide

$$\mu_0 i_{env} = \oint \vec{B} d\vec{s}$$



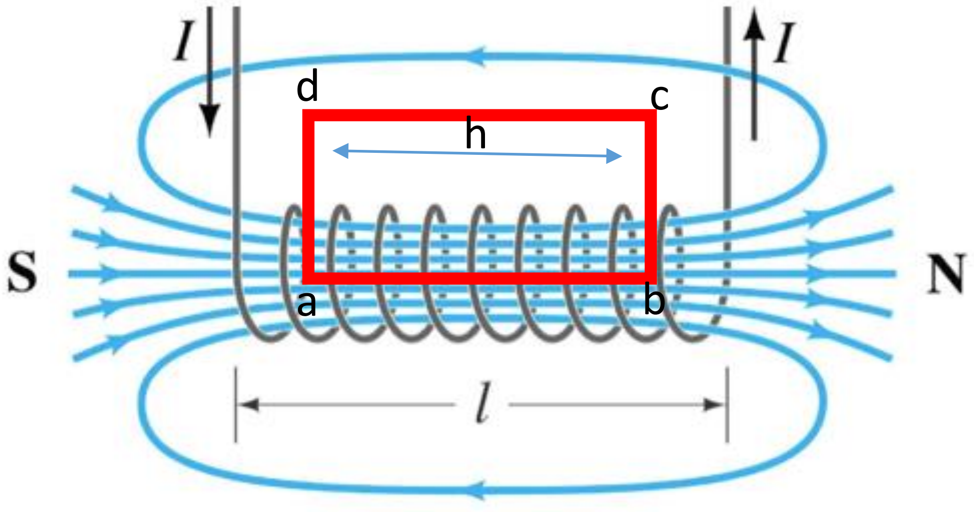
Campo no Solenóide

$$\mu_0 i_{env} = \oint \vec{B} d\vec{s}$$

$$\oint \vec{B} d\vec{s} = \int_a^b \vec{B} d\vec{s} + \int_b^c \vec{B} d\vec{s} + \int_c^d \vec{B} d\vec{s} + \int_d^a \vec{B} d\vec{s}$$

$$\oint \vec{B} d\vec{s} = Bh + 0 + 0 + 0$$

$$\oint \vec{B} d\vec{s} = Bh$$

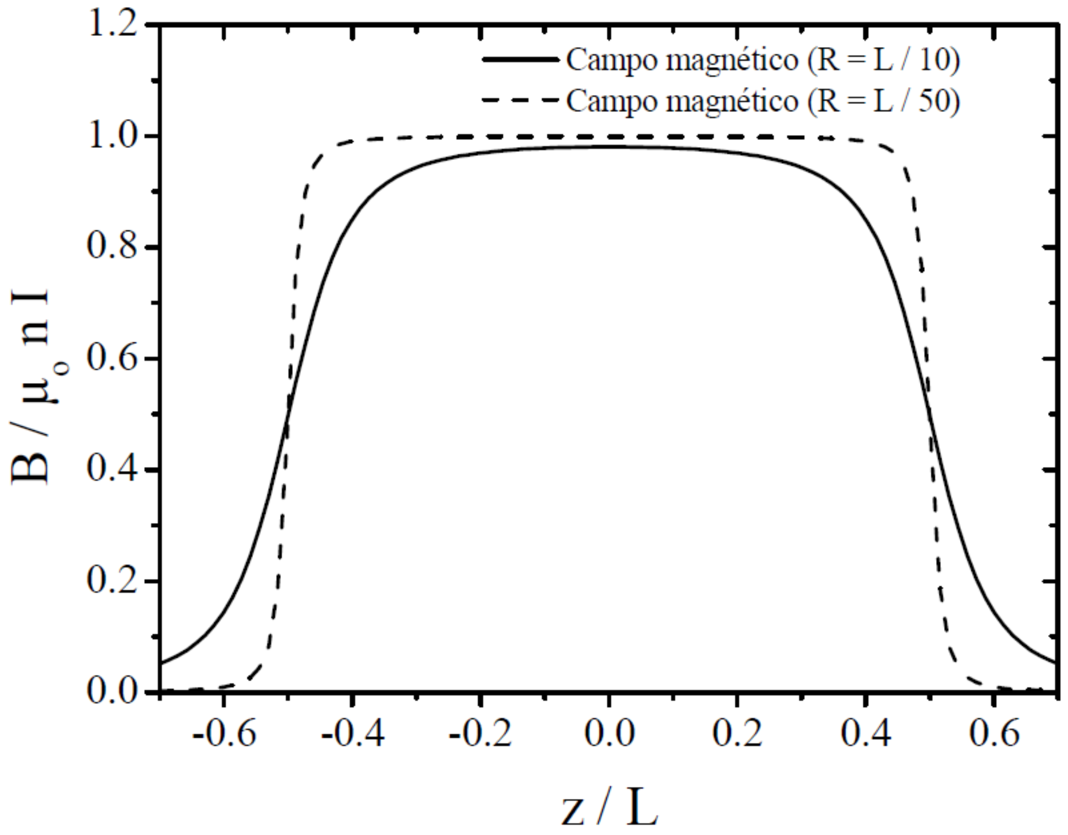


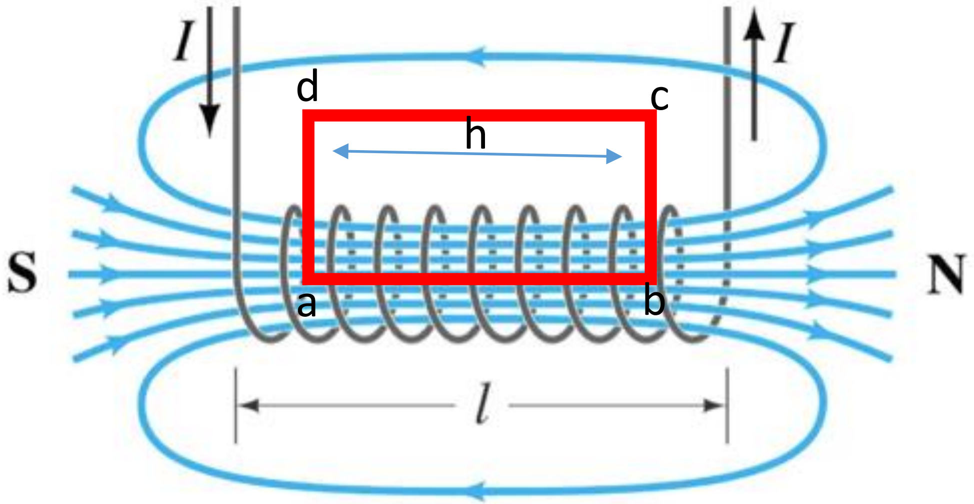
$$\mu_0 i_{env} = Bh \rightarrow \mu_0[i(nh)] = Bh \rightarrow B = \mu_0 in$$

Número de espiras/comprimento

Campo no Solenóide – a prática

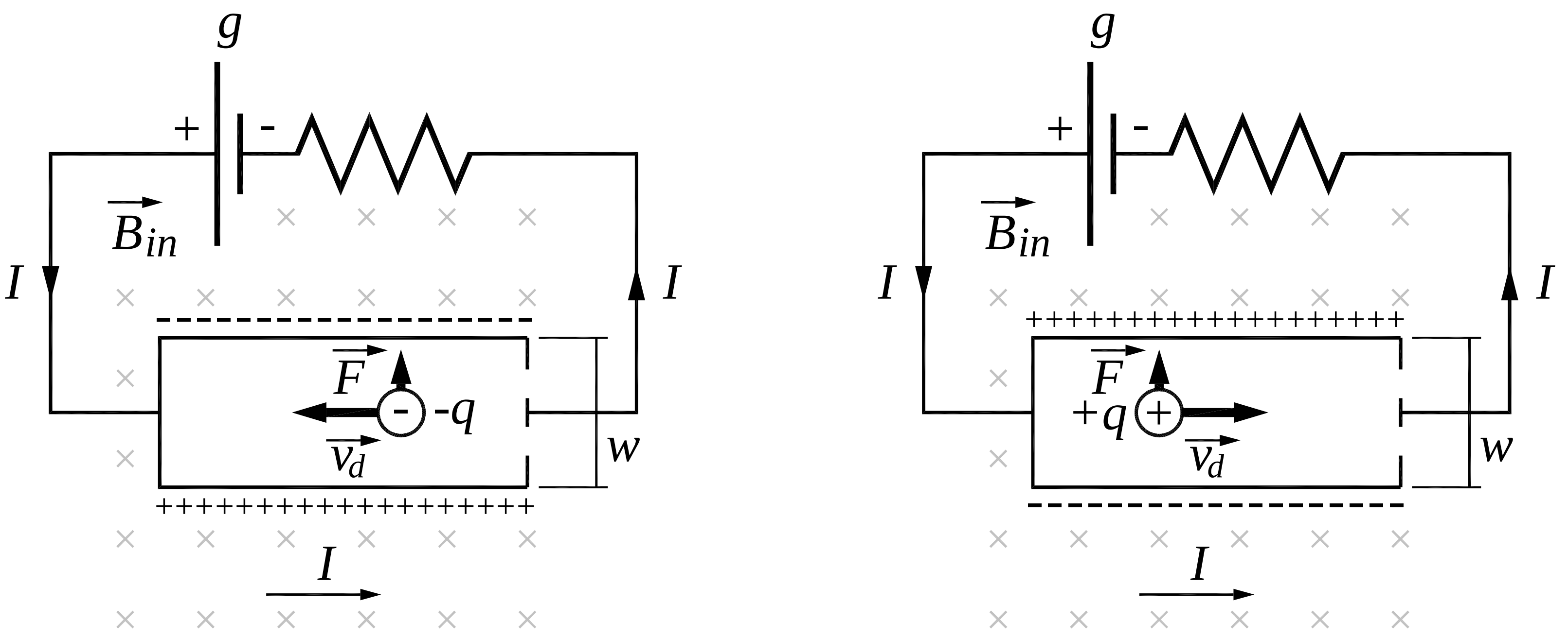
$B = \mu_0 i n$





Efeito Hall

$$\overrightarrow{F_B} = q\vec{v} \times \overrightarrow{B}$$



O efeito Hall

Quantificando o efeito Hall:

$$F_{el} = F_B$$

$$eE = ev_d B$$

$$E = \frac{i}{neA} B \rightarrow n = \frac{iB}{EeA}$$

$$n = \frac{iB}{Ee(l.d)} \rightarrow n = \frac{iB}{Ve(l)}$$

Lembrando: $v_d = \frac{J}{ne} = \frac{i}{neA}$

J → densidade de corrente (i/A)
A → área da seção
n → portadores/volume → concentração de portadores

O efeito Hall

Quantificando o efeito Hall:

$$\boldsymbol{V} = \frac{i\boldsymbol{B}}{ne(l)}$$

$$F_{el} = F_B$$

$$eE = ev_dB$$

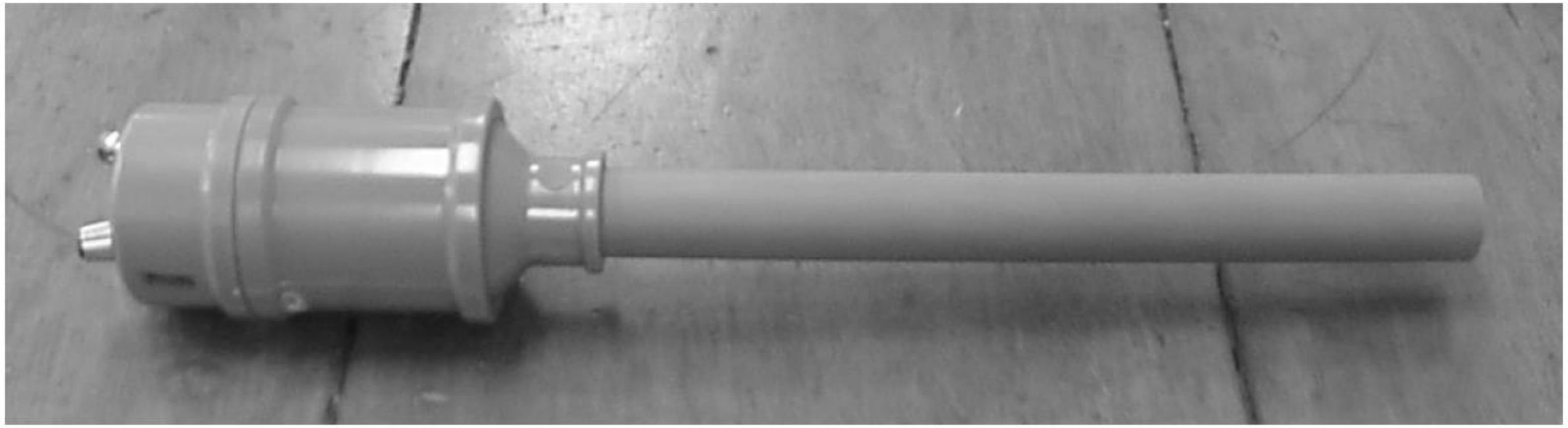
$$E = \frac{i}{neA}B \rightarrow n = \frac{iB}{EeA}$$

Lembrando: $v_d = \frac{J}{ne} = \frac{i}{neA}$

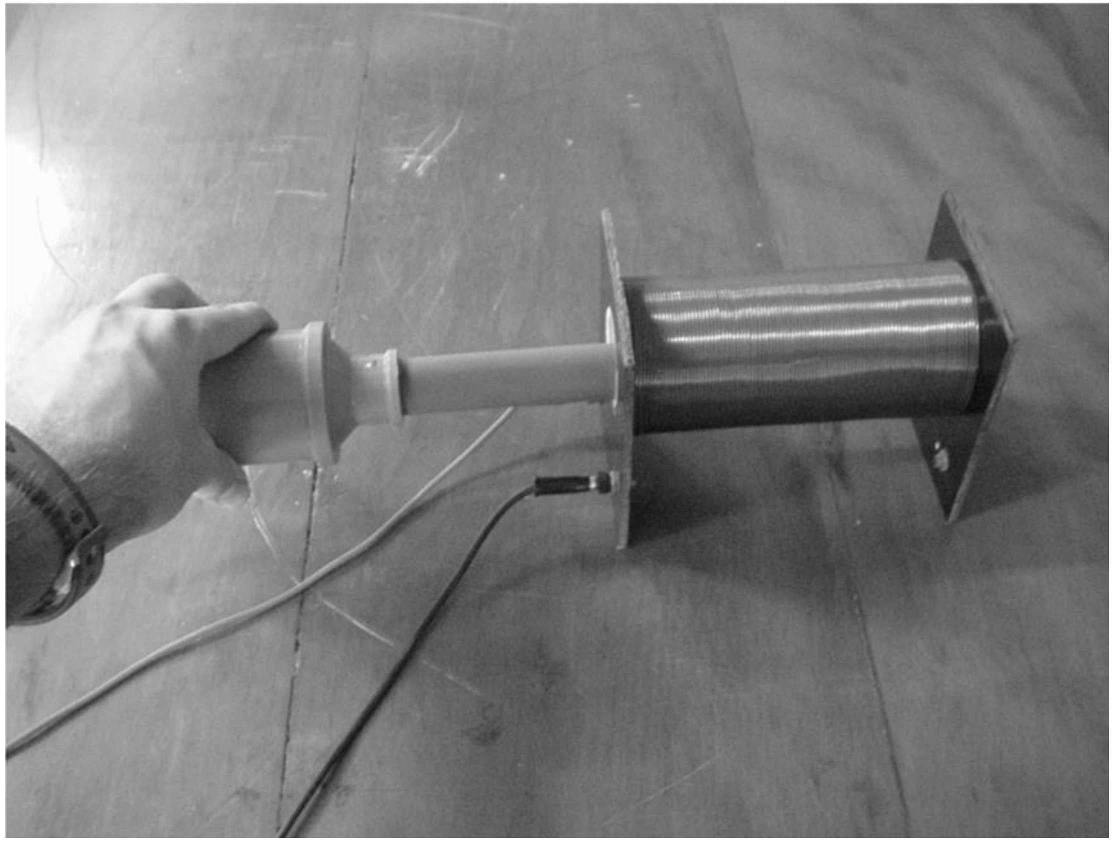
$$n = \frac{iB}{Ee(l.d)} \rightarrow n = \frac{iB}{Ve(l)}$$

J → densidade de corrente (i/A)
A → área da seção
n → portadores/volume → concentração de portadores

Sonda Hall



Calibração



Vídeo!

Medida do campo magnético de um fio retilíneo

Animação!