Centro Federal de Educação Tecnológica de Santa Catarina
Departamento Acadêmico de Eletrônica

Retificadores

Lei de Ampère, Fluxo Magnético Circuitos Magnéticos, Entreferros, Força Magnética e Aplicações

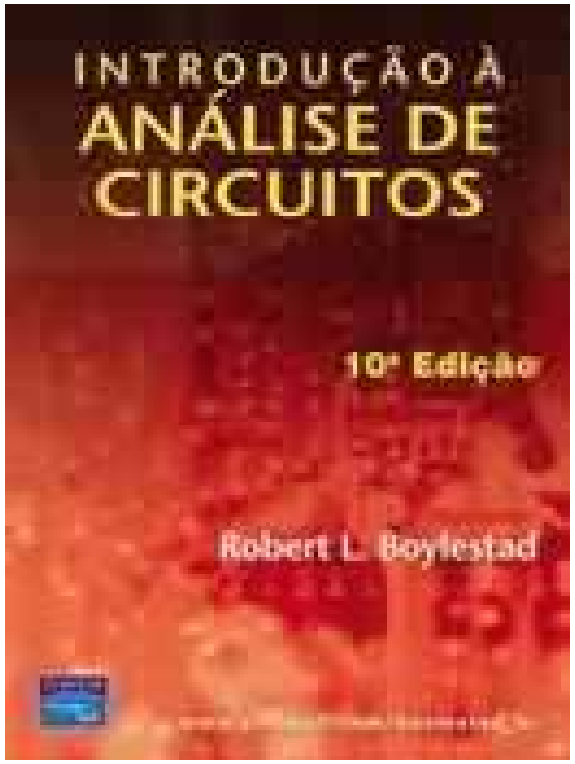
Prof. Clóvis Antônio Petry.

Florianópolis, abril de 2008.

Bibliografia para esta aula

Capítulo 11: Circuitos magnéticos

1. Lei de Ampère;
2. Fluxo;
3. Circuitos magnéticos;
4. Entreferros;
5. Força magnética;
6. Aplicações.



www.cefetsc.edu.br/~petry

Lei circuital de Ampère

O somatório das forças em um caminho fechado é nulo:

$$\sum V = 0$$

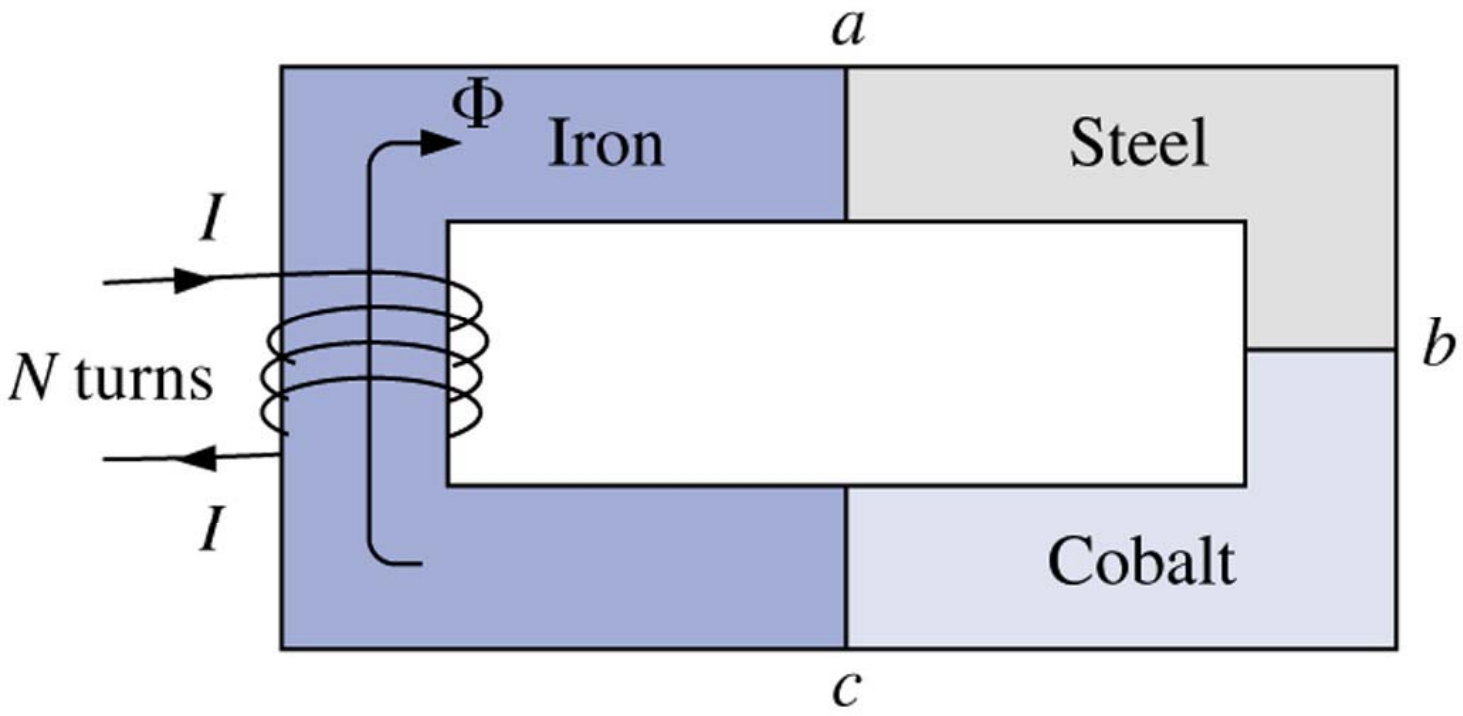
Lei de Kirchhoff das tensões

Lei circuital de Ampère

$$\sum \mathfrak{I} = 0$$

Ação de	Circuitos elétricos	Circuitos magnéticos
Causa	E	$\mathcal{F}$
Efeito	I	Φ
Oposição	R	$\mathcal{R}$

Lei circuital de Ampère



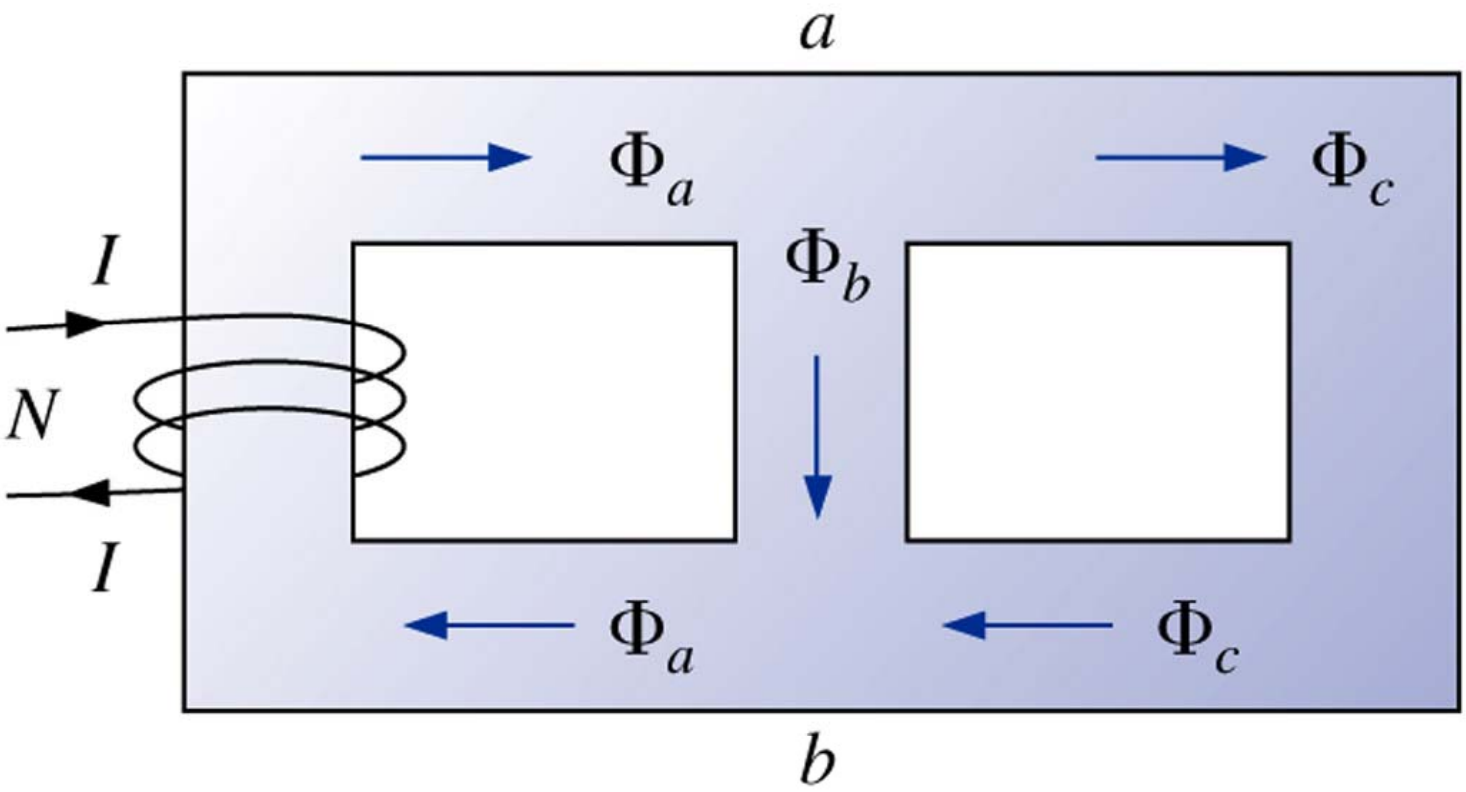
$$\sum \Im = 0 \qquad N \cdot I - H_{ab} \cdot l_{ab} - H_{bc} \cdot l_{bc} - H_{ca} \cdot l_{ca} = 0$$

$$N \cdot I = H_{ab} \cdot l_{ab} + H_{bc} \cdot l_{bc} + H_{ca} \cdot l_{ca}$$

Fmm aplicada

Queda de fmm

Fluxo Φ

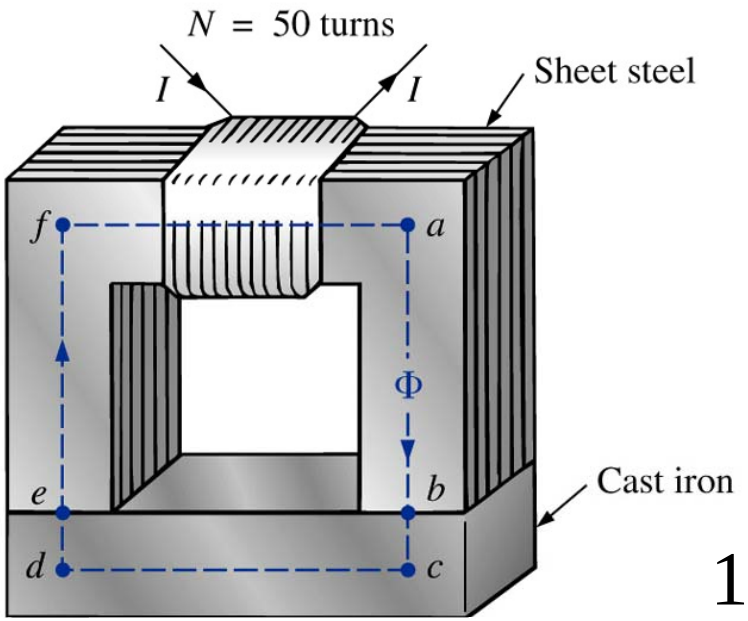


$$\Phi_a = \Phi_b + \Phi_c \quad \text{(na junção a)}$$

$$\Phi_b + \Phi_c = \Phi_a \quad \text{(na junção b)}$$

Circuitos magnéticos

Exemplo 11.4: Determinar a corrente I necessária para estabelecer o fluxo Φ:



$l_{ab} = l_{cd} = l_{ef} = l_{fa} = 4$ in.
$l_{bc} = l_{de} = 0.5$ in.
Area (throughout) = 1 in.^{2}
$\Phi = 3.5 \times 10^{-4}$ Wb

$$l_{efab} = 4 + 4 + 4 = 12\ pol.$$

$$l_{bcde} = 0,5 + 4 + 0,5 = 5\ pol.$$

$$12\ pol. = 304,8 \cdot 10^{-3}\ m$$

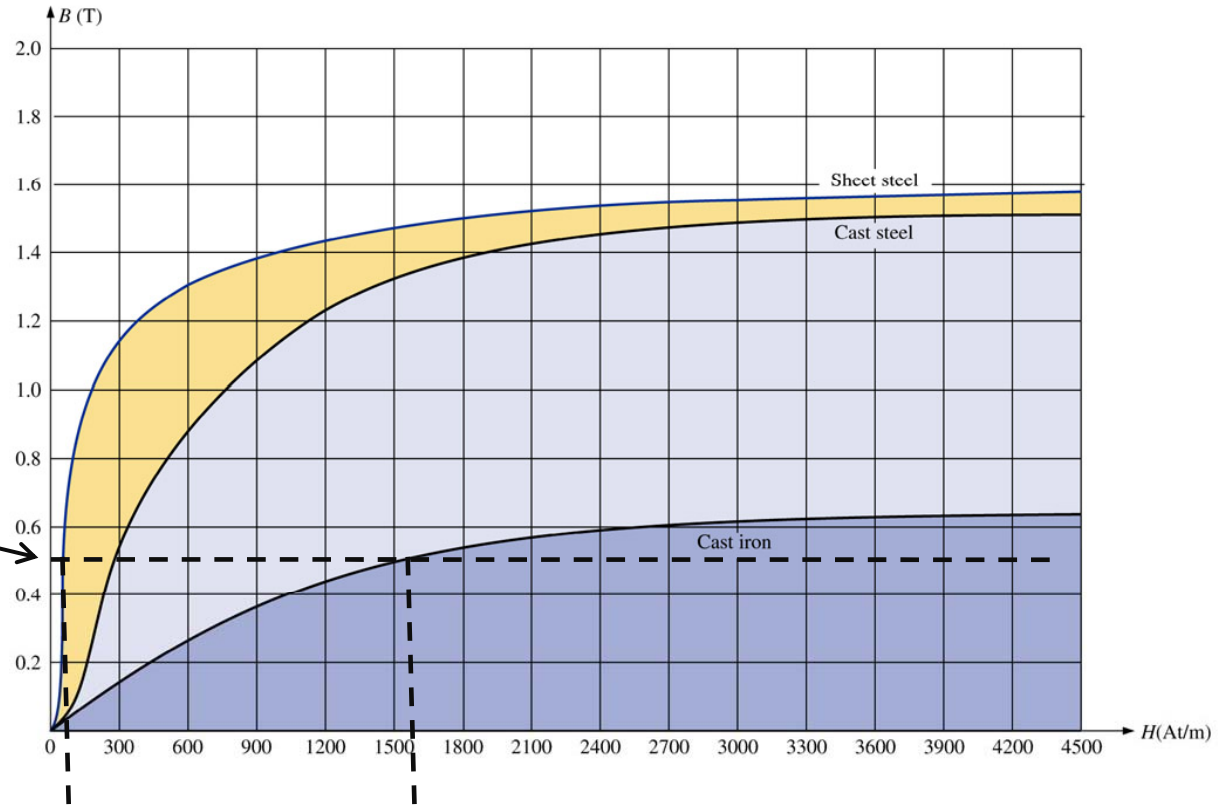
$$5\ pol. = 127 \cdot 10^{-3}\ m$$

$$1\ pol.^2 = 6,452 \cdot 10^{-4}\ m$$

$$B = \frac{\Phi}{A} = \frac{3,5 \cdot 10^{-4}\ Wb}{6,452 \cdot 10^{-4}\ m^2} = 0,542\,T$$

Circuitos magnéticos

Exemplo 11.4: Determinar a corrente I necessária para estabelecer o fluxo Φ:

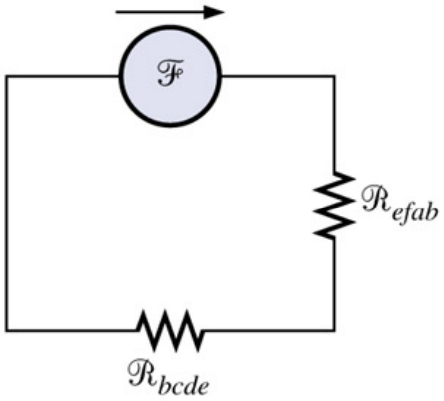


$0,542\,T$

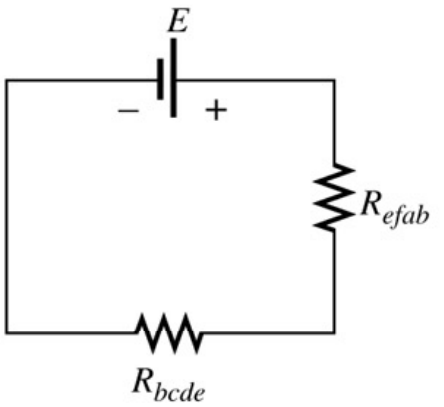
$H_{aço} \approx 70\,A/m$ $H_{ferro} \approx 1600\,A/m$

Circuitos magnéticos

Exemplo 11.4: Determinar a corrente I necessária para estabelecer o fluxo Φ:



(a)



(b)

$$H_{efab} \cdot l_{efab} = 70 \cdot 304,8 \cdot 10^{-3} = 21,34\,A$$

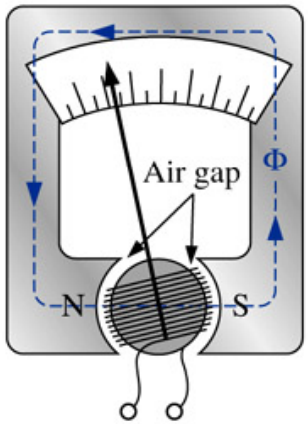
$$H_{bcde} \cdot l_{bcde} = 1600 \cdot 127 \cdot 10^{-3} = 203,2\,A$$

$$N \cdot I = H_{efab} \cdot l_{efab} + H_{bcde} \cdot l_{bcde} = 224,54\,A$$

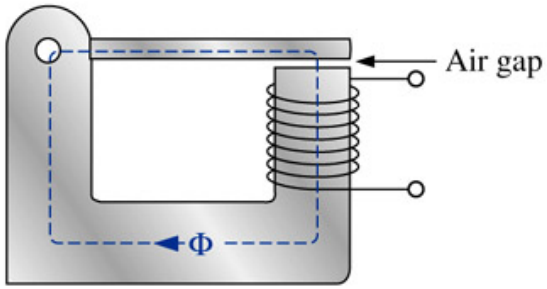
$$I = \frac{224,54}{N} = \frac{224,54}{50} = 4,49\,A$$

Entreferros

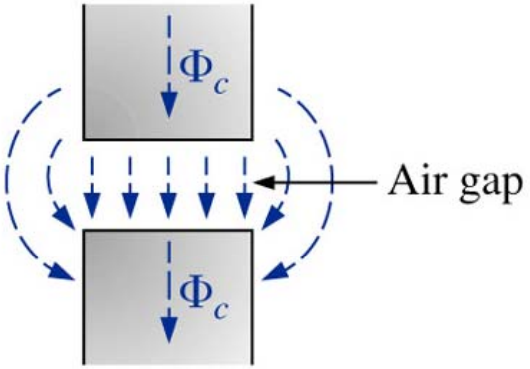
Espaço sem núcleo nos circuitos magnéticos:



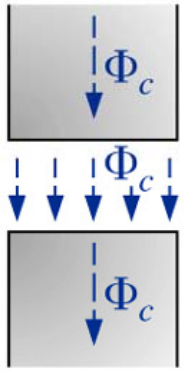
Meter movement



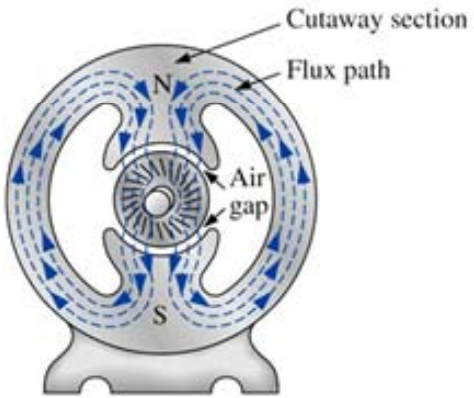
Relay



(a)



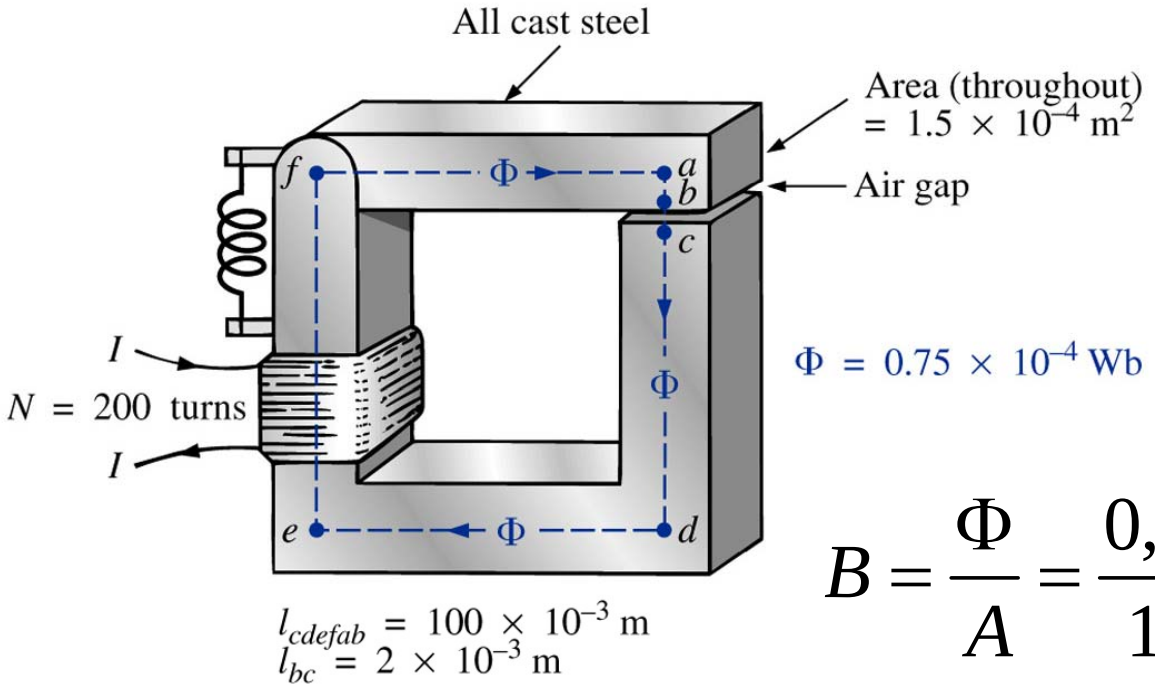
(b)



Generator

Entreferros

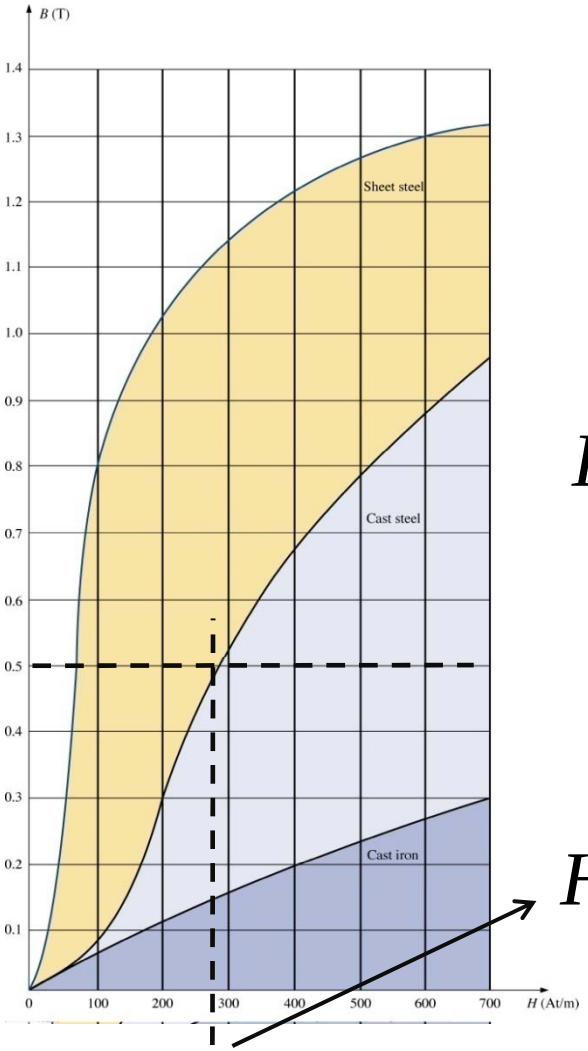
Exemplo 11.6: Determinar a corrente I necessária para estabelecer o fluxo Φ:



$$B = \frac{\Phi}{A} = \frac{0,75 \cdot 10^{-4}\, Wb}{1,5 \cdot 10^{-4}\, m^2} = 0,5T$$

Entreferros

Exemplo 11.6: Determinar a corrente I necessária para estabelecer o fluxo Φ:



$$H_g = \frac{B_g}{\mu_o} = \frac{B_g}{4\pi \cdot 10^{-7}}$$

$$H_g = \frac{0,5}{4\pi \cdot 10^{-7}} = 3,98 \cdot 10^5 \; A/m$$

$0,5T$ →

$H_{aço} \cong 280A/m$

Entreferros

Exemplo 11.6: Determinar a corrente I necessária para estabelecer o fluxo Φ:

$$H_{nucleo} \cdot l_{nucleo} = 280 \cdot 100 \cdot 10^{-3} = 28\,A$$

$$H_g \cdot l_g = 3,98 \cdot 10^5 \cdot 2 \cdot 10^{-3} = 796\,A$$

$$N \cdot I = H_{nucleo} \cdot l_{nucleo} + H_g \cdot l_g = 824\,A$$

$$I = \frac{824}{N} = \frac{824}{200} = 4,12\,A$$

Entreferros

Exemplo 11.6: Determinar a corrente I necessária para estabelecer o fluxo Φ:

Para a corrente determinada, determinar
B desconsiderando o entreferro

$$N \cdot I = H_{nucleo} \cdot l_{nucleo} = 200 \cdot 4{,}12 = 824\,A$$

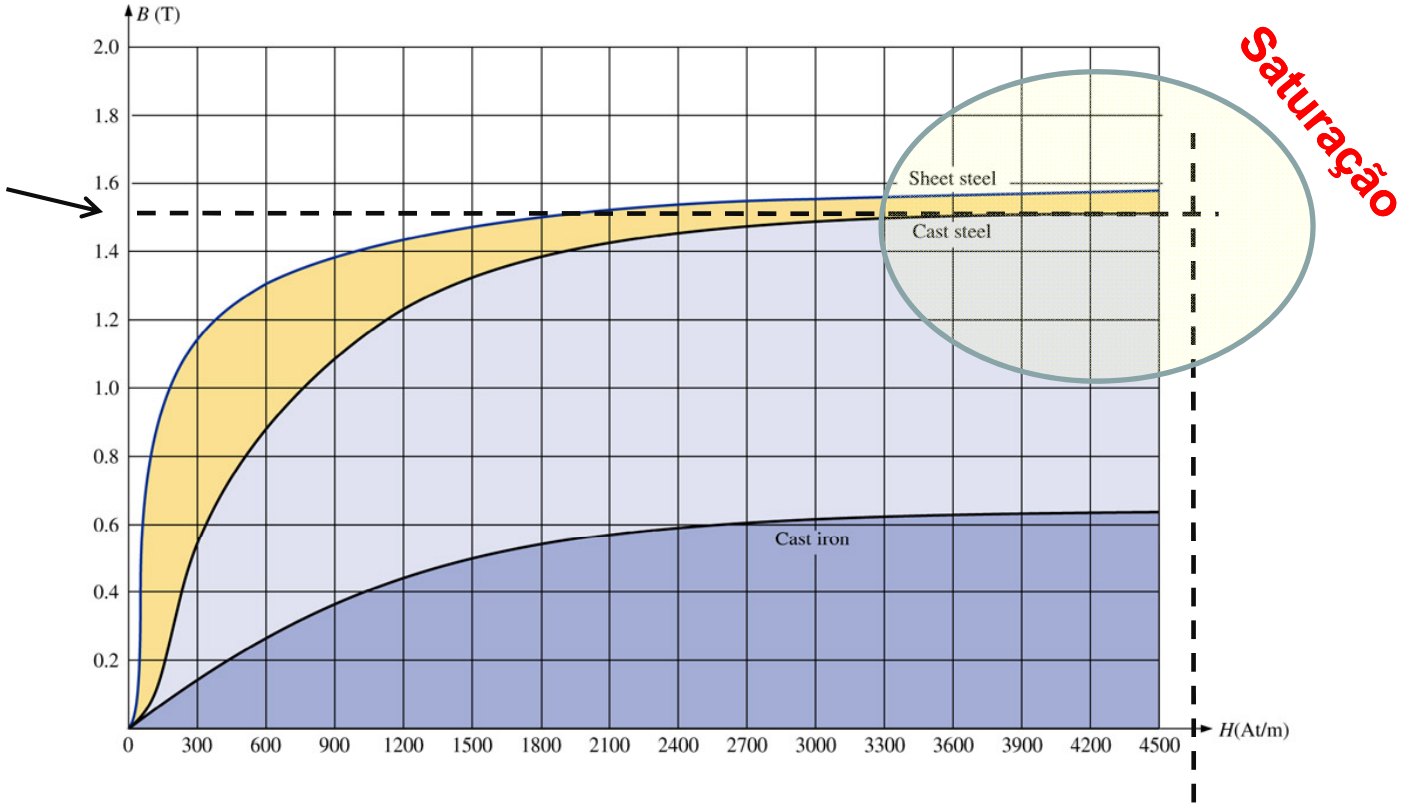
$$H_{nucleo} = \frac{N \cdot I}{l_{nucleo}} = \frac{824}{100 \cdot 10^{-3}} = 8240\,A/m$$

Entreferros

Exemplo 11.6: Determinar a corrente I necessária para estabelecer o fluxo Φ:

Para a corrente determinada, determinar B desconsiderando o entreferro

$1,5T$

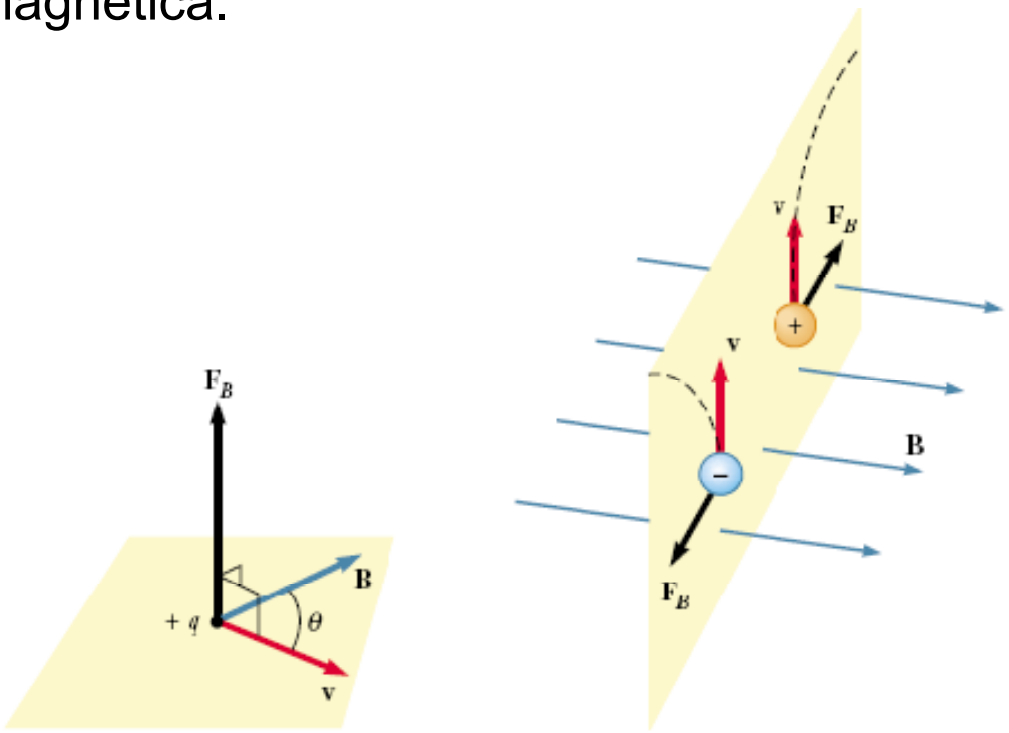


$$H_{ferro} = 8240\, A/m$$

Força eletromagnética

Força eletromagnética:

- Um condutor percorrido por uma corrente elétrica e imerso em um campo magnético sofre a ação de uma força eletromagnética.

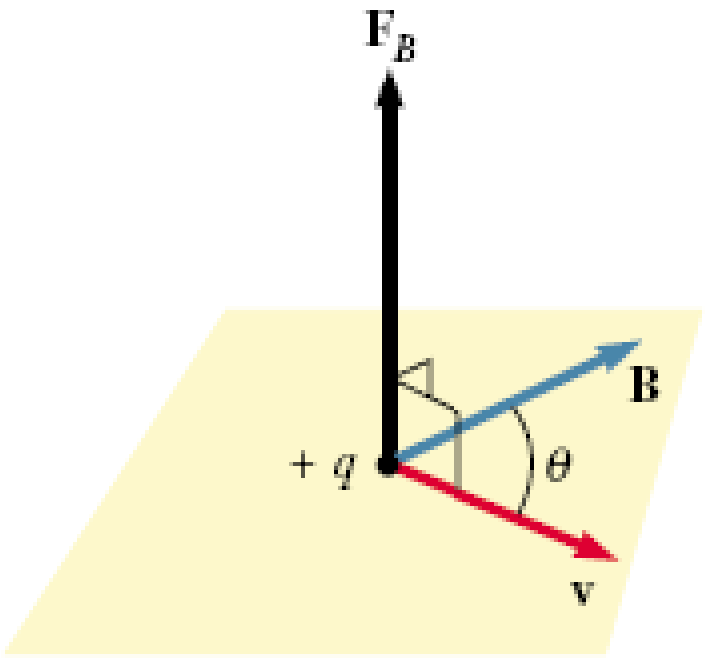


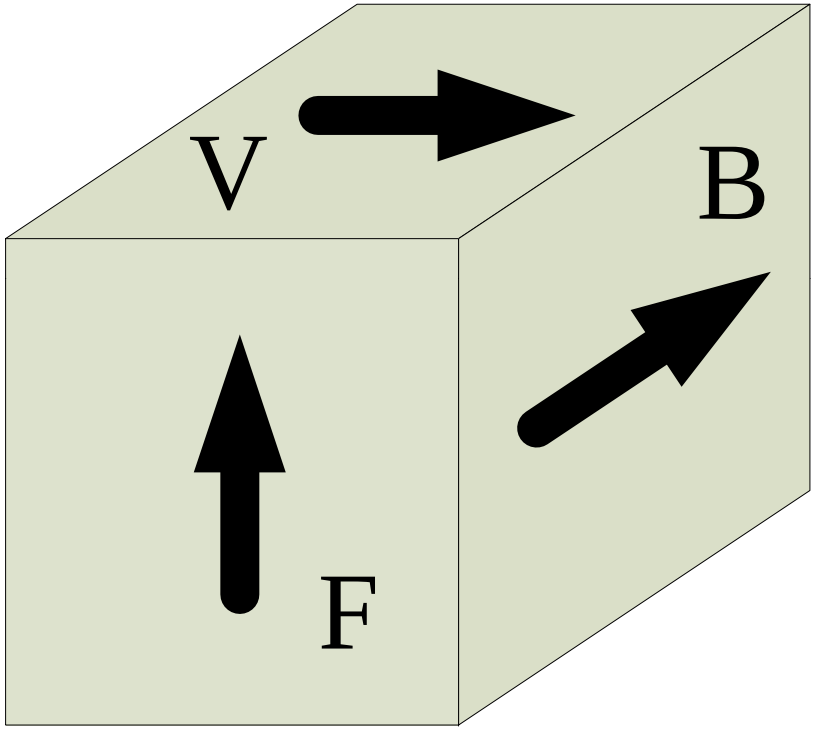
A força é perpendicular aos vetores v e B.

Força eletromagnética

A força pode ocorrer em:

- Um condutor retilíneo;
- Uma partícula;
- Condutores paralelos;
- Em uma espira.



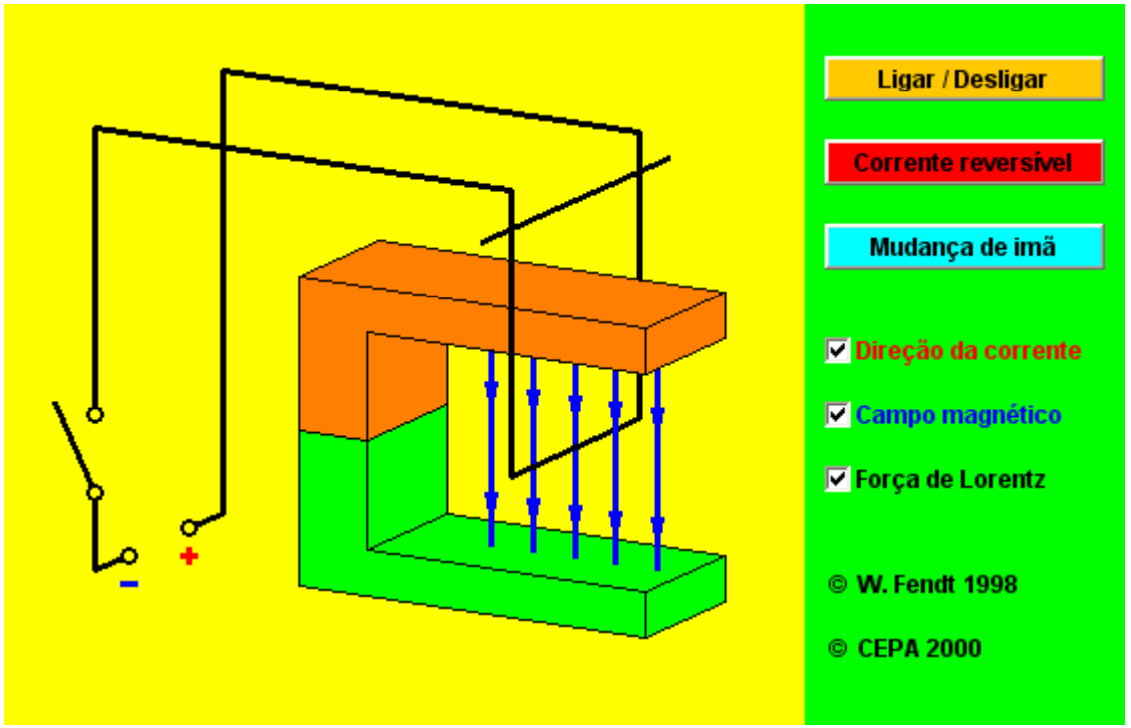


Método da caixa de vetores

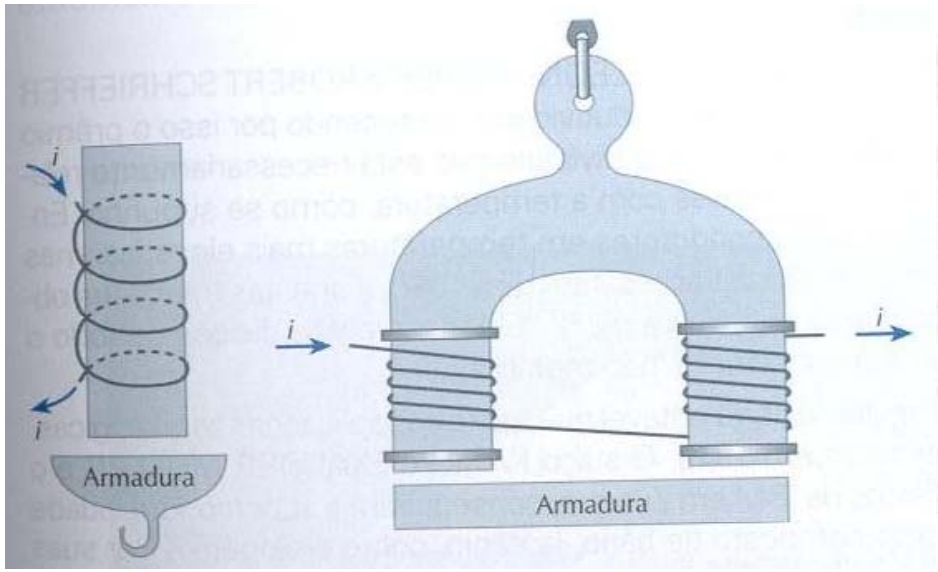
Força eletromagnética

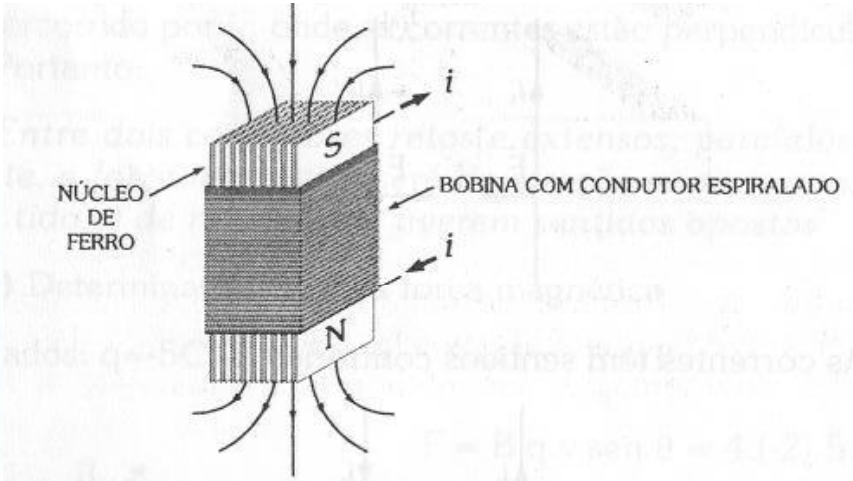
Torque em uma espira:

Applets em java →

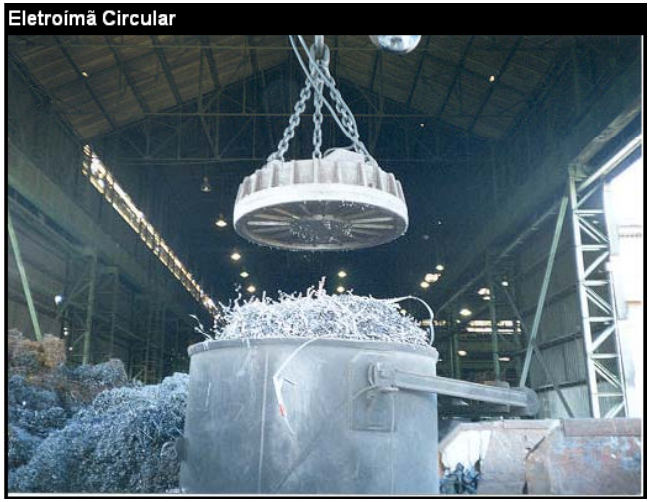


Aplicações - Eletroímã

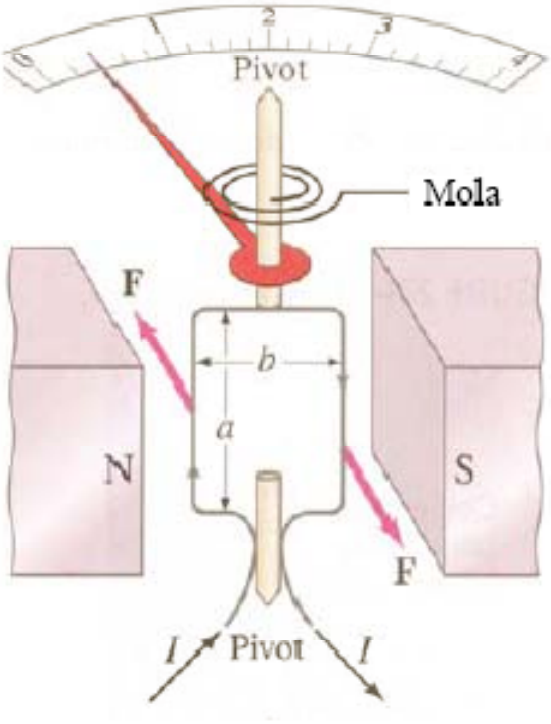




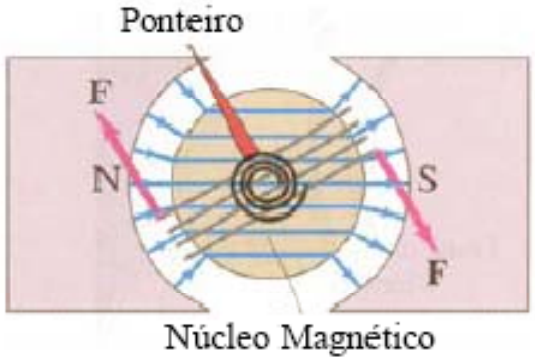
Eletroímã Circular



Aplicações - Amperímetro

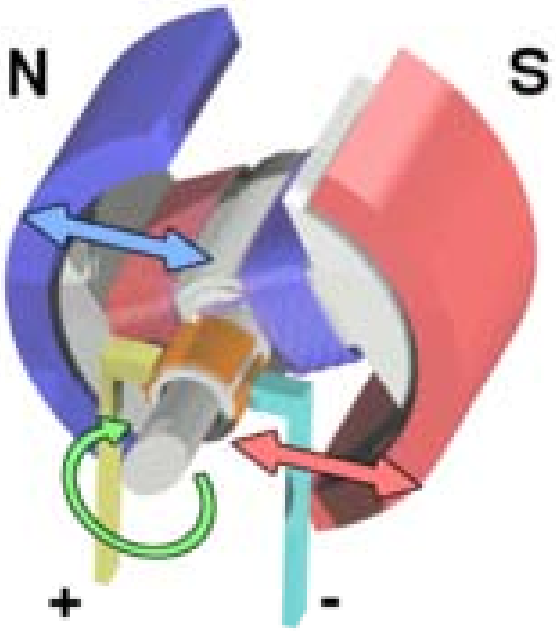


(a)

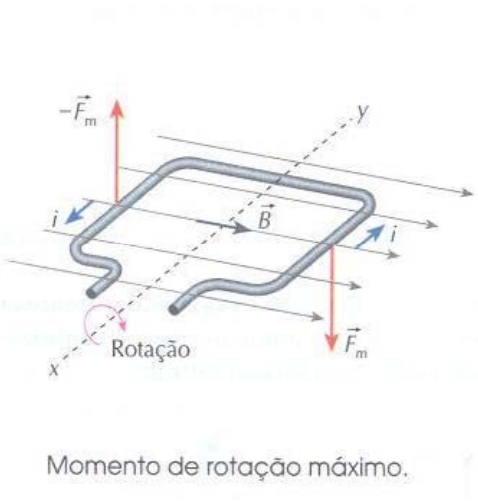


(b)

Aplicações – Motor CC



Construção de um motor CC



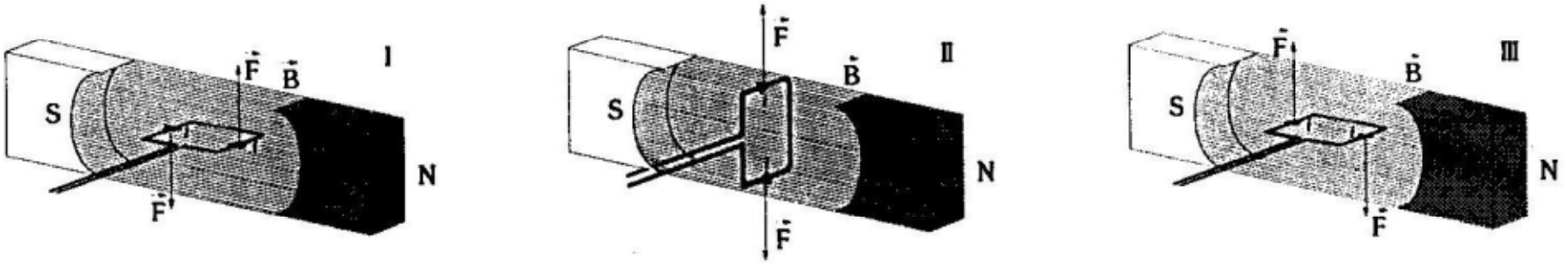
Momento de rotação máximo.

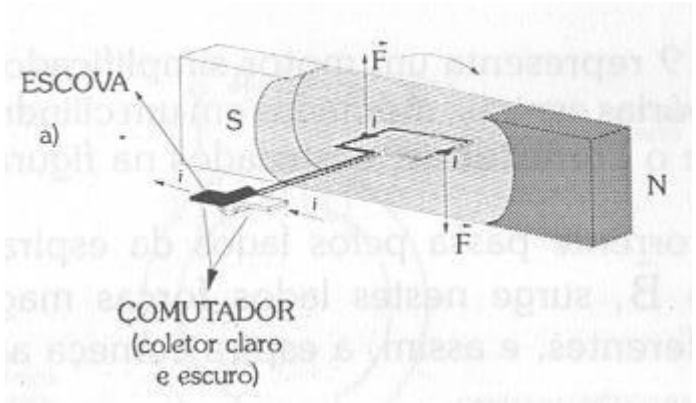
Momento de rotação nulo.

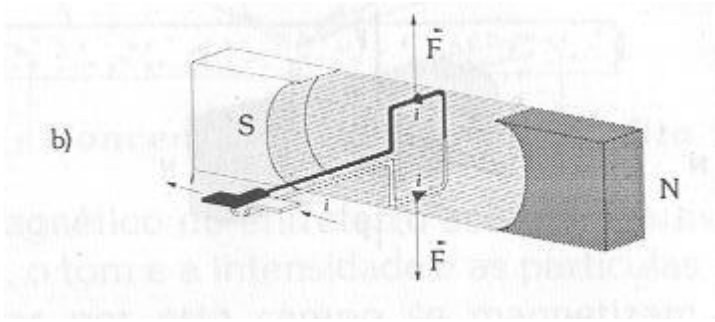
Funcionamento dos motores de CC

Aplicações – Motor CC

Forças num motor de CC

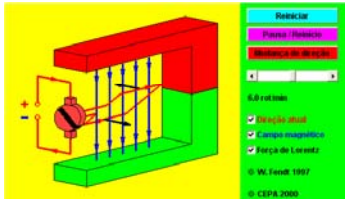




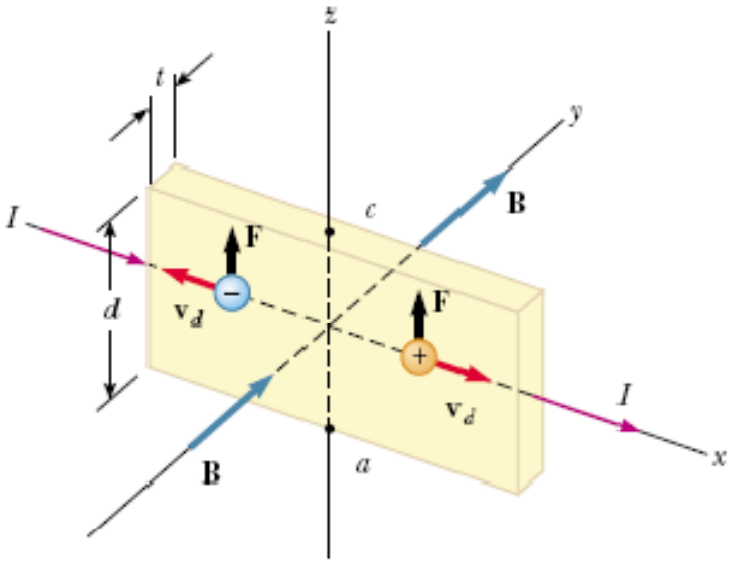


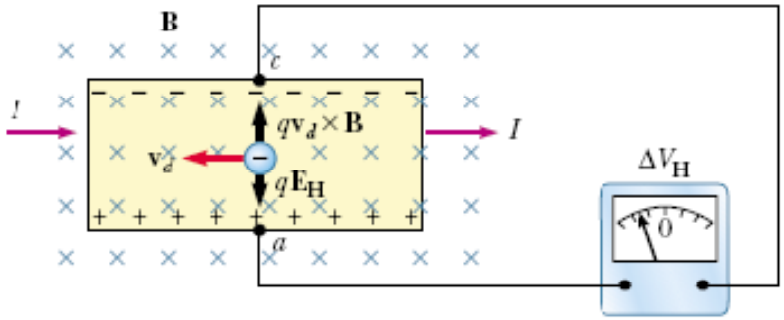
Funcionamento do motor CC

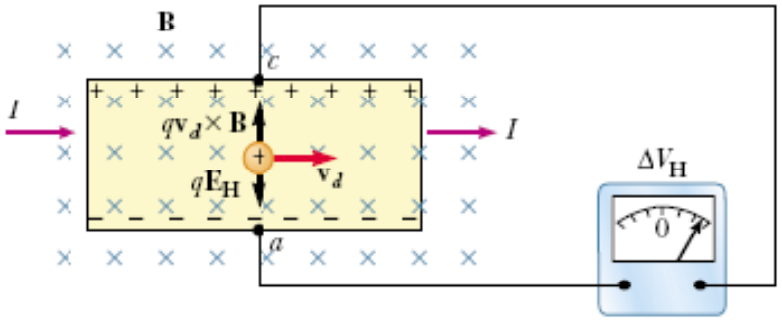
Applets em java →



Aplicações - Efeito Hall

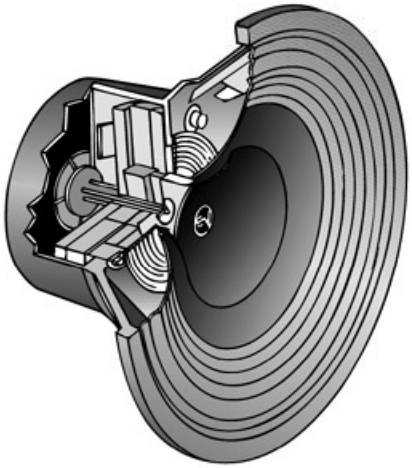


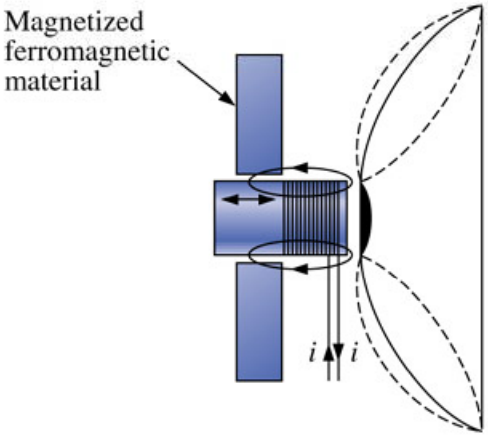


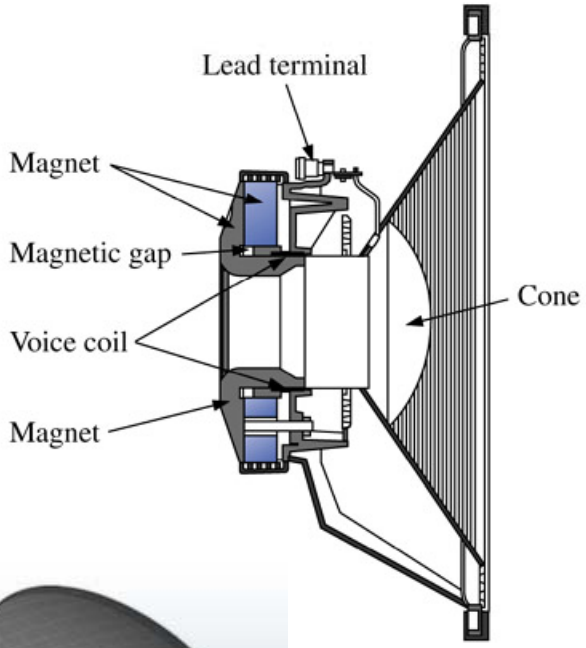


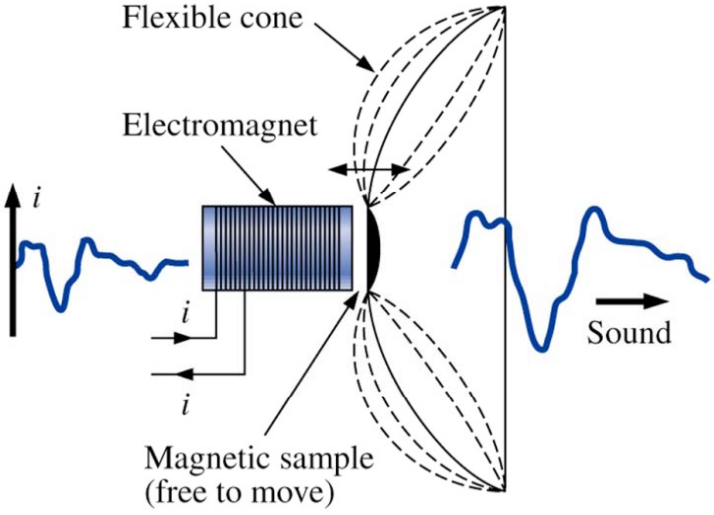
Aplicações – Gravação magnética

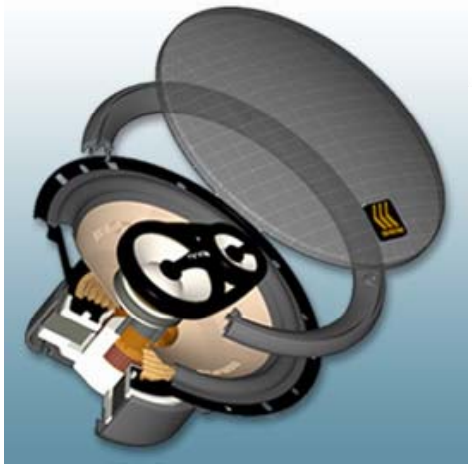
Aplicações – Alto-falante



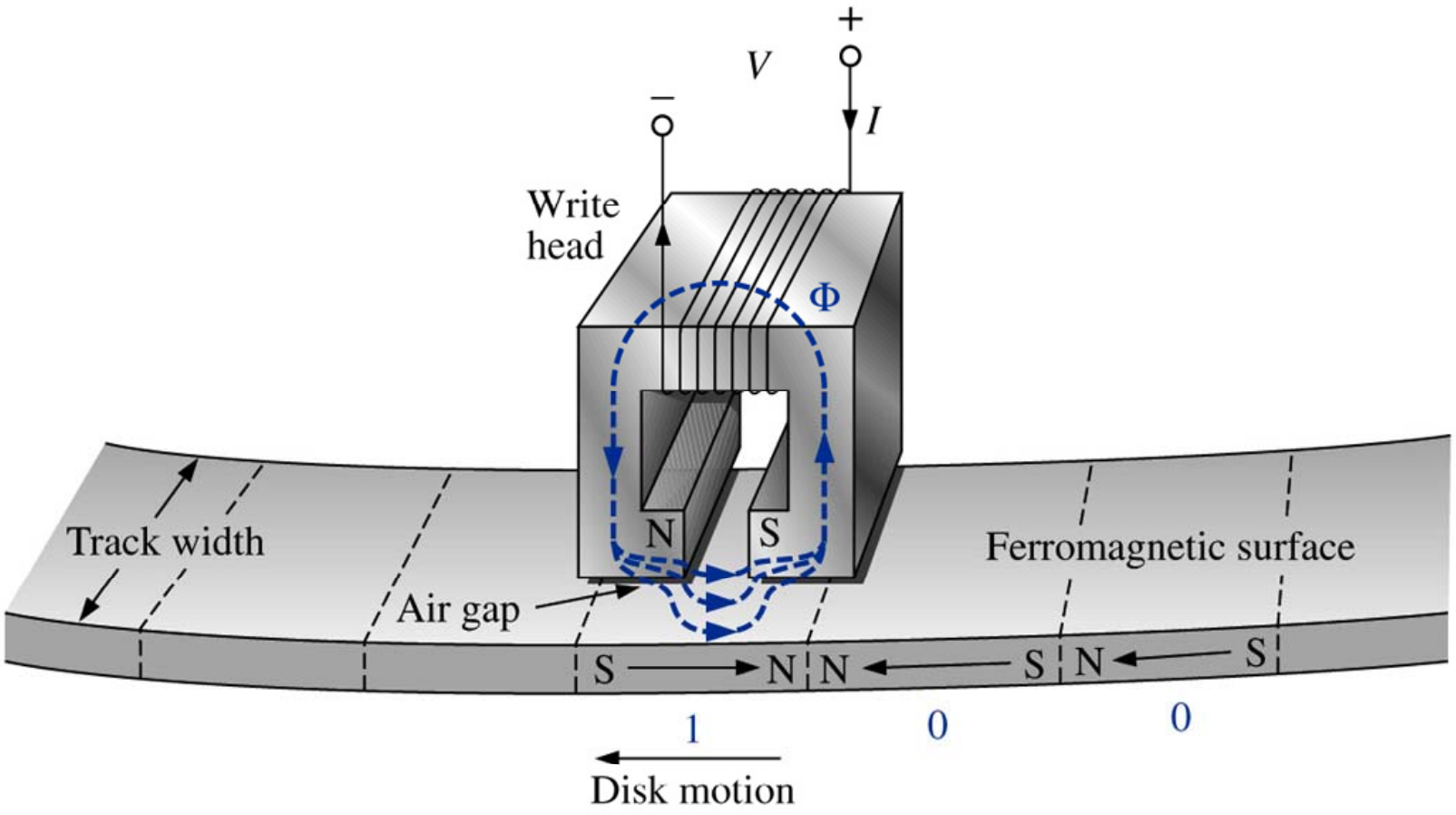




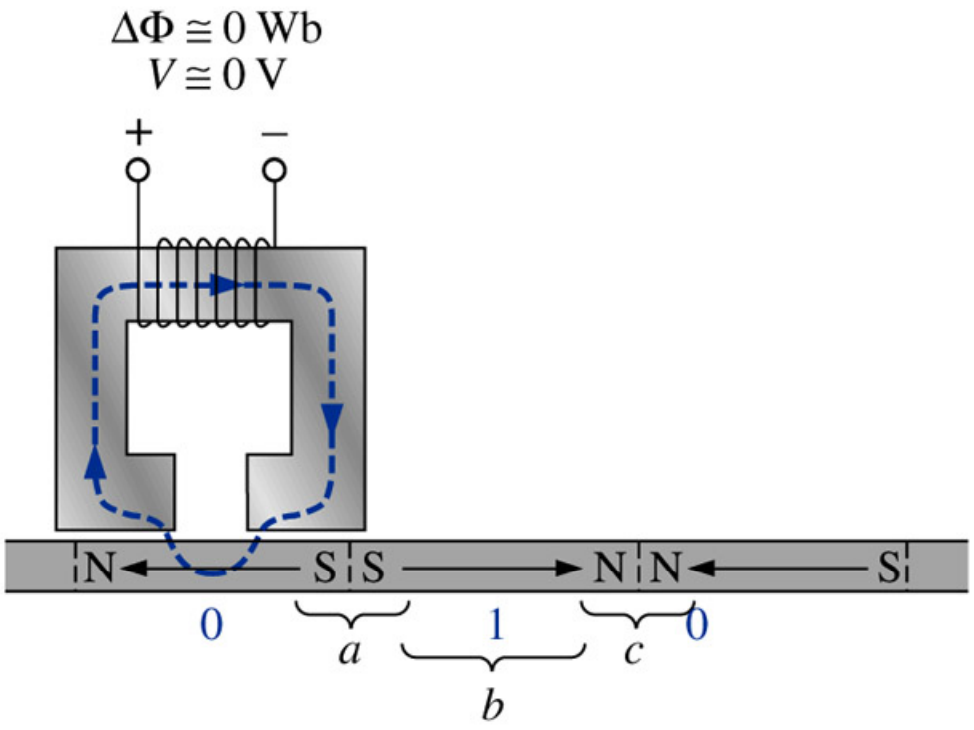


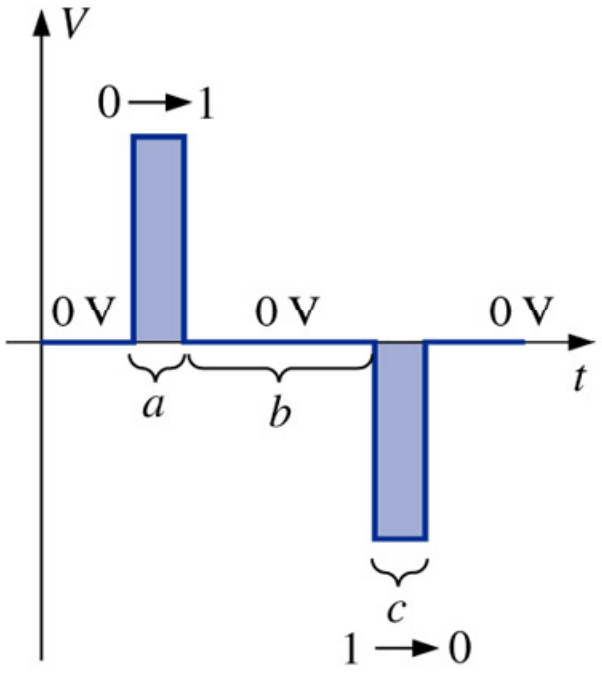


Aplicações – Discos rígidos



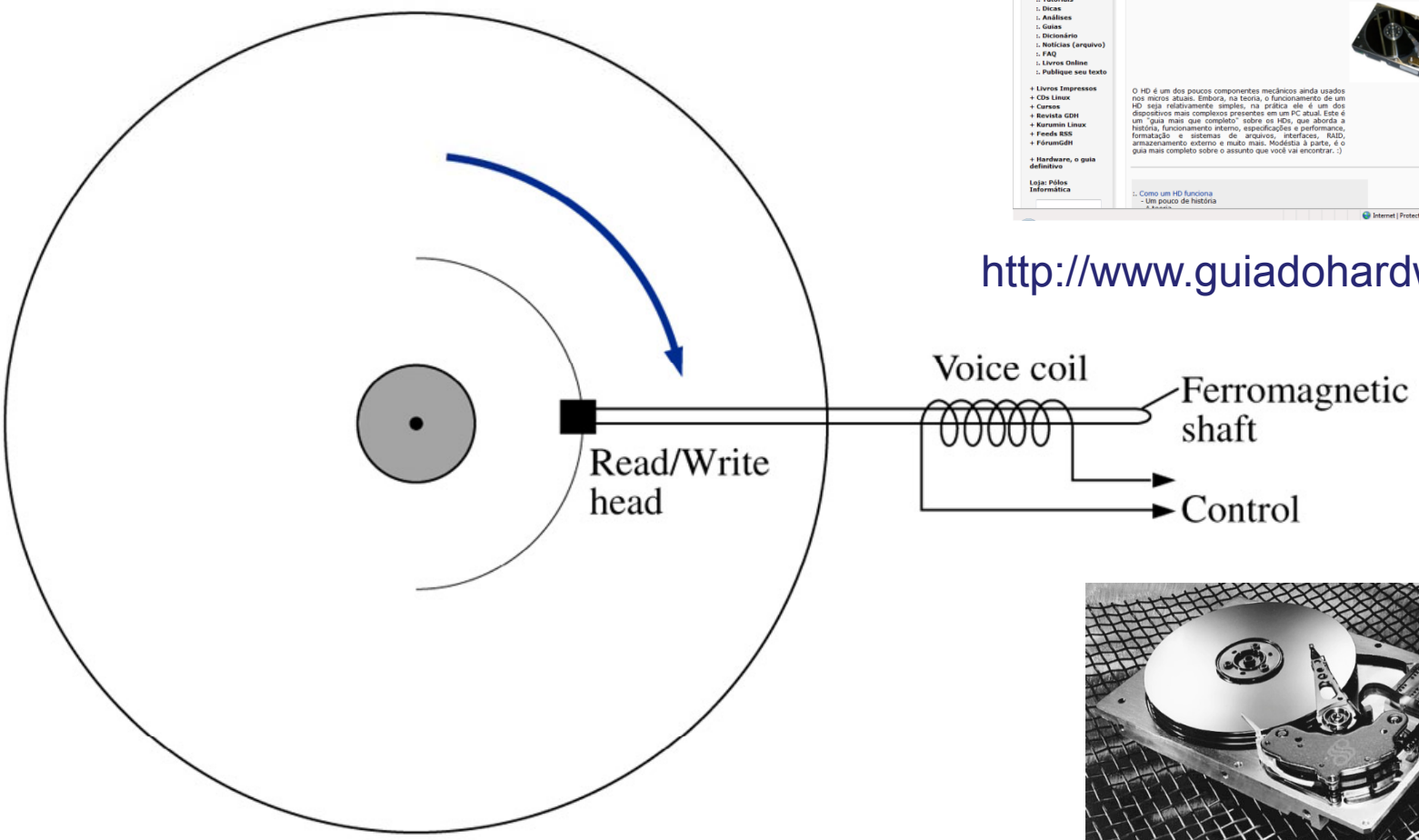
Aplicações – Discos rígidos



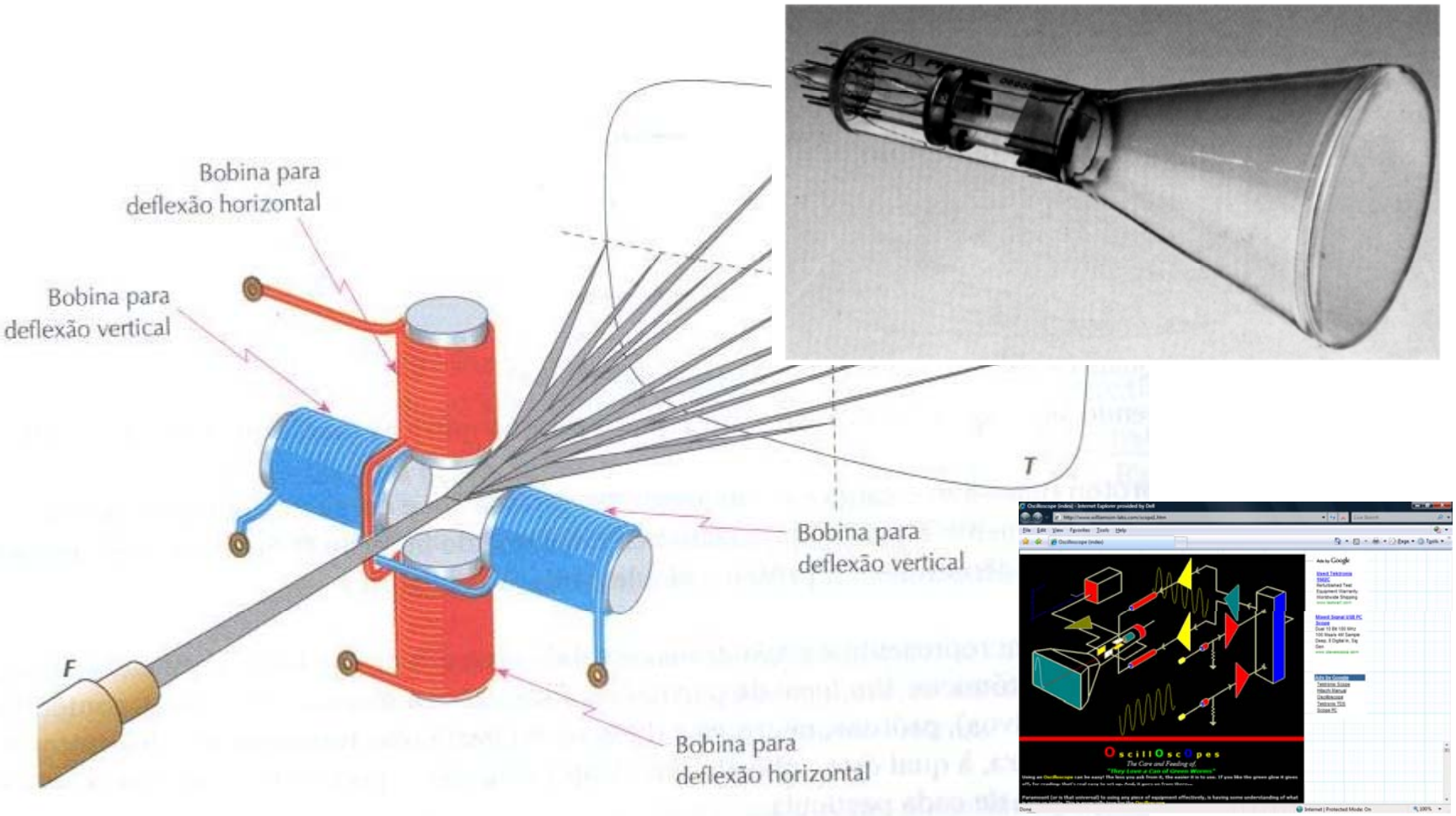


Aplicações – Discos rígidos

http://www.guiadohardware.net/

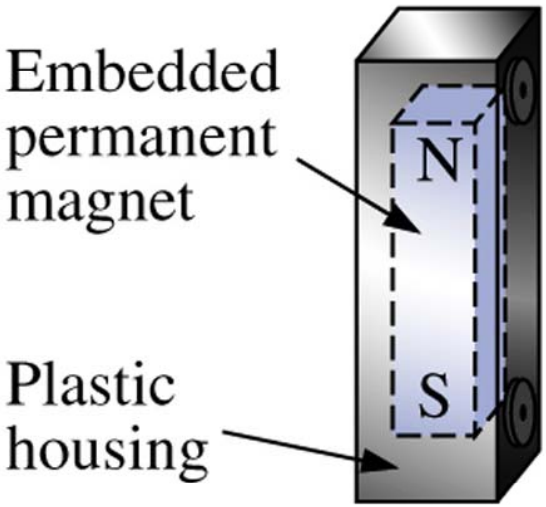


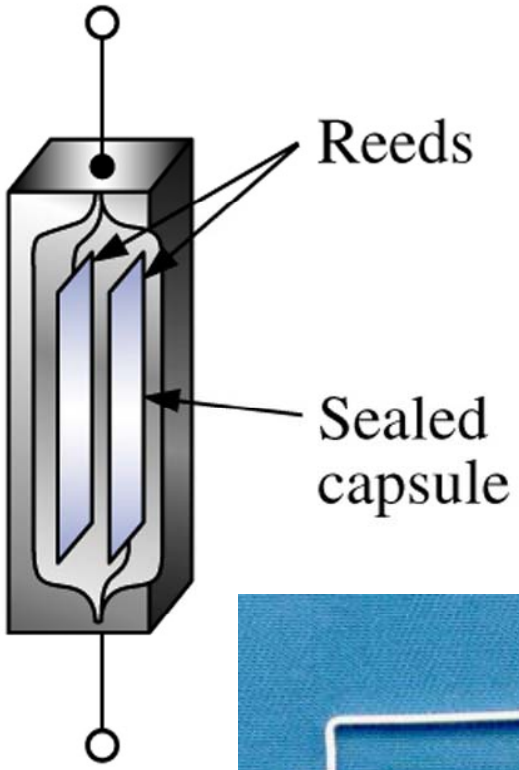
Aplicações – Tubo de raios catódicos

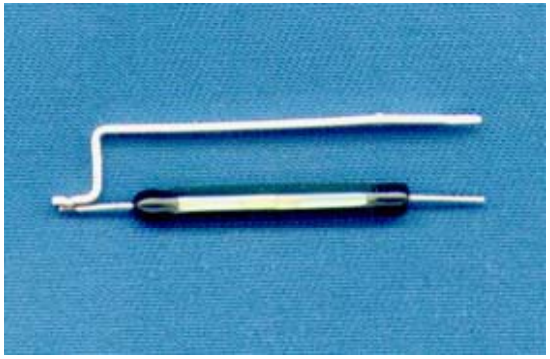


http://www.williamson-labs.com/scope1.htm

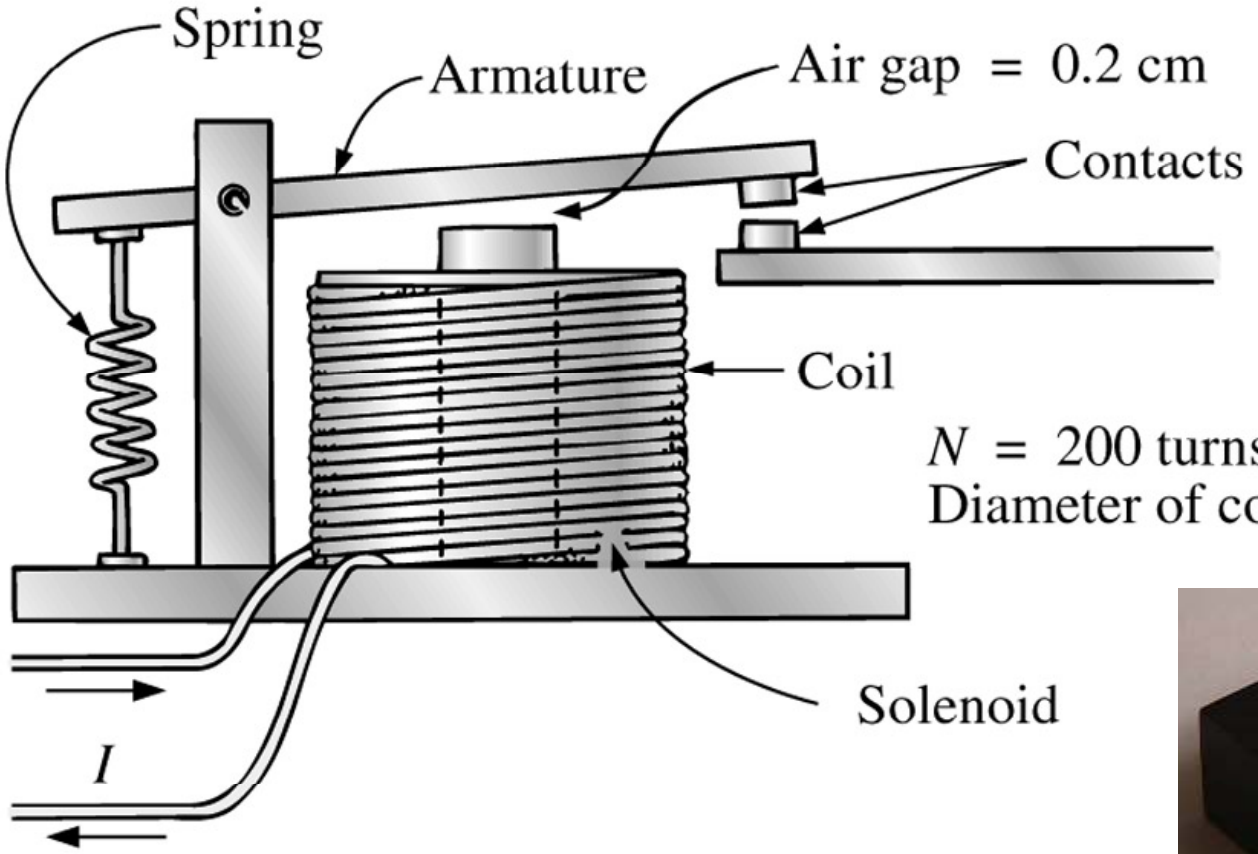
Aplicações – Sensor magnético (reed-switch)

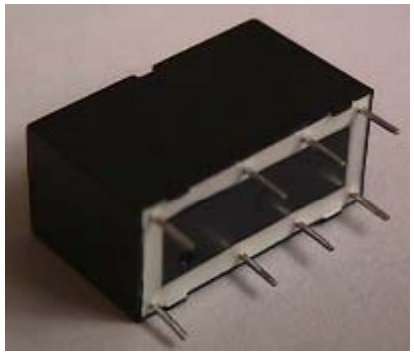




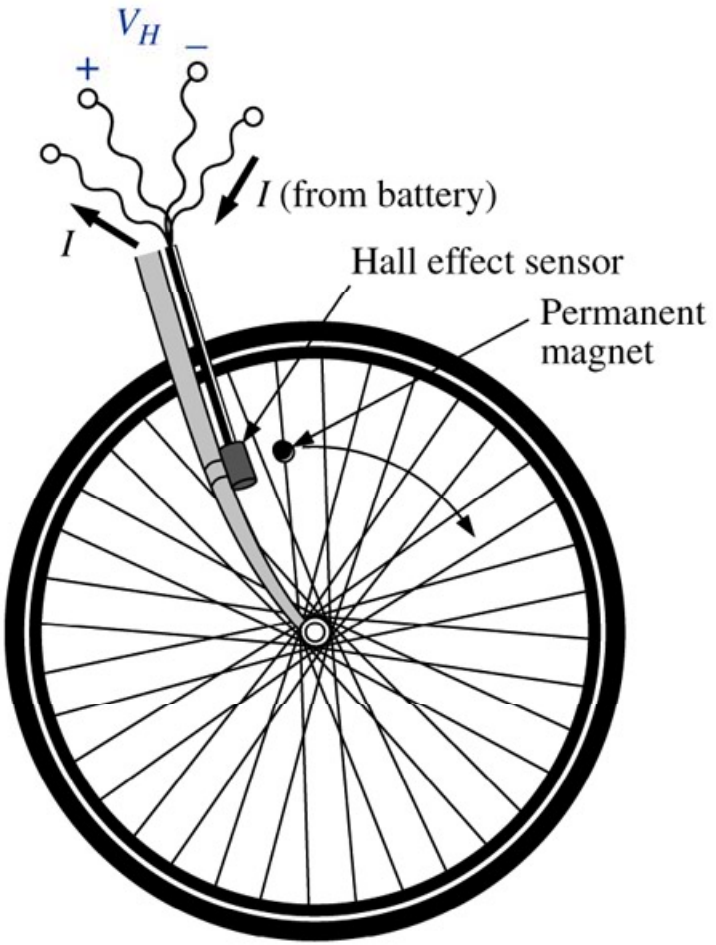


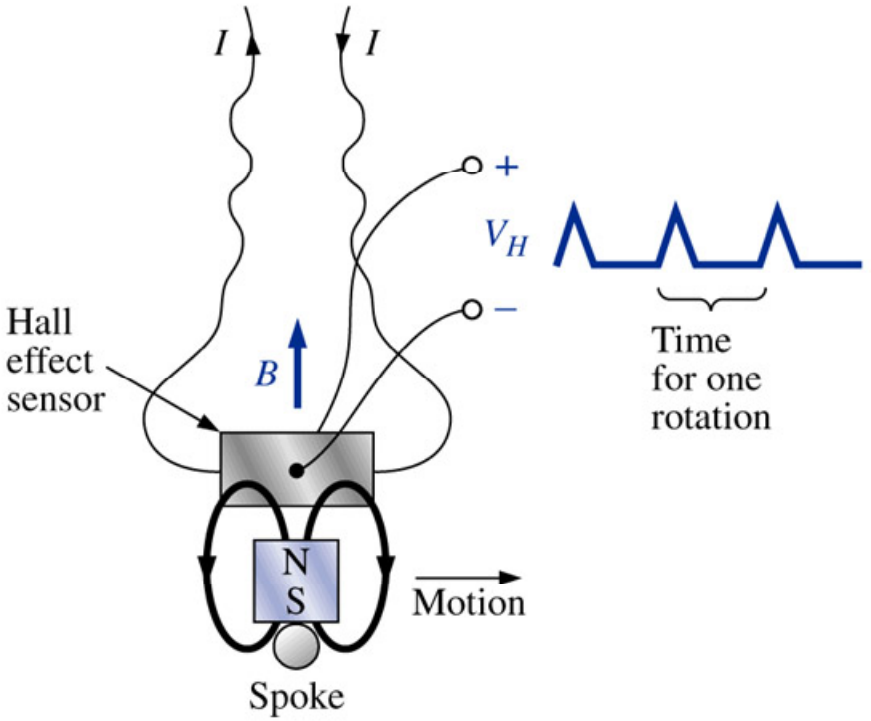
Aplicações - Relé





Aplicações – Indicador de velocidade

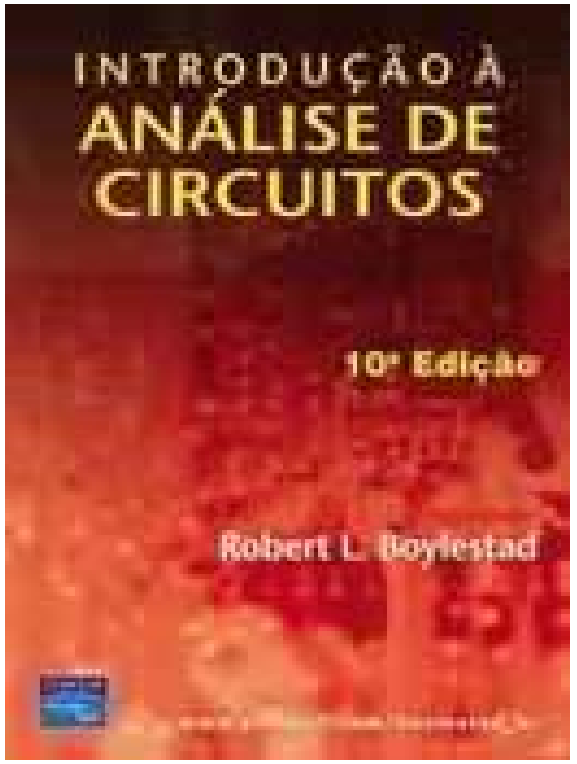




Na próxima aula

Capítulo 11: Circuitos magnéticos

1. Leis de Faraday e Lenz;
2. Auto-indutância;
3. Indutores.



www.cefetsc.edu.br/~petry