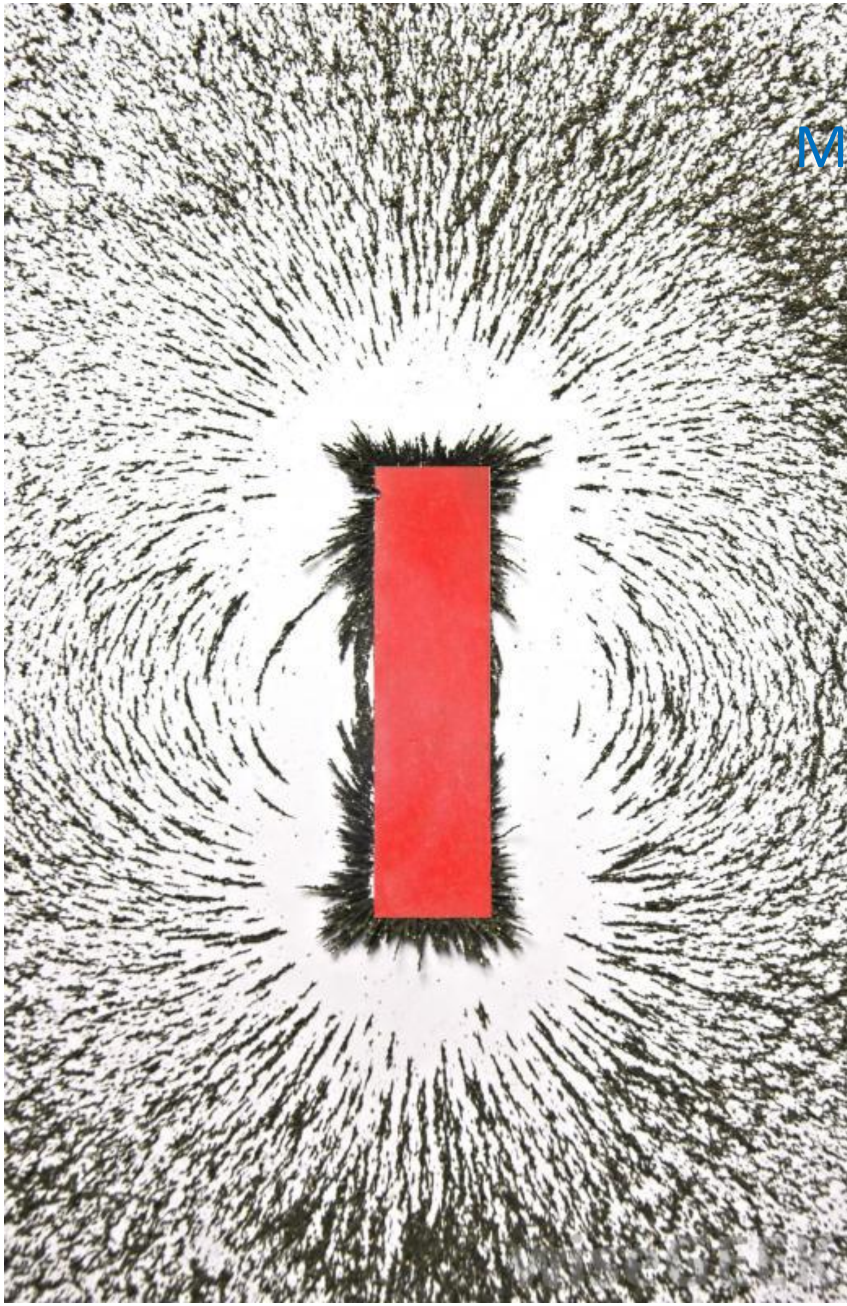
Campo Magnético
e
Lei de Faraday

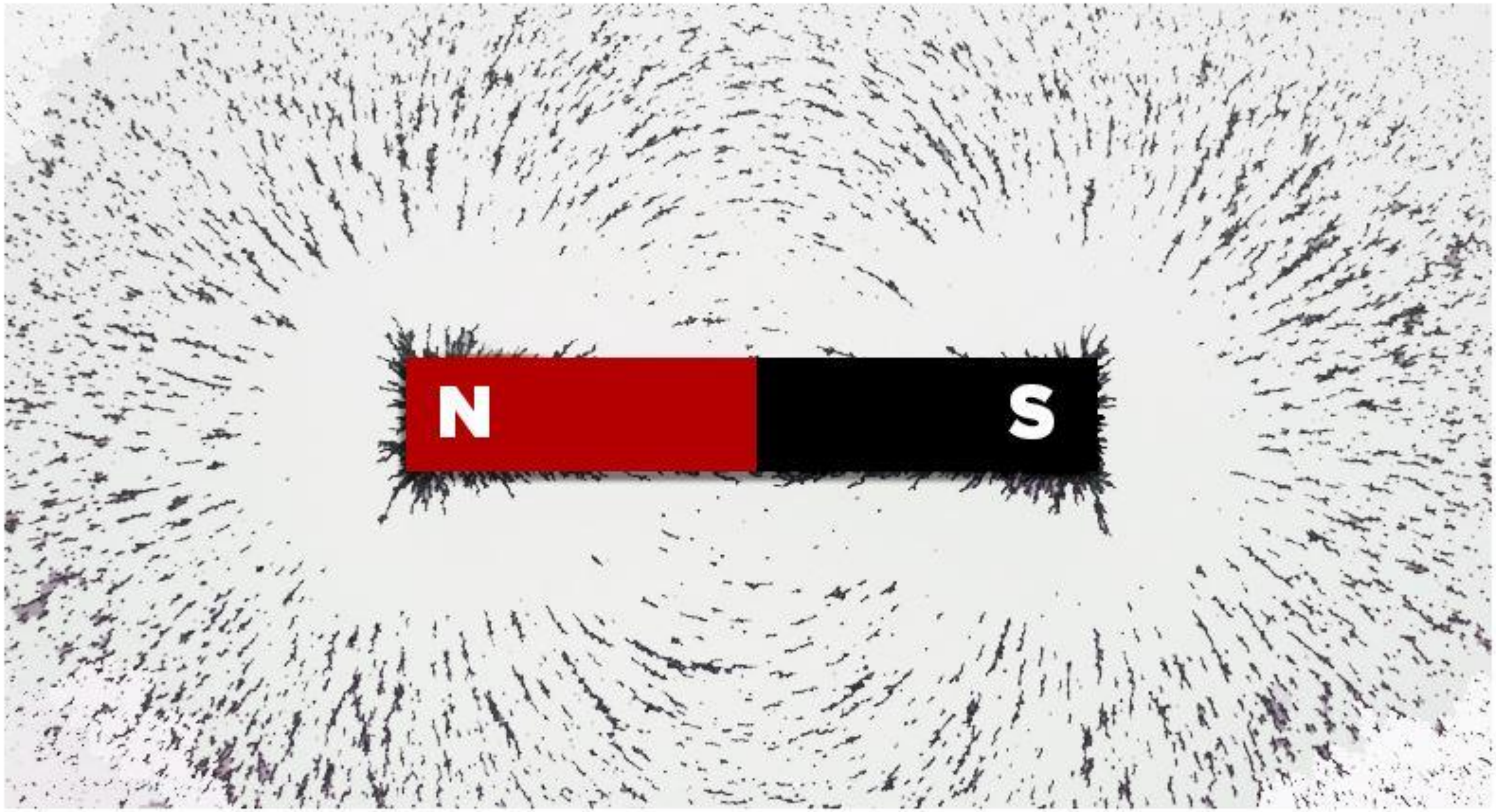


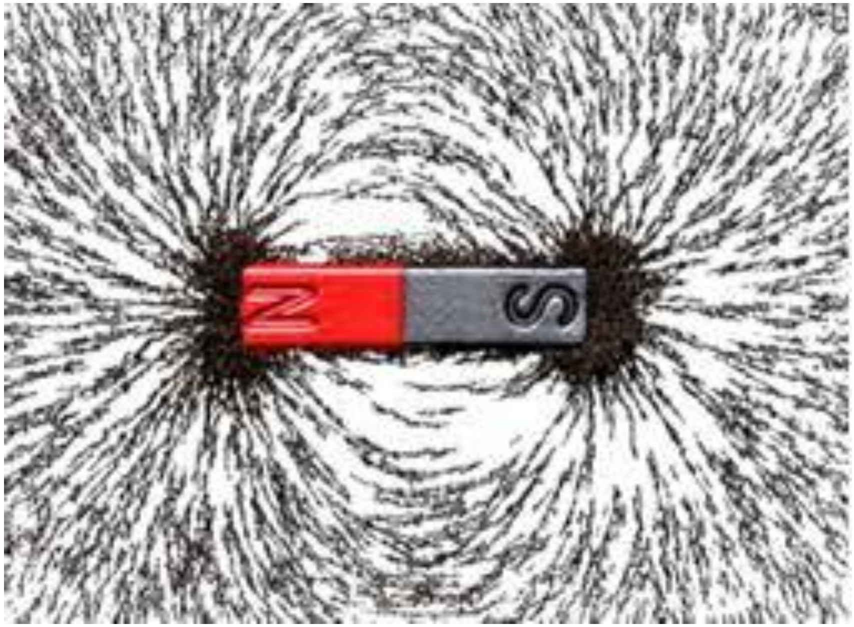
Magnetismo

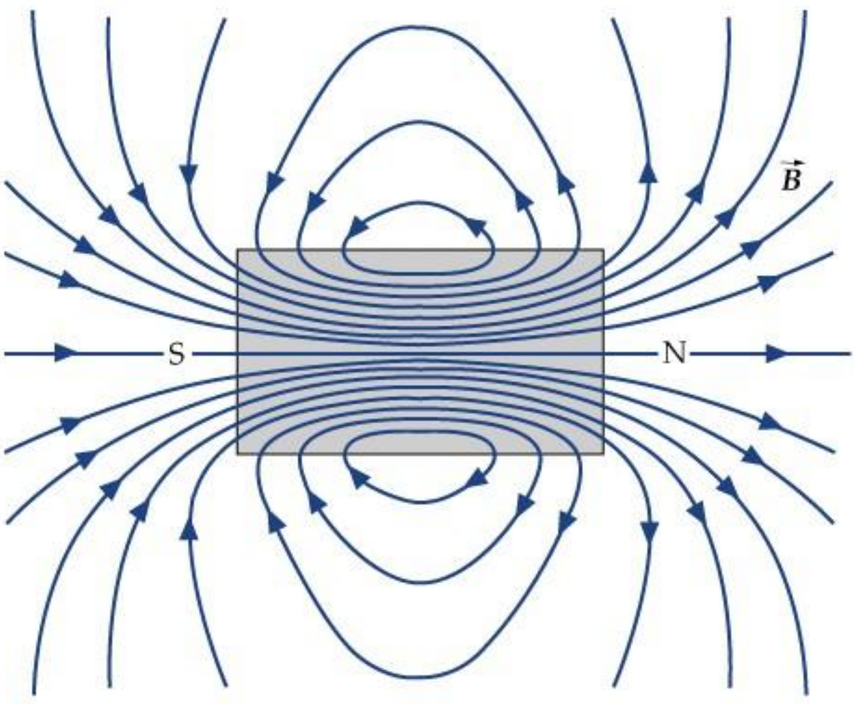
verificou-se que os pedaços de ferro eram atraídos mais intensamente em certas partes do imã – os <u>polos</u> dos imãs

Magnetismo

verificou-se que os pedaços de ferro eram atraídos mais intensamente em certas partes do imã – os polos dos imãs.



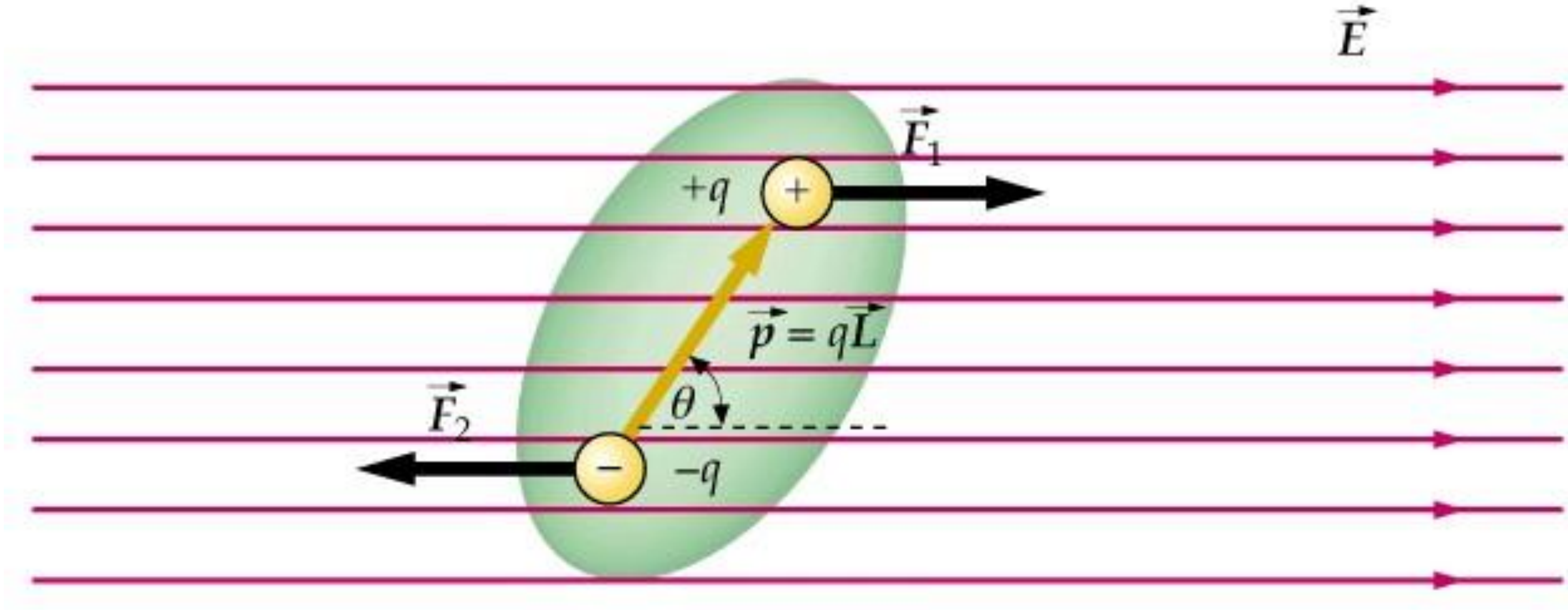




(a)

As linhas de indução ou linhas de campo indicam a direção do campo magnético $\vec{B}$

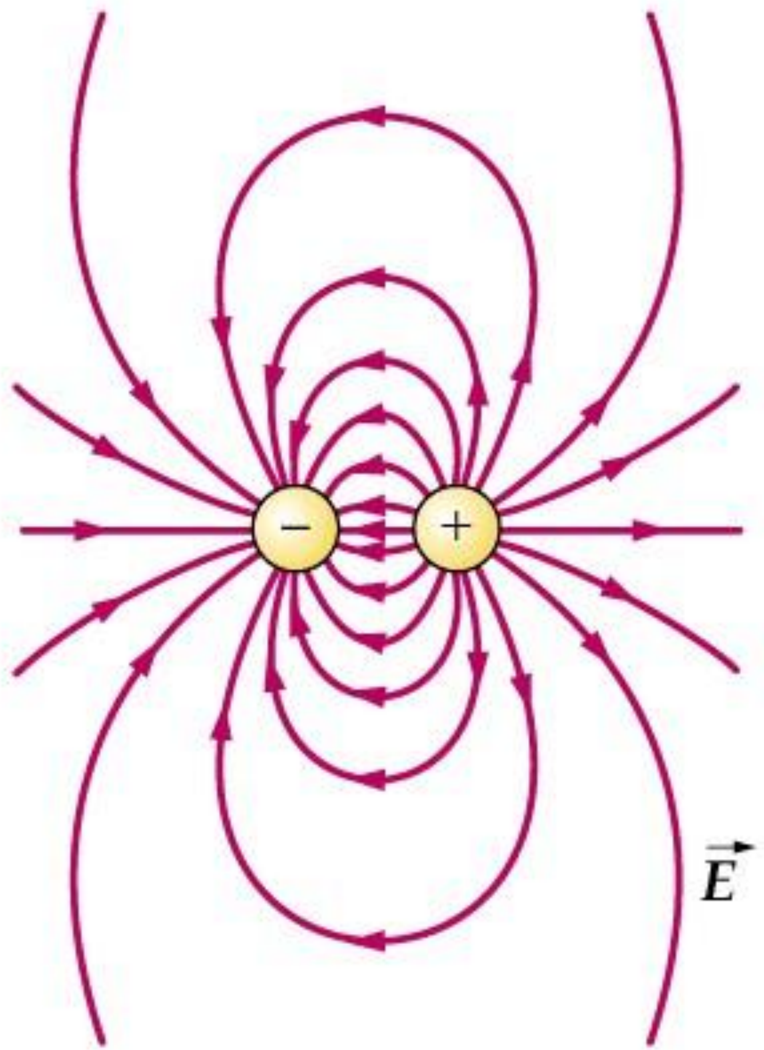
Torque em um Dipolo elétrico em campo Uniforme



$$\vec{\tau} = \vec{p} \times \vec{E}$$

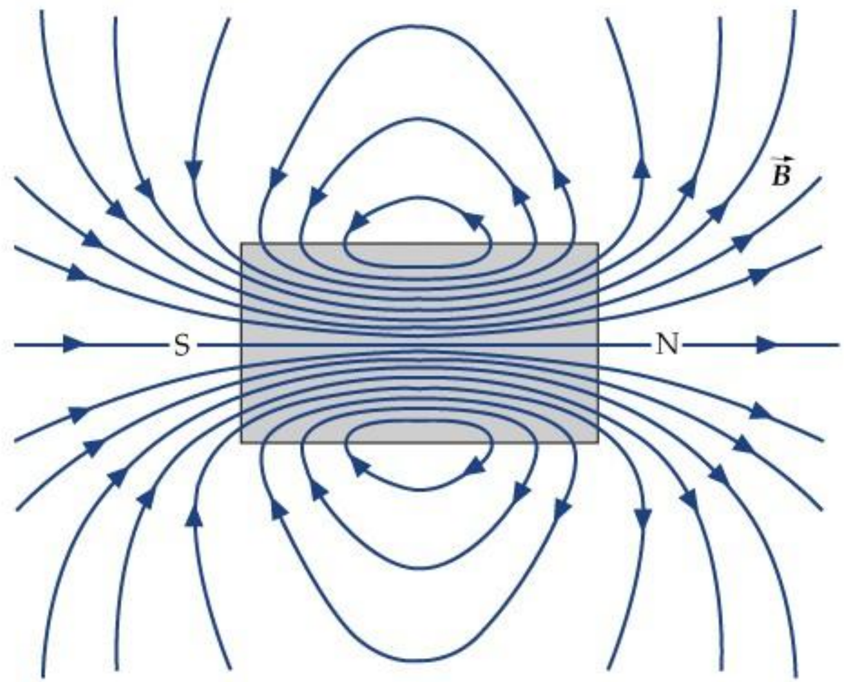
$$U = -\vec{p}.\vec{E}$$

$$U = -p.E.cos\theta$$



dipolo elétrico

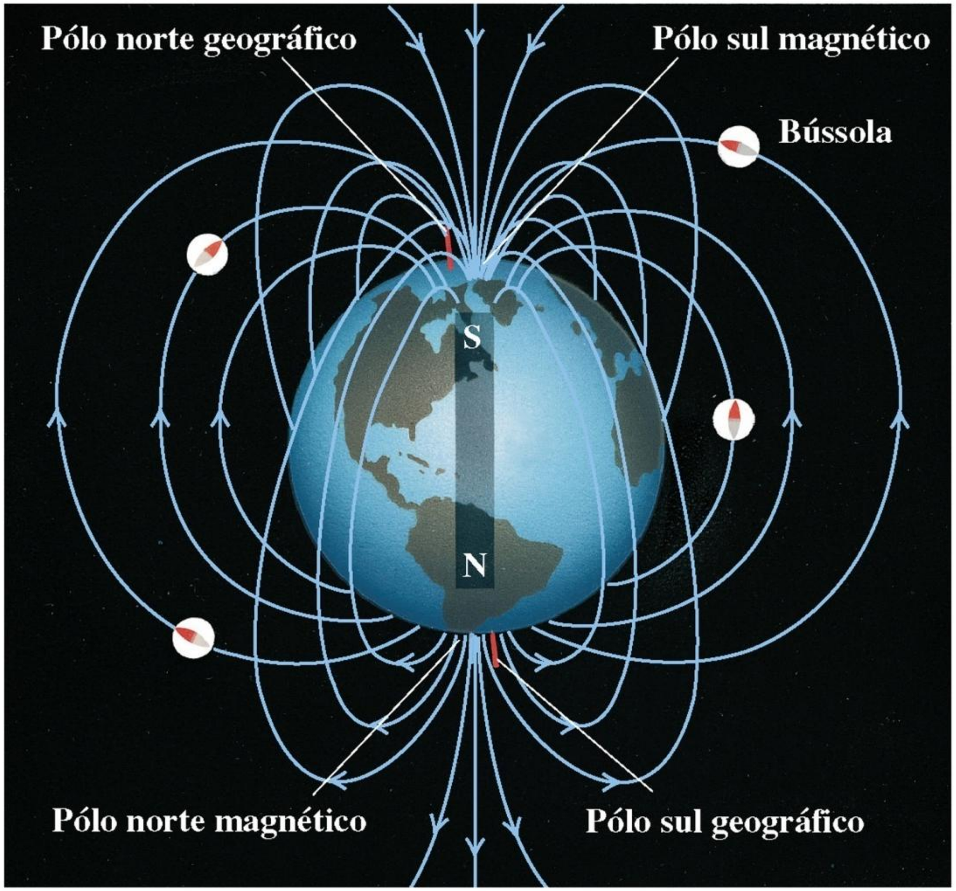
$\vec{p} = q\vec{L}$

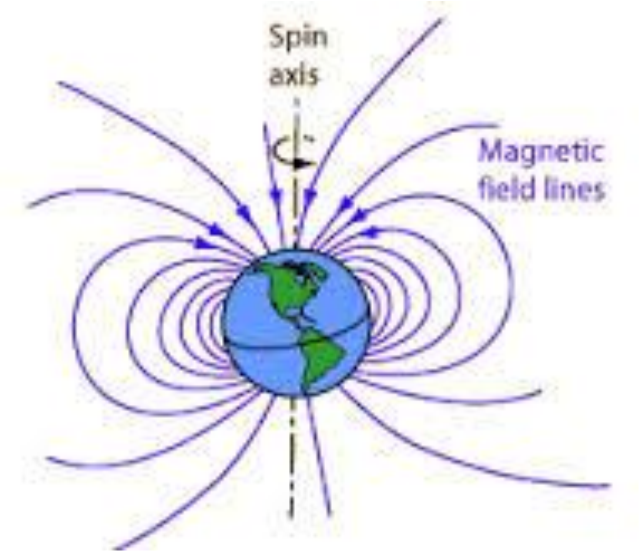


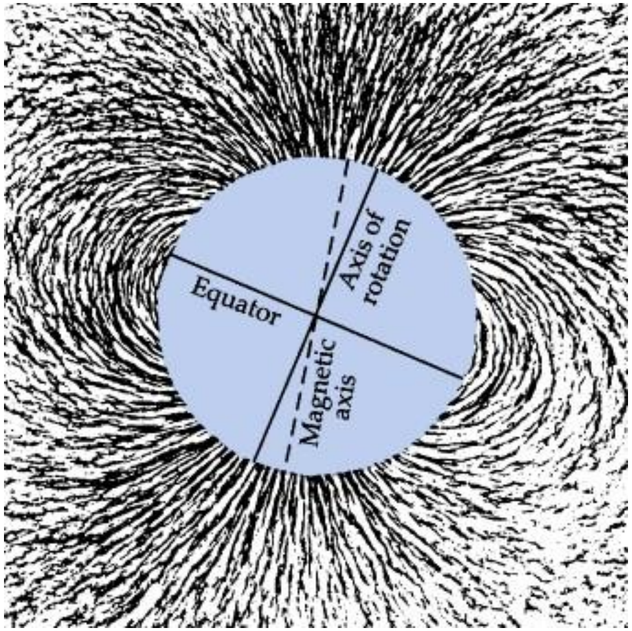
(a)

dipolo magnético – é o limite em que o tamanho do imã tende a zero

Campo Magnético da Terra





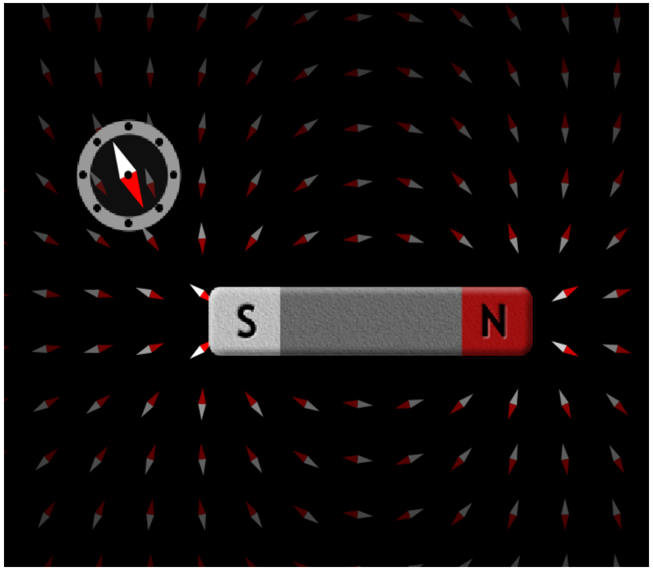


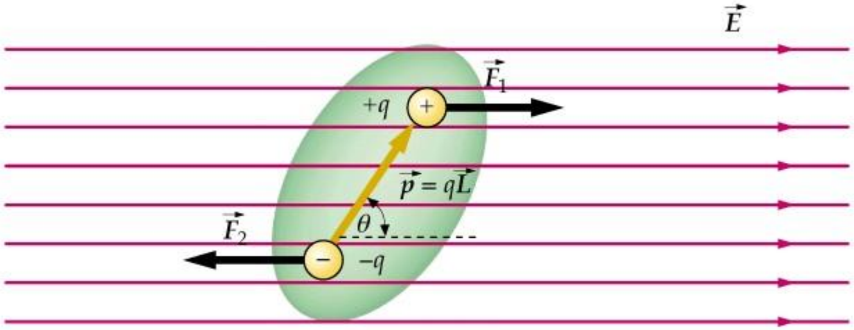
$B_T \sim 0{,}2\ G = 2\ 10^{-5}\ T$ (São Carlos)

Torque em Dipolo magnético

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

$$U = -\vec{\mu}.\vec{B}$$

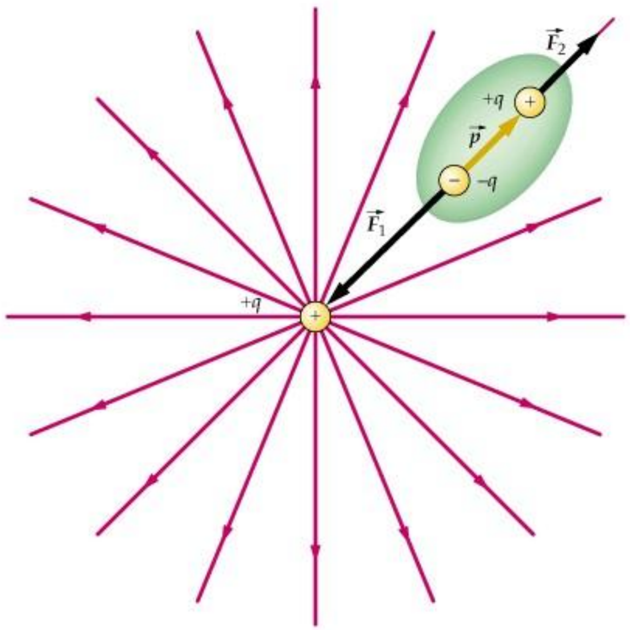




$$\vec{\tau} = \vec{p} \times \vec{E}$$

$$U = -p.E.cos\theta$$

Força em Dipolo elétrico em campo NÃO Uniforme



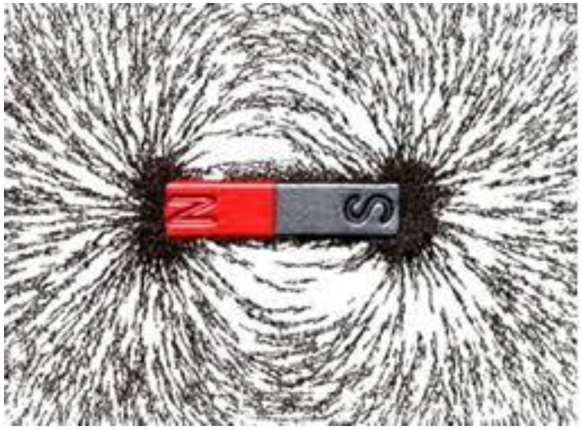
Força em um dipolo elétrico num Campo Elétrico não uniforme:

$$\vec{F} = \vec{p}\nabla.\,\vec{E}$$

O dipolo elétrico é atraído para a região com maior gradiente ($\nabla\vec{E}$).

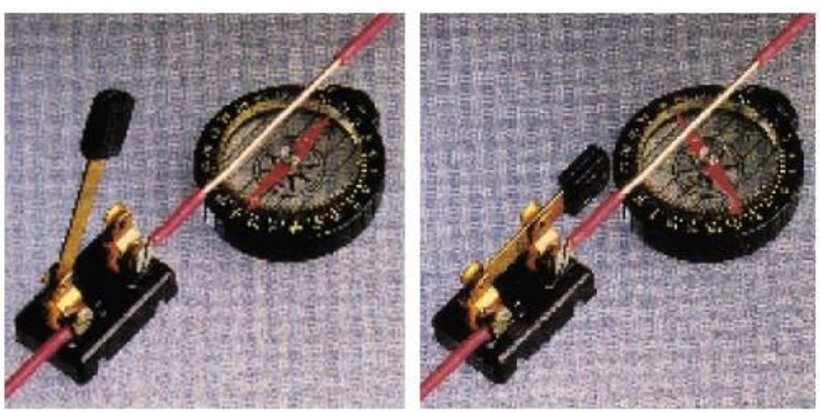
Um efeito similar ocorre com os dipolos magnéticos, o que explica porque a limalha de ferro se concentra nos pólos dos imãs

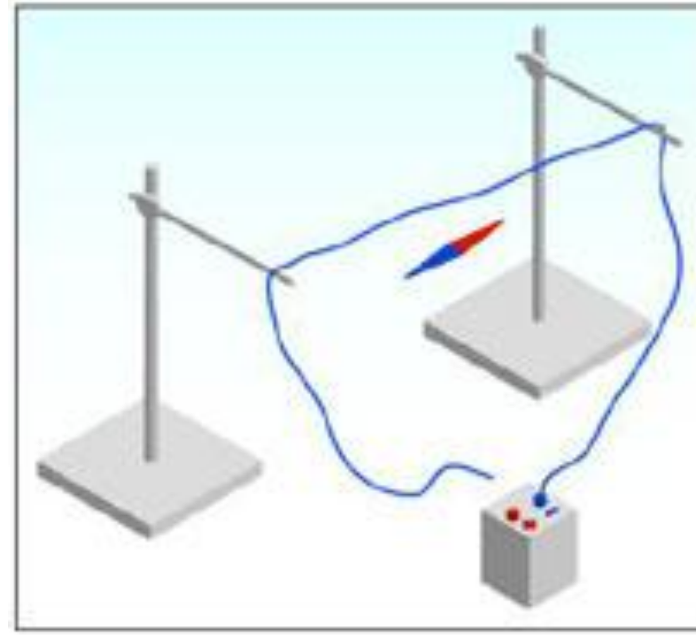
$$\vec{F} = \vec{\mu}\nabla.\,\vec{B}$$

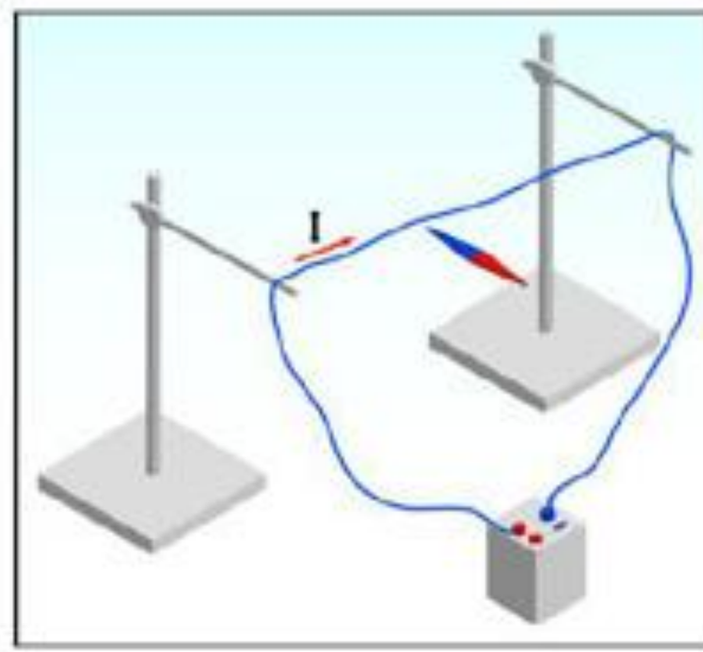


Fontes do Campo Magnético

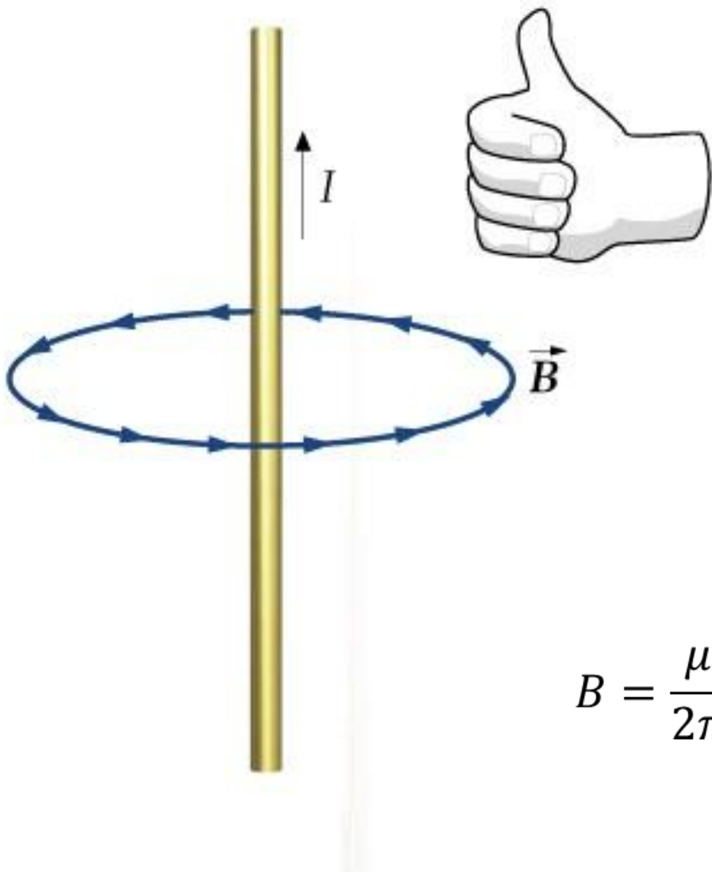
Hans Christian Ørsted
Dinamarca (1777 – 1851)





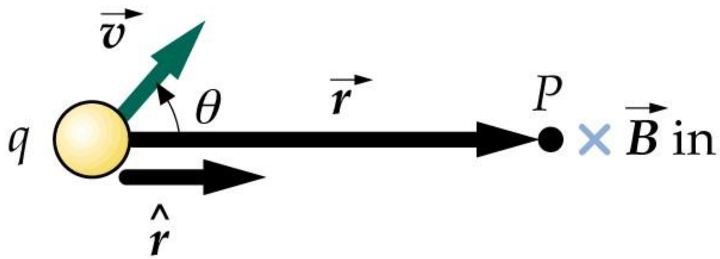


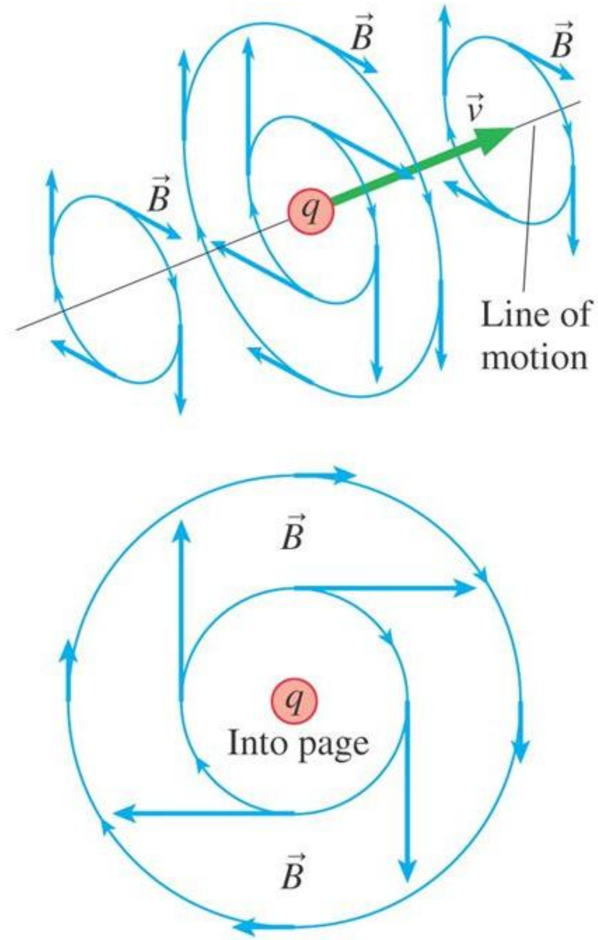
Campo Magnético devido a corrente em um fio infinito



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

Campo magnético de uma carga em movimento





Copyright © 2008 Pearson Education, Inc., publishing as Pearson Addison-Wesley.

$$\vec{B} = \frac{\mu_o}{4\pi} q\vec{v} \times \vec{B}$$

It was known that cathode rays could penetrate matter and were deflected by magnetic and electric fields.

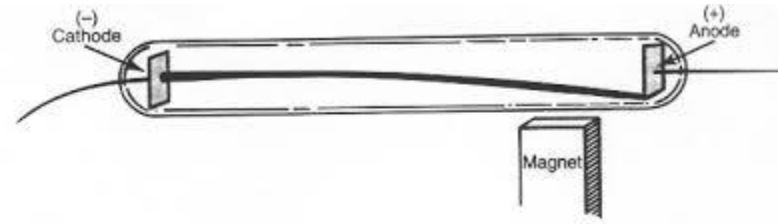
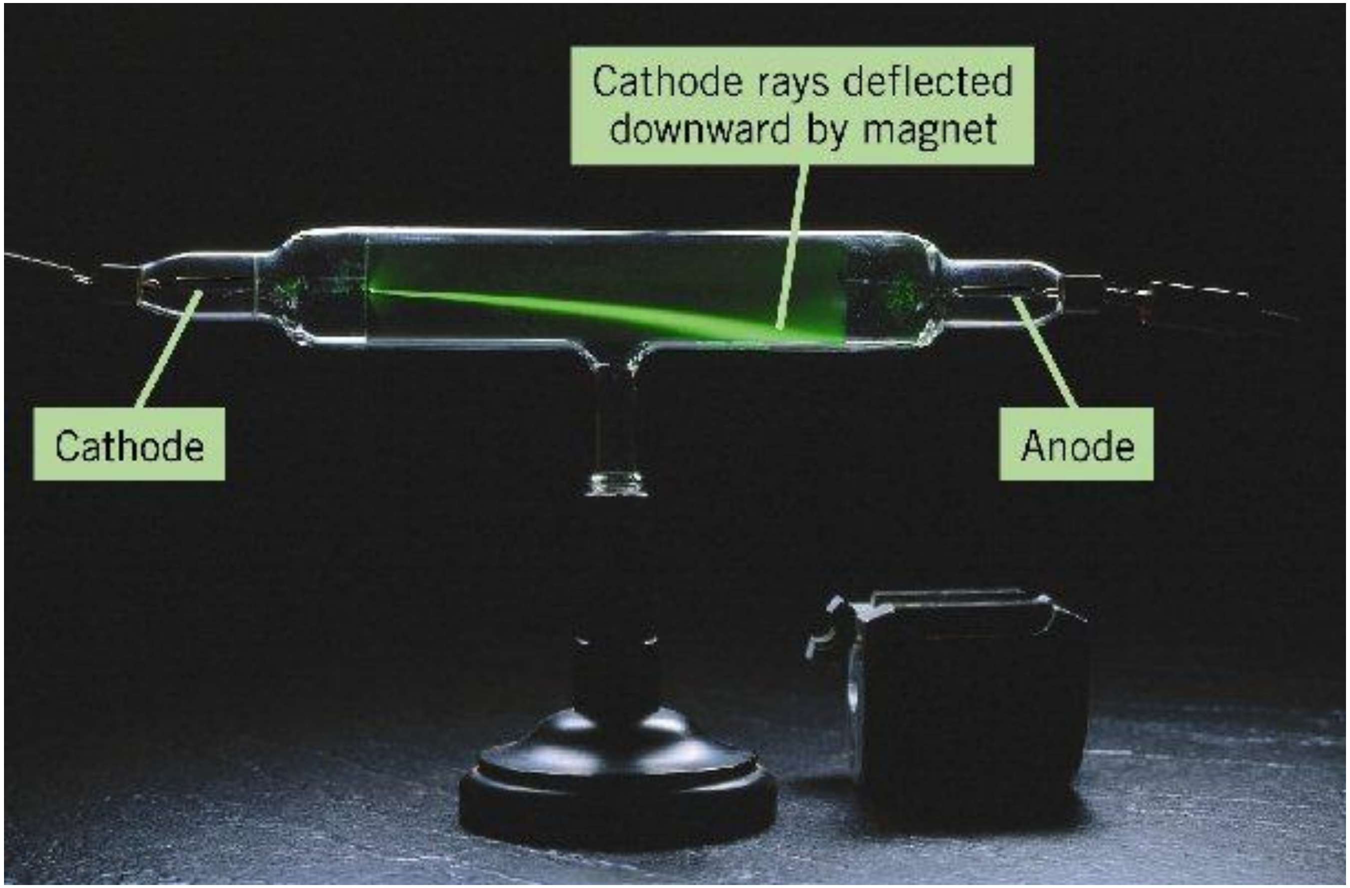


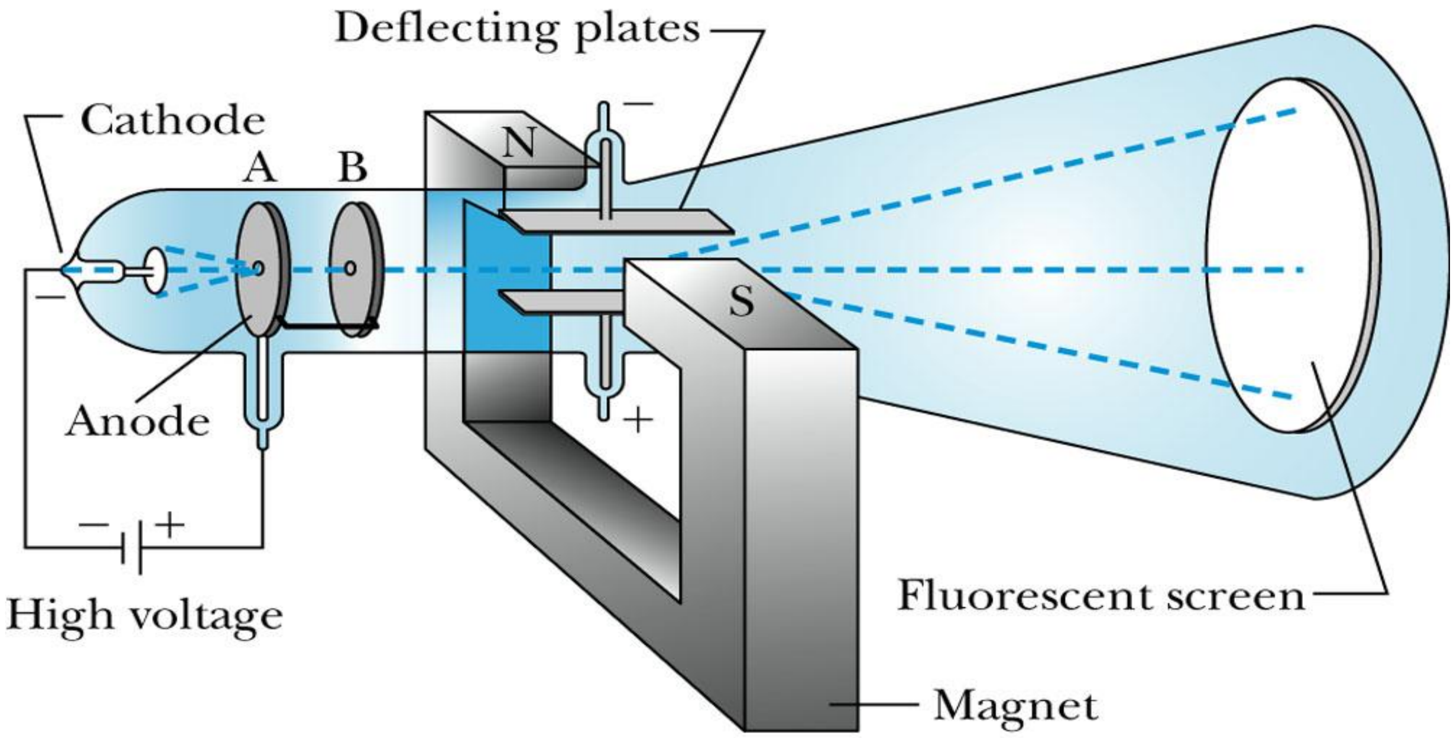
FIGURE 3. *Electron Experiment*



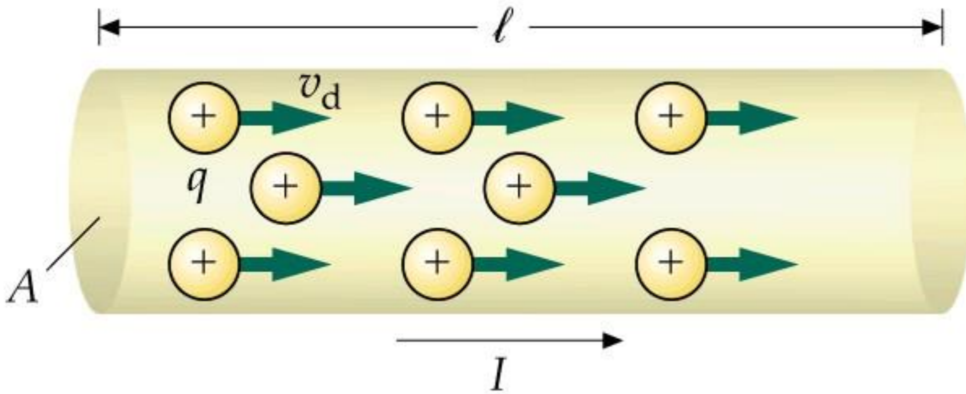
Joseph John Thomson (1856 – 1940)   Inglaterra

Thomson's Cathode-Ray Experiment

Thomson used an evacuated cathode-ray tube to show that the cathode rays were negatively charged particles (electrons) by deflecting them in electric and magnetic fields.

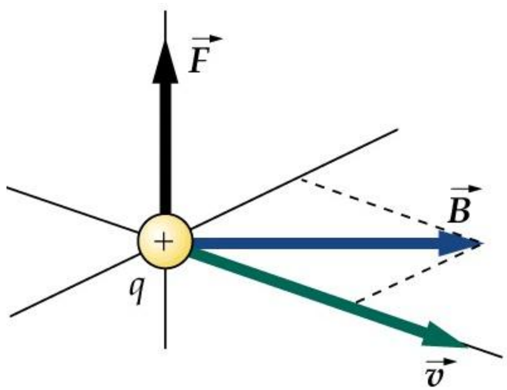


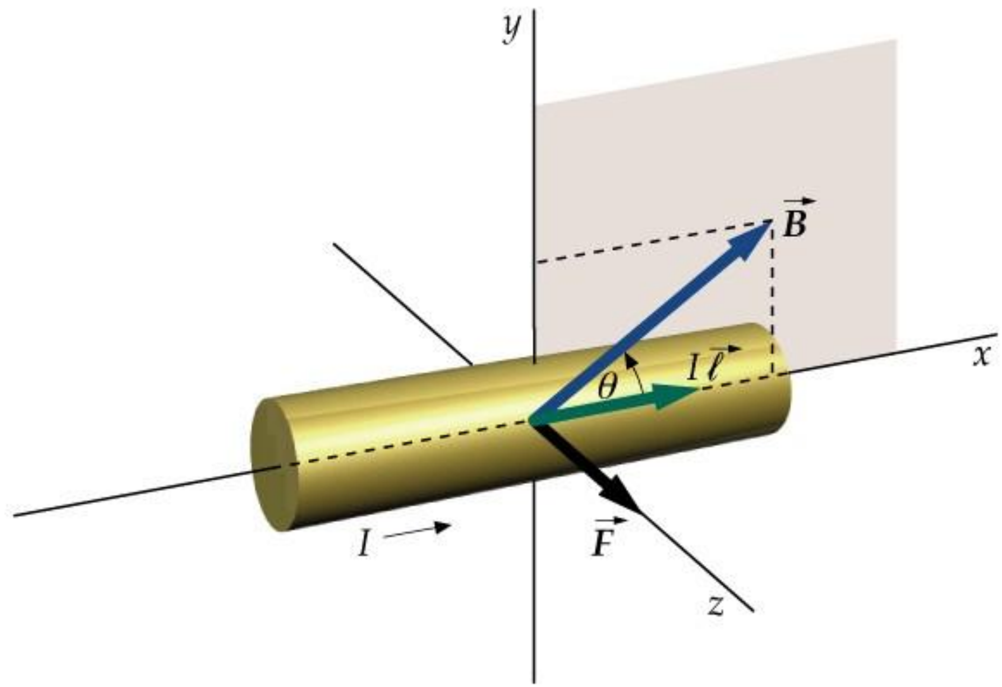
Força Magnética em fio com Corrente Elétrica



$$d\vec{F} = I d\vec{l} \times \vec{B}$$

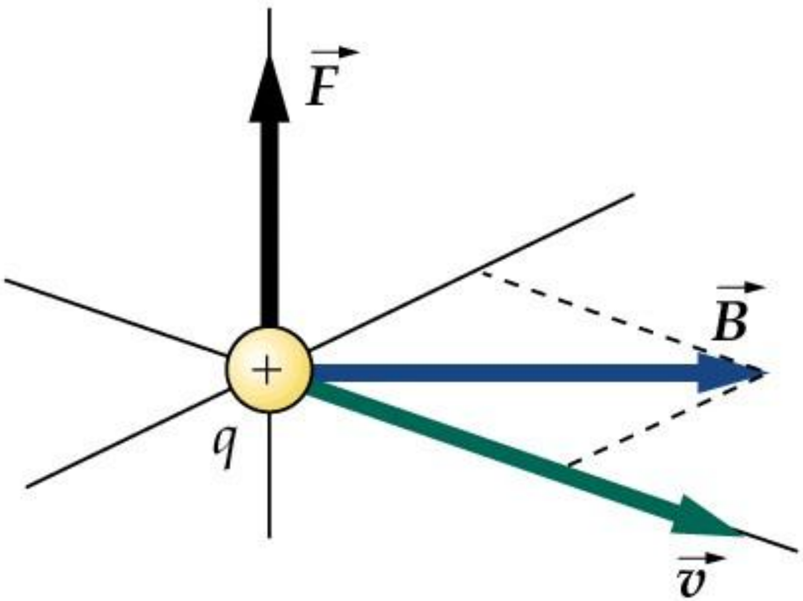
elemento de corrente de comprimento dl

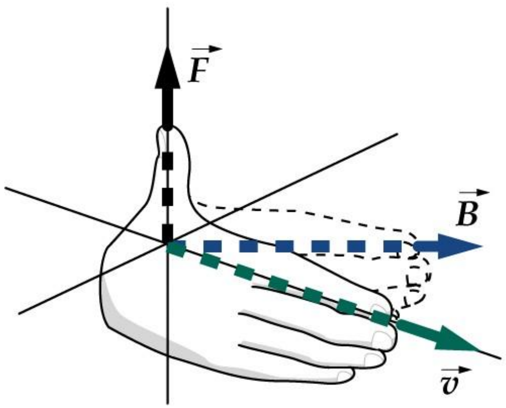




Força Magnética em uma carga em movimento

$$\vec{F} = q\vec{v} \times \vec{B}$$





Produto Vetorial

Regra da Mão Direita

Força Magnética em uma carga em movimento

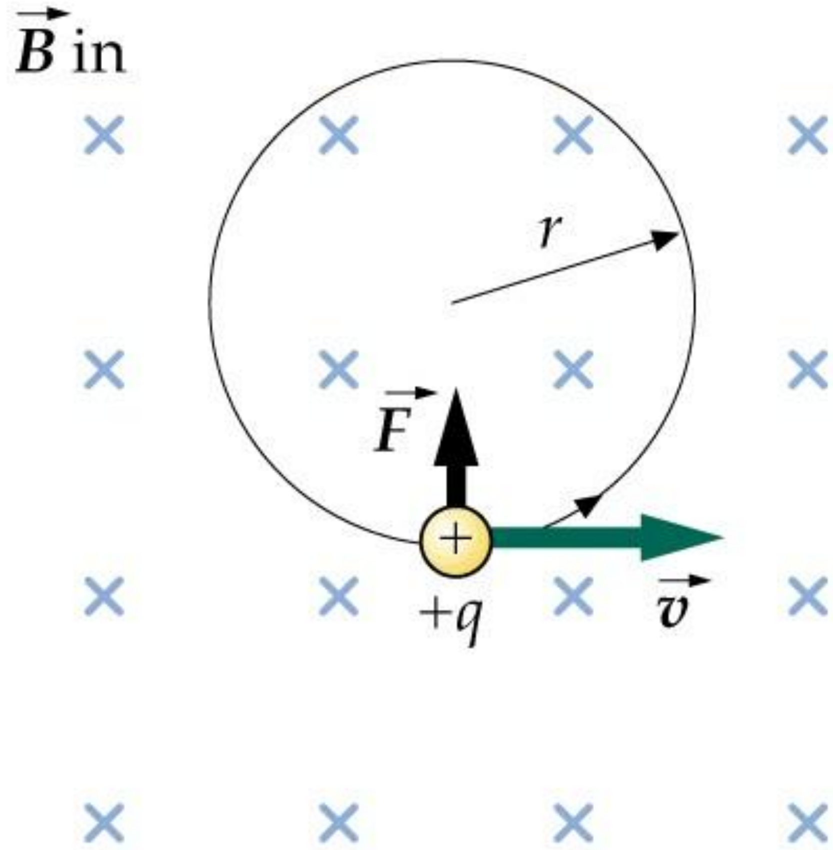
$$\vec{F} = q\vec{v} \times \vec{B}$$

$$\Downarrow$$

$$q.v.B = m\frac{v^2}{r}$$

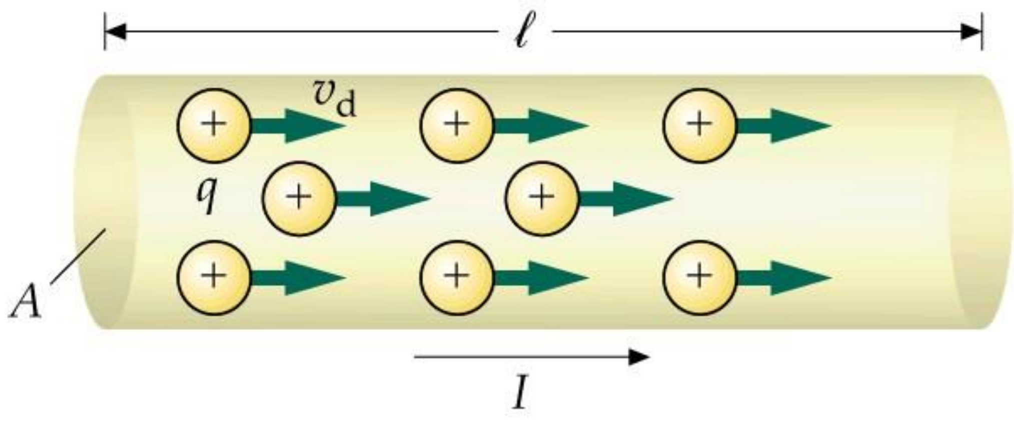
$$\Downarrow$$

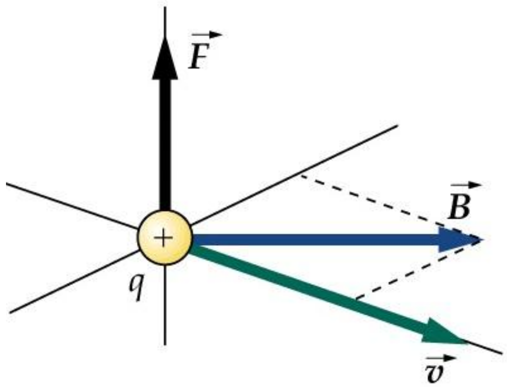
$$r = \frac{m.v}{qB}$$

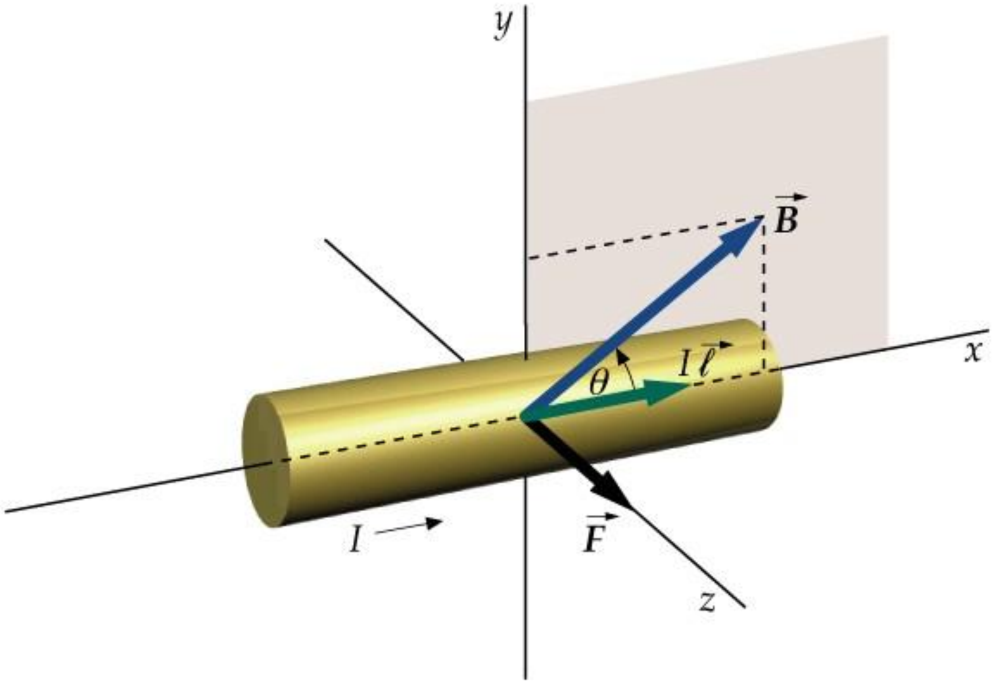


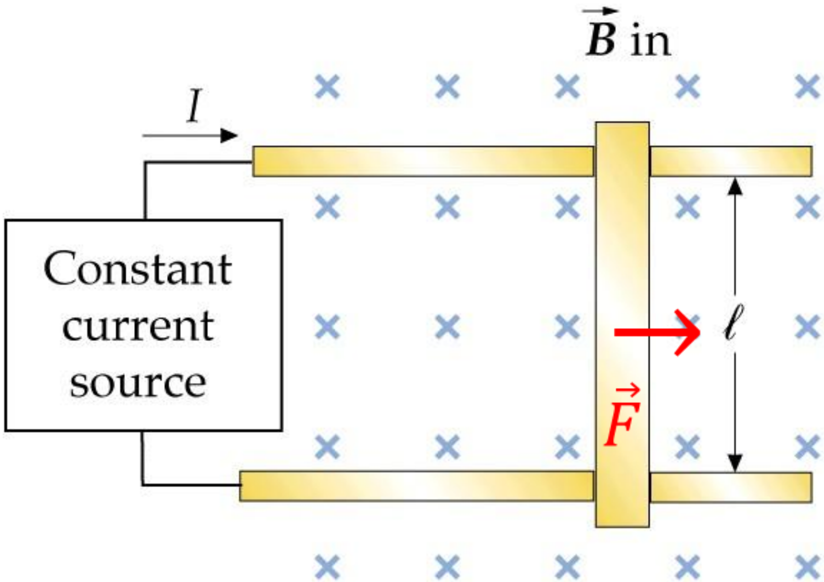
A força Magnética NÃO realiza trabalho → não altera a energia cinética

Força Magnética em fio com Corrente Elétrica



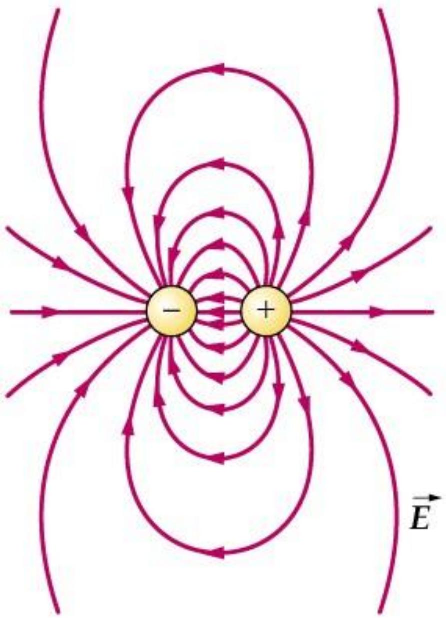






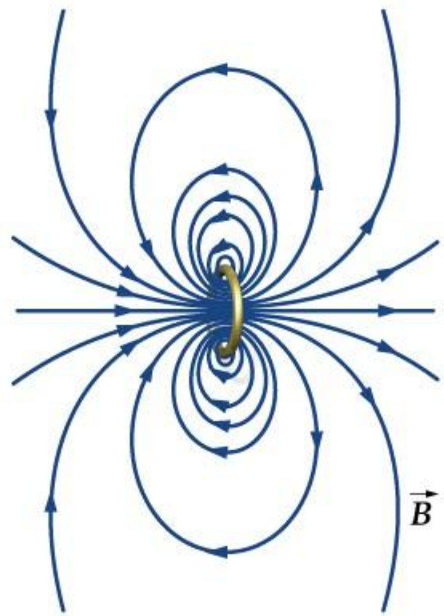
$$F = IlB$$

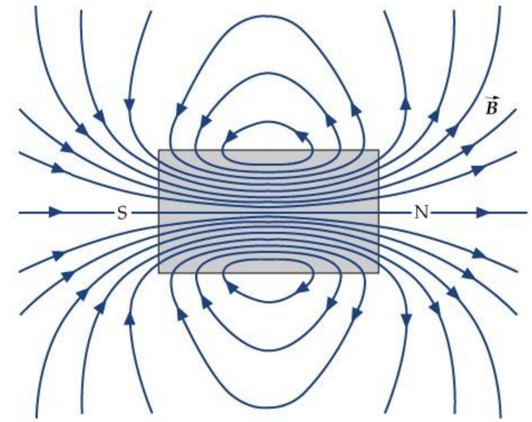
Obs: no vídeo o Prof. Eduardo usou uma fonte de tensão constante ao invés de uma fonte de corrente constante e o campo magnético aproximadamente perpendicular ao plano das barras metálicas, mas não era uniforme. Consequentemente, a expressão F = i.L.B, com corrente (i) e campo magnético (B) constantes é uma aproximação grosseira da demonstração. É claro que o objetivo foi demonstrar qualitativamente o fenômeno da Entretanto, a demonstração atende dipolo elétrico $\vec{p} = q\vec{L}$



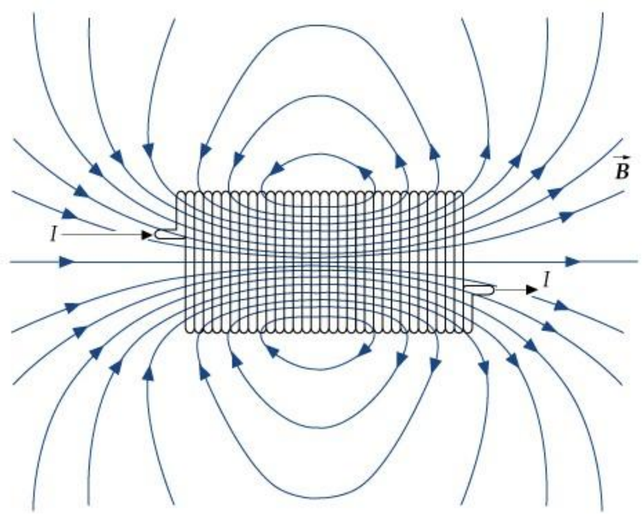
dipolo magnético $\vec{\mu} = I\vec{A}$

I = corrente
A = área do anel





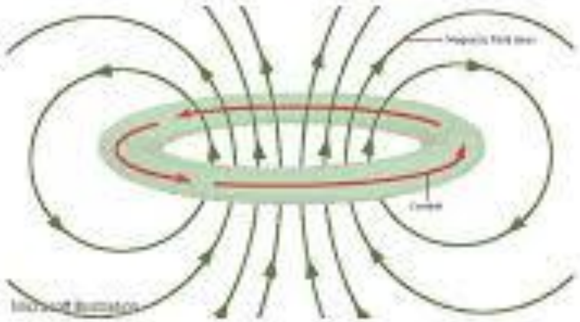
(a)



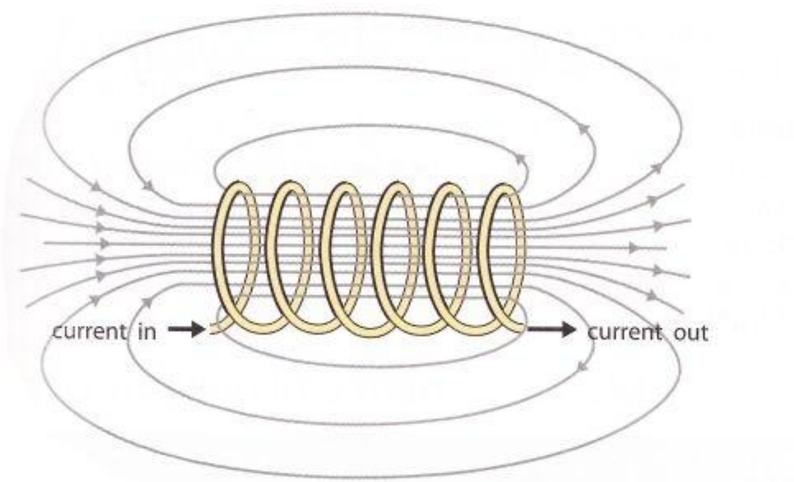
The Right Hand Rule

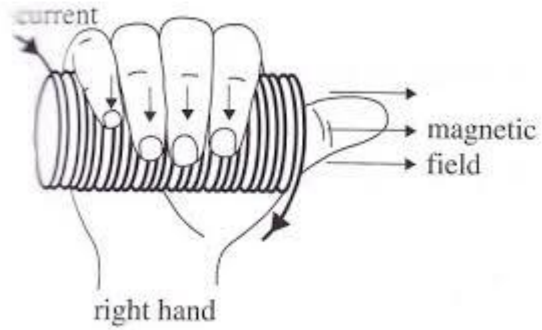
The magnetic field of a coil

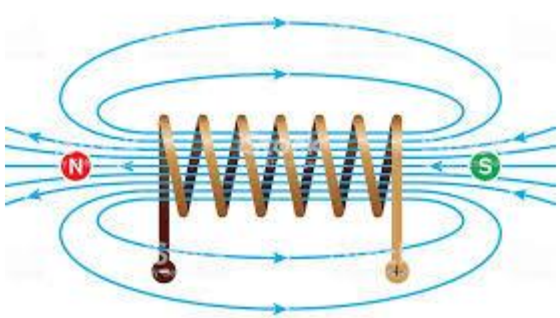
- The overall field around a coil is the sum of the fields around each individual wire



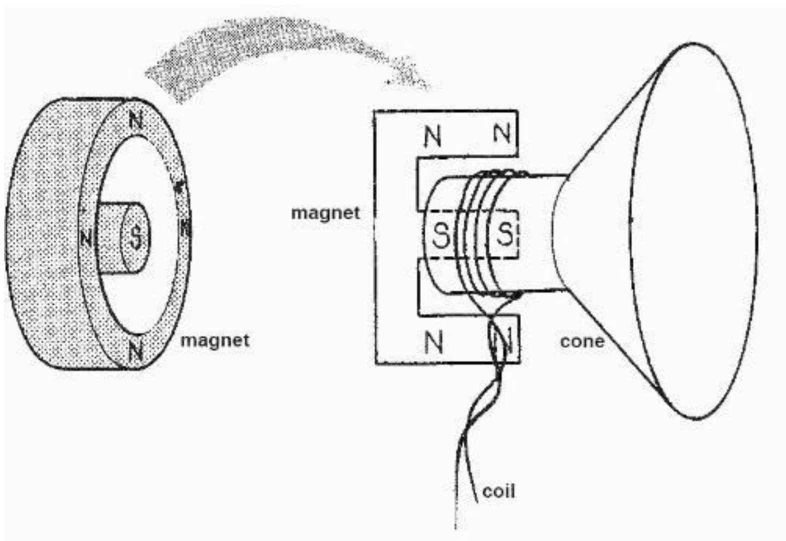
Campo Magnético de um Solenóide

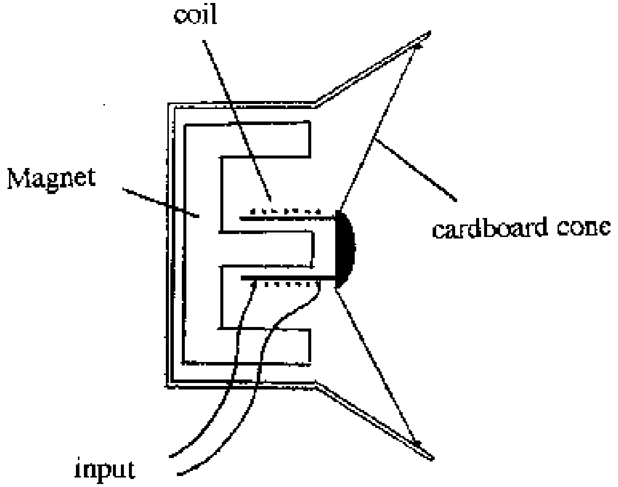


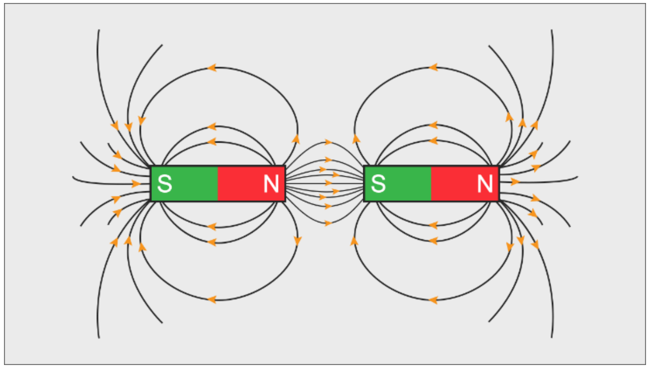


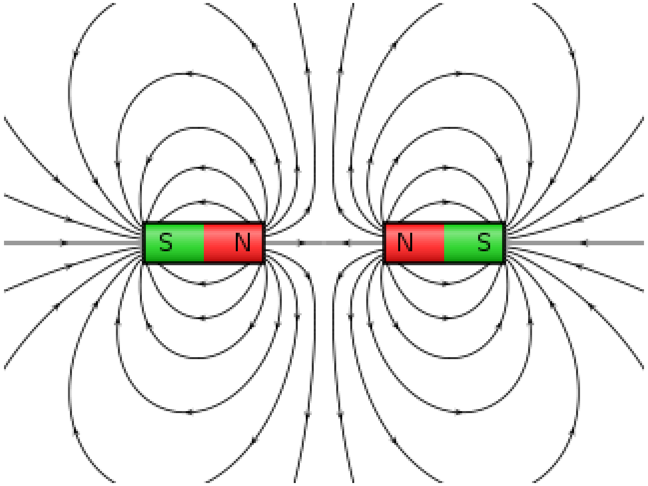


Auto-falante

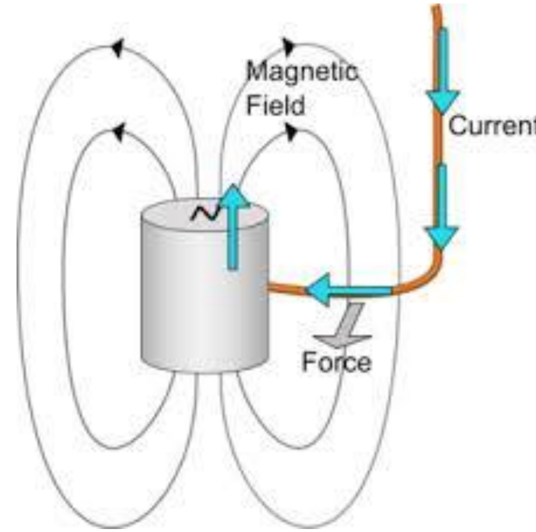


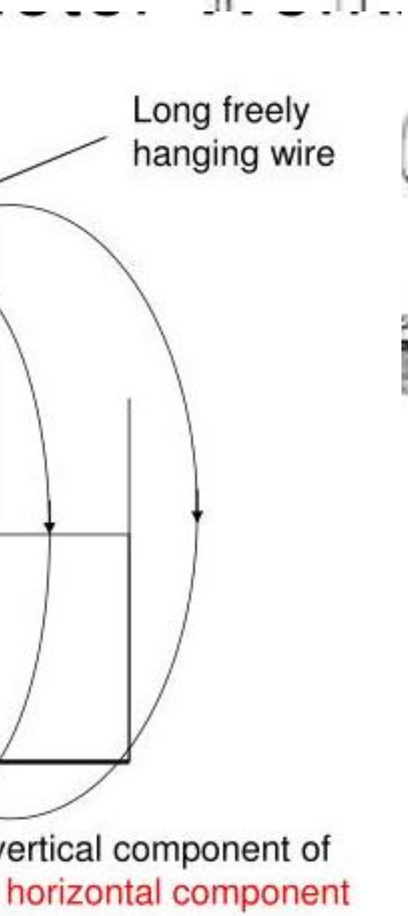


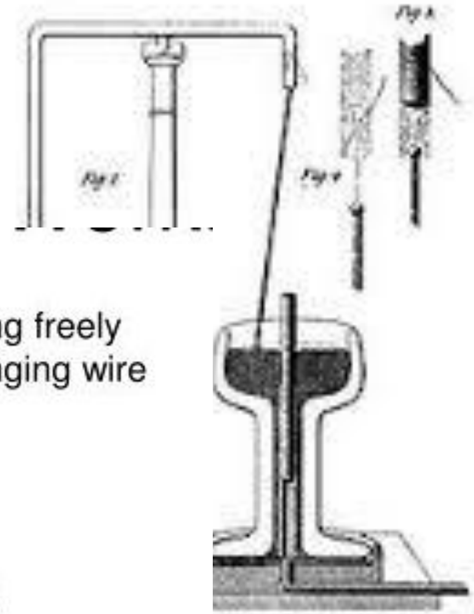




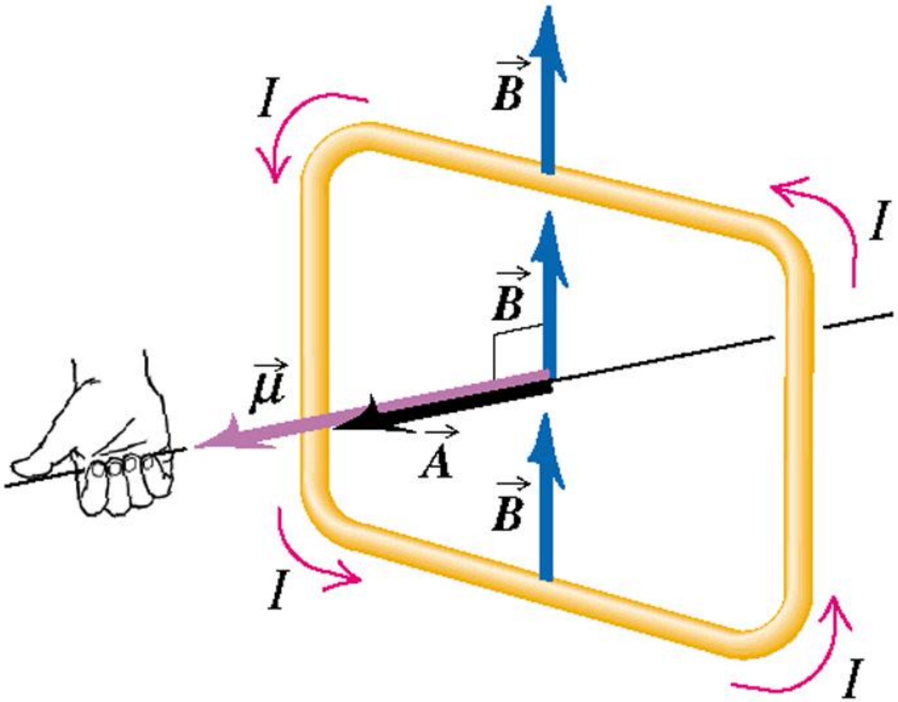

1791-1867

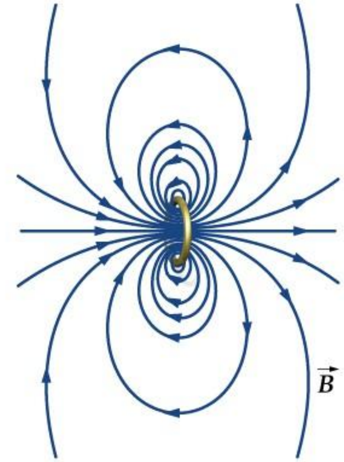

Magnetic
Field
Current
N
Force


Long freely
hanging wire
vertical component of
horizontal component



Momento Magnético ($\vec{\mu}$) de uma espira de corrente

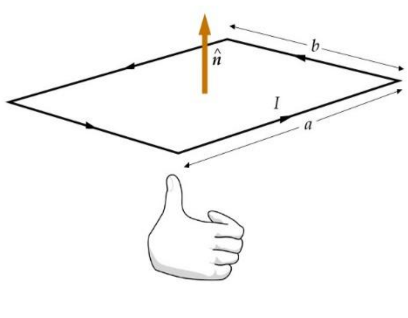




$$\vec{\mu} = I.\vec{A}$$

torque

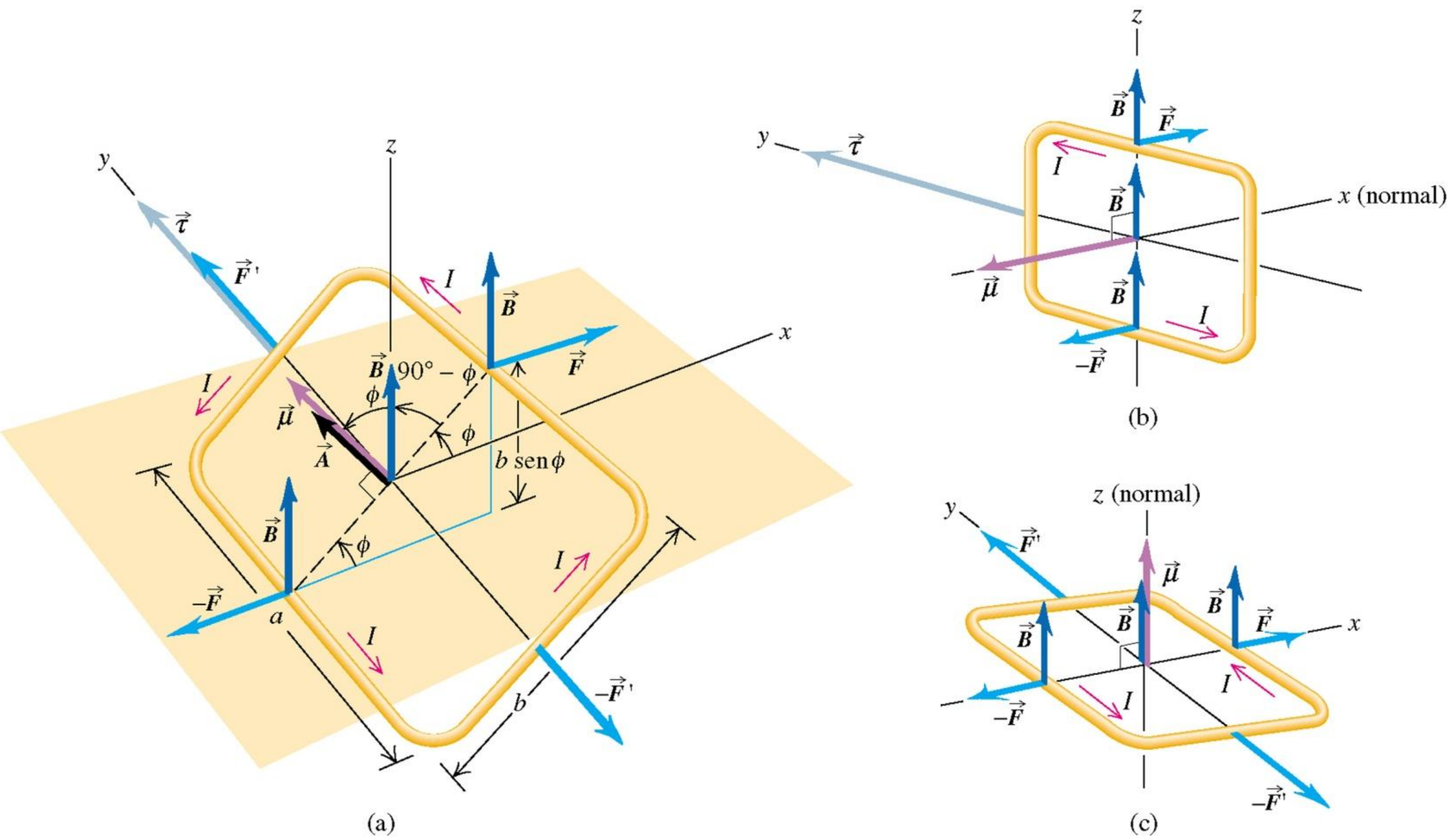
$$\vec{\tau} = \vec{\mu} \times \vec{B}$$



Se a corrente (I) está no sentido dos dedos o

$\vec{\mu}$ aponta na direção do polegar

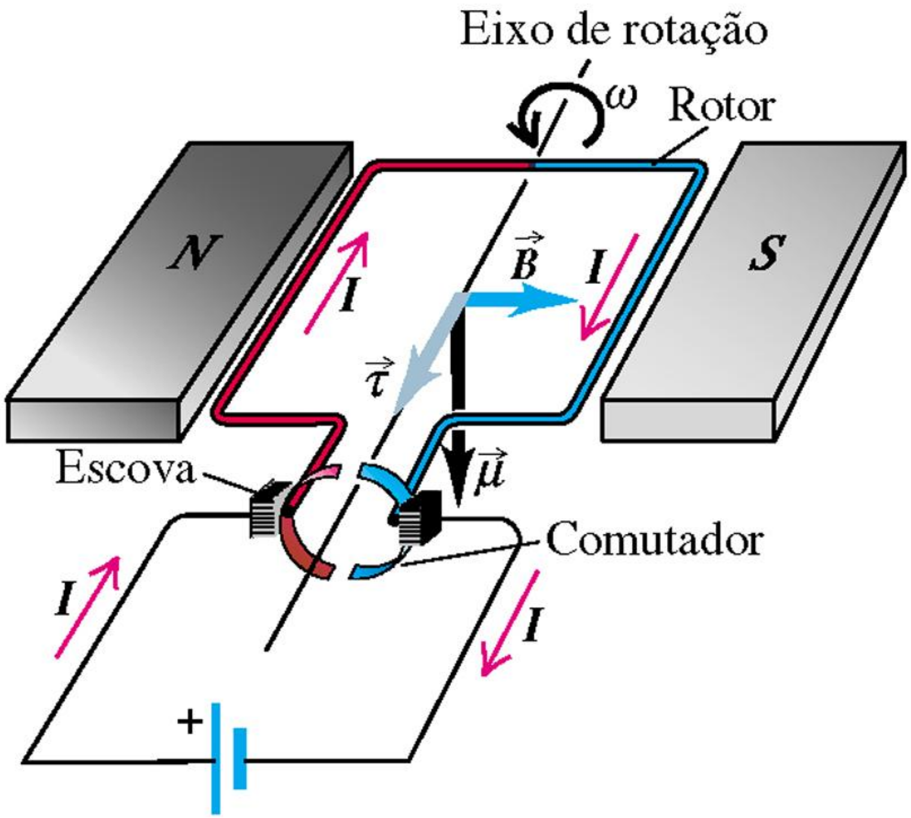
Torque em uma espira em um Campo Magnético Uniforme



$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

$$U = -\vec{\mu}.\vec{B}$$

Motor de Corrente contínua ("Direct Currente", DC)



$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

$$\tau = \mu . B . sen\theta$$

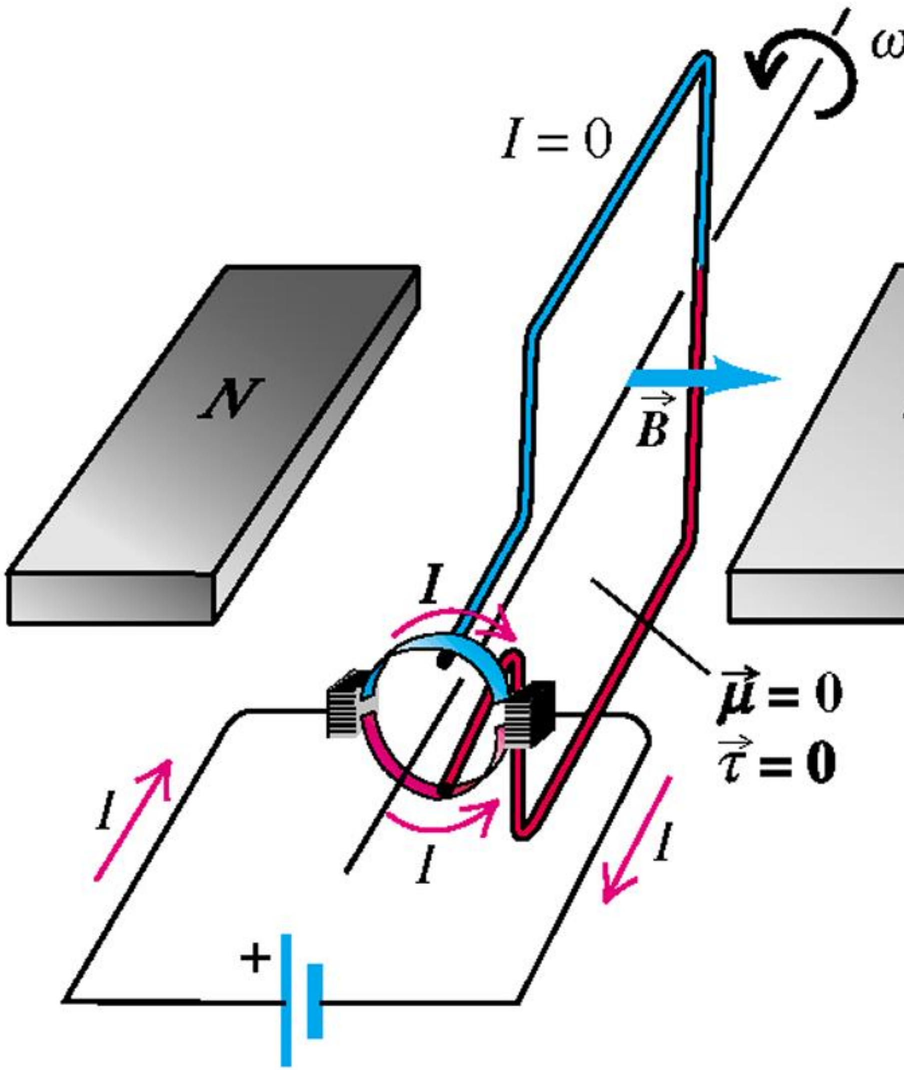
$$U = -\vec{\mu} . \vec{B}$$

$$\theta = \pi/2$$

O torque na espira faz ela girar no sentido anti-horário buscando a posição de energia mínima $(\mu /\!/ B)$

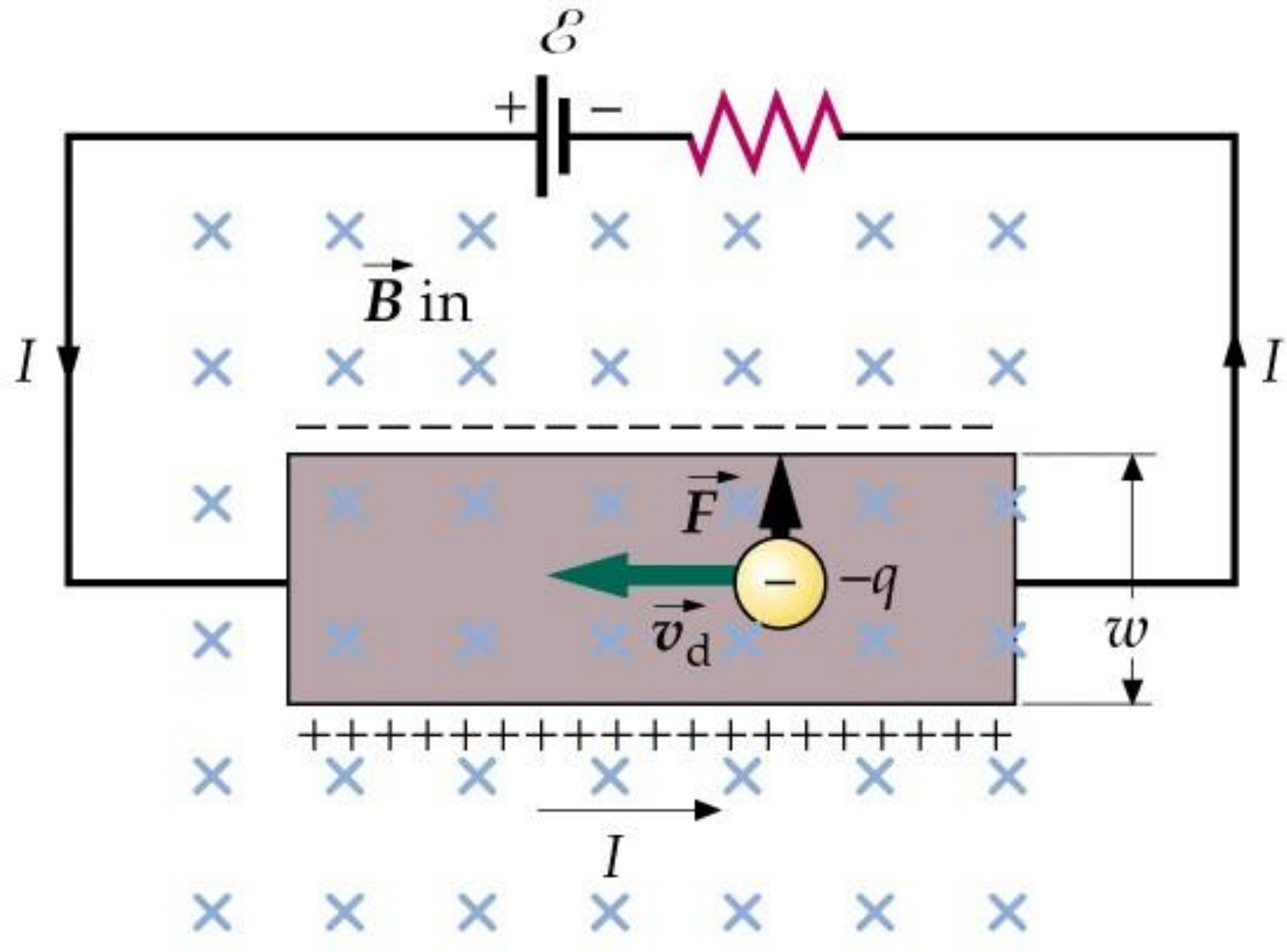
©2004 by Pearson Education Figuras 28-32

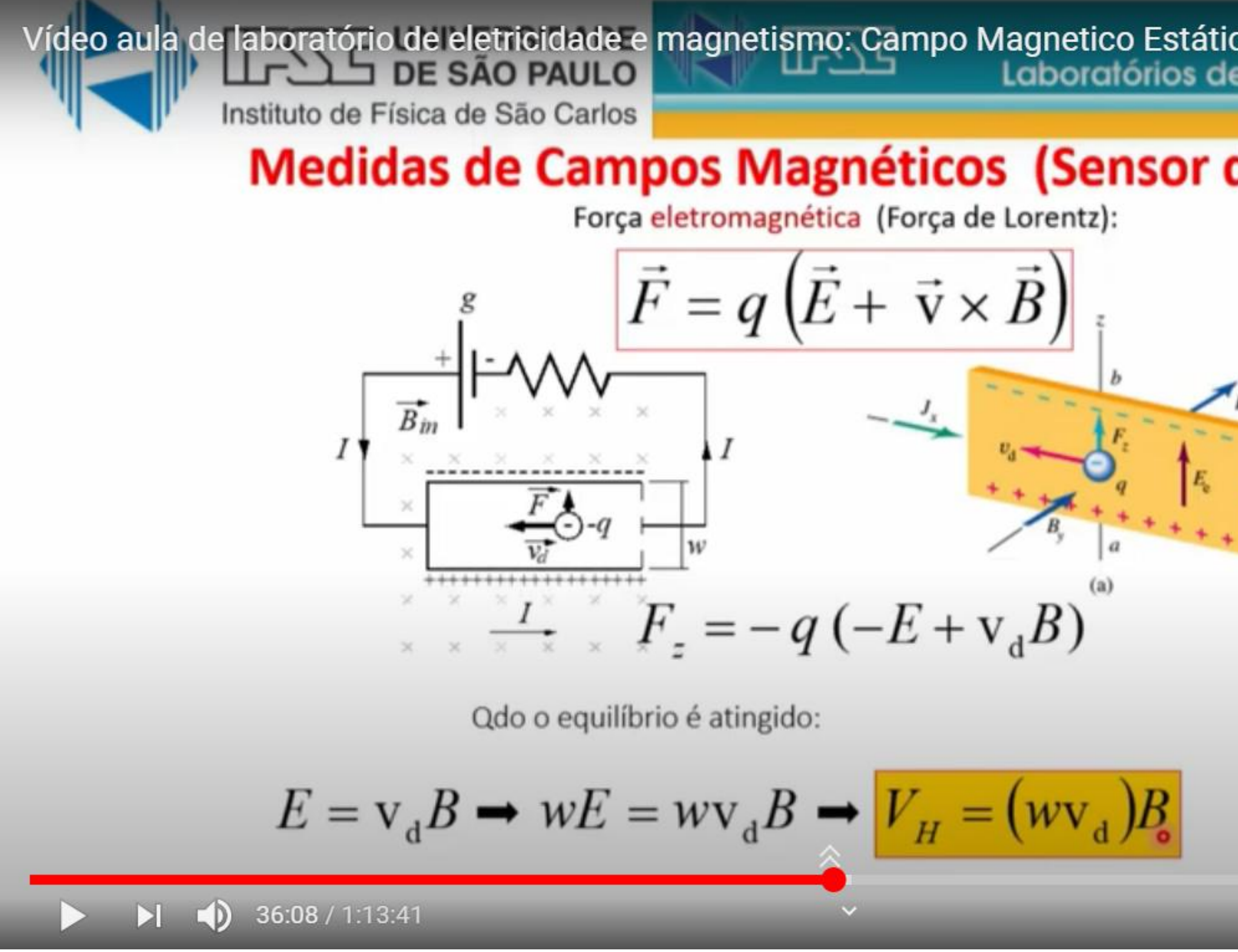
$$\theta = \pi/2$$

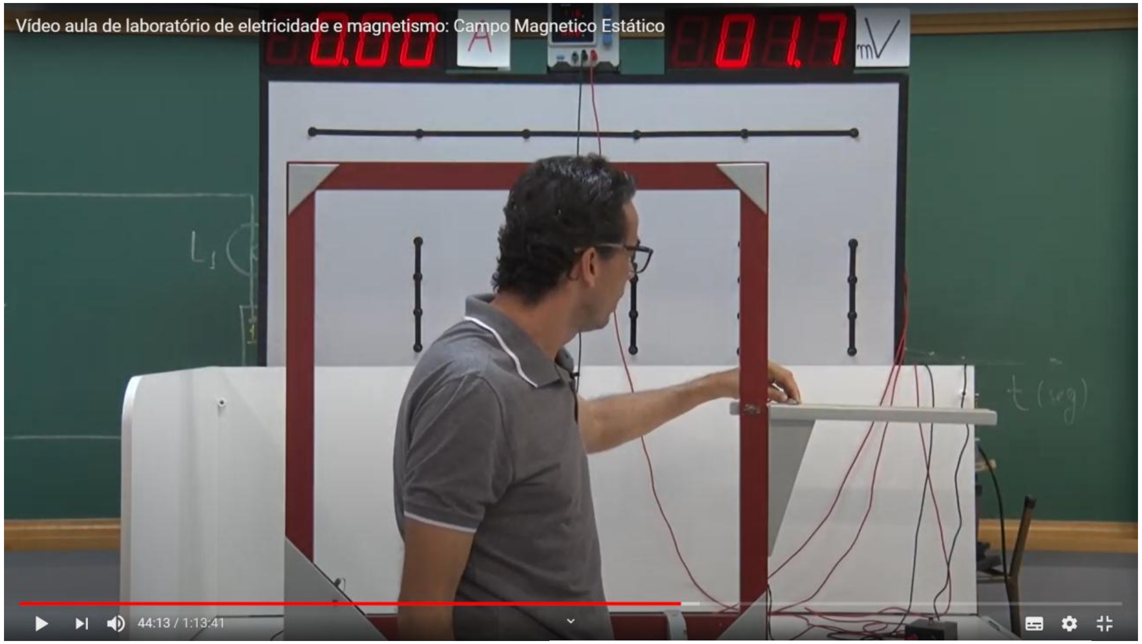


Cada escova está em contado com ambos segmentos do comutador
- Corrente nula → torque zero mas $\omega \neq 0$

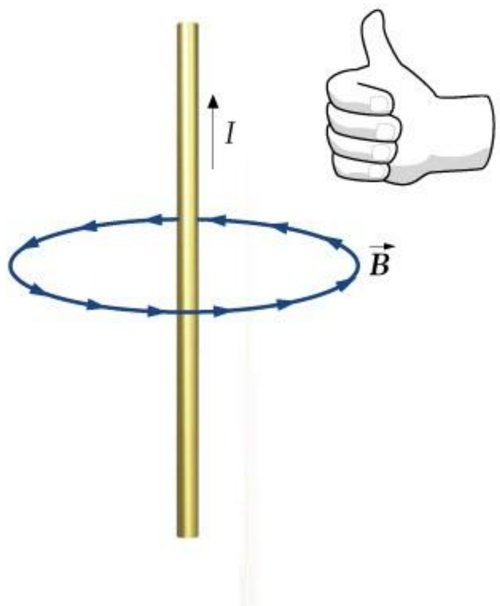
Efeito Hall




Vídeo aula de laboratório de eletricidade e magnetismo: Campo Magnetico Estático
DE SÃO PAULO
Instituto de Física de São Carlos
Laboratórios de Ensino de Física
USP
Medidas de Campos Magnéticos (Sensor de Efeito Hall)
Força eletromagnética (Força de Lorentz):
$\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right)$
$F_z = -q\,(-E + v_d B)$
Qdo o equilíbrio é atingido:
$E = v_d B \Rightarrow wE = w v_d B \Rightarrow V_H = (w v_d) B$
36:08 / 1:13:41

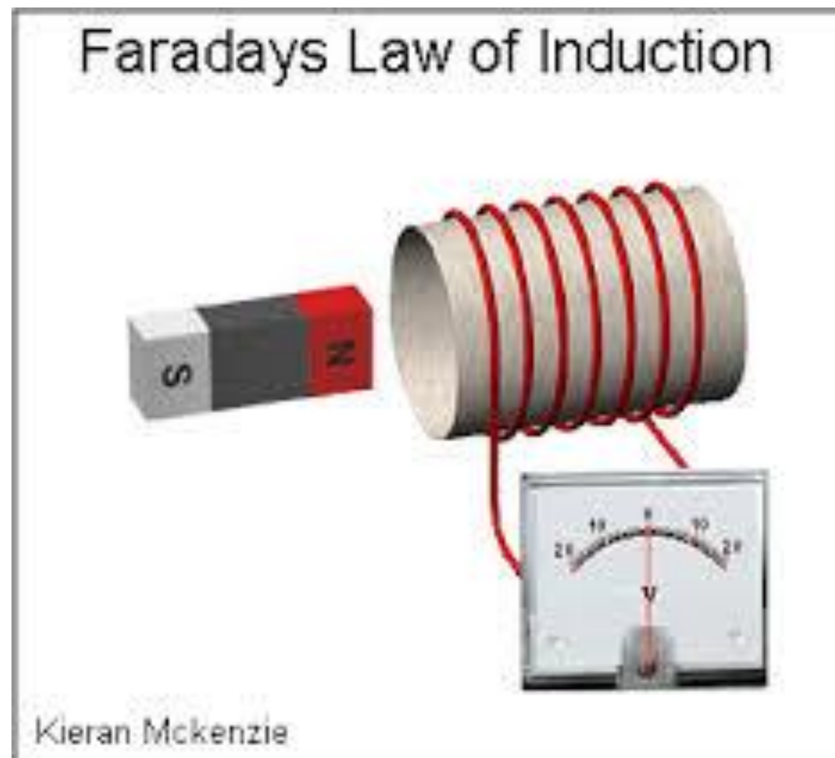


$$B = \frac{\mu_o}{2\pi r}$$

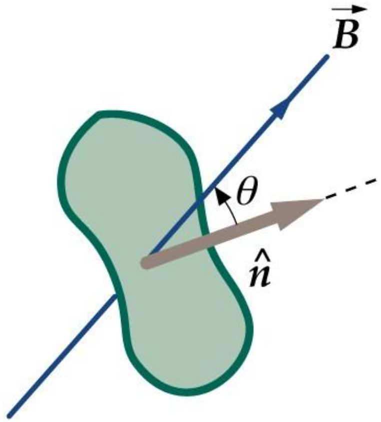


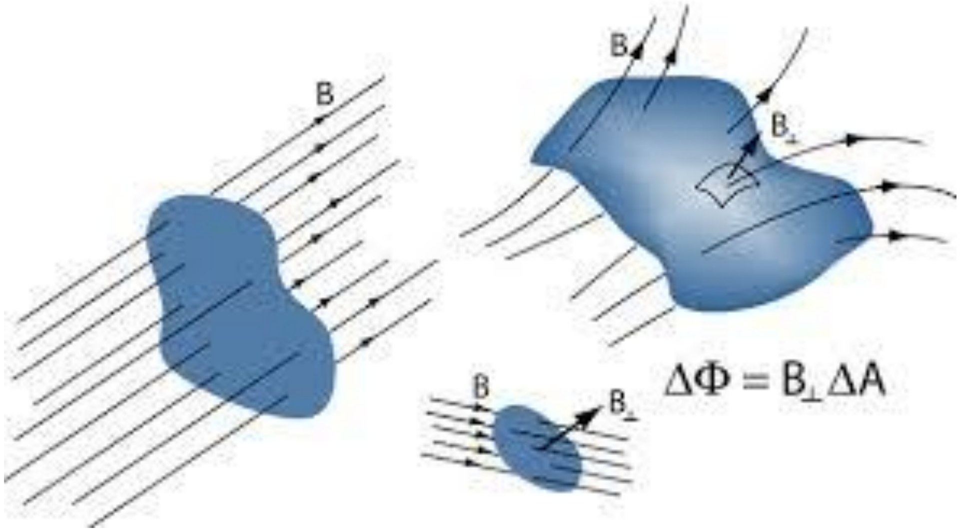
Indução magnética

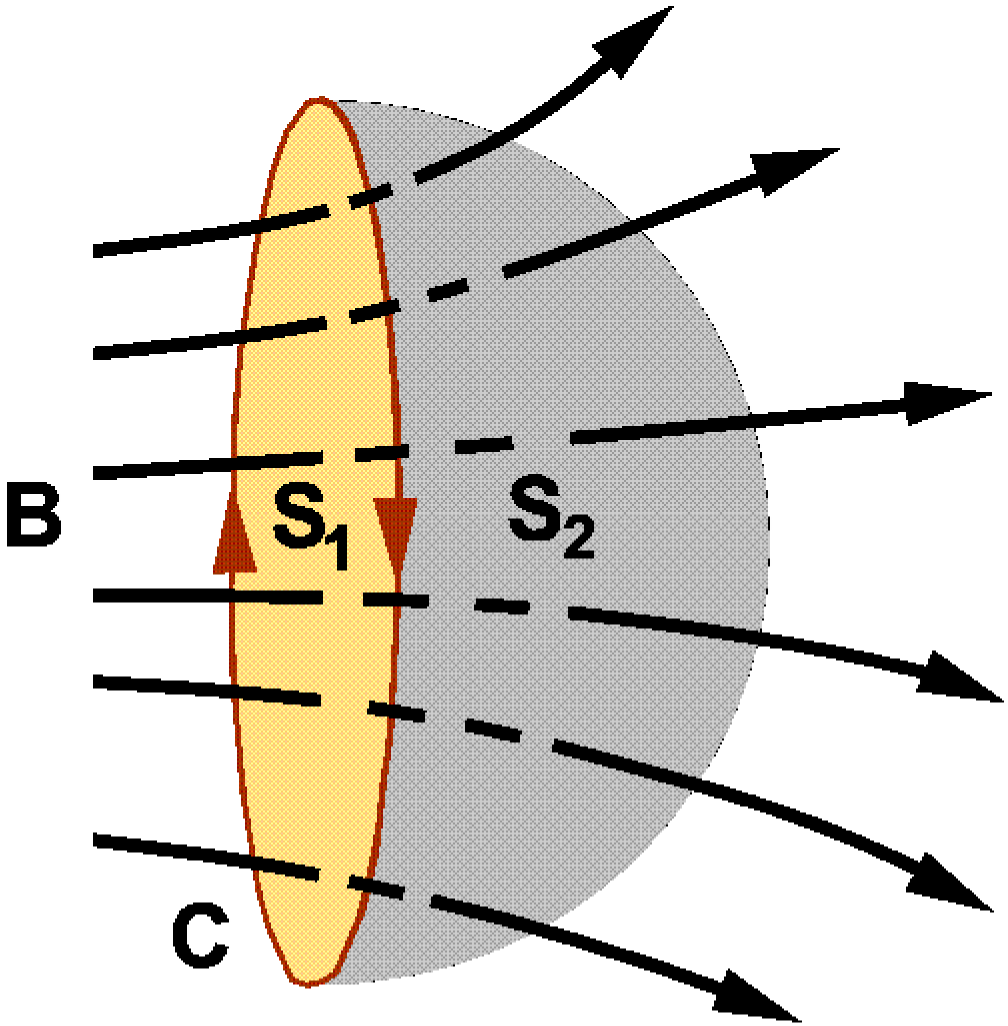
H. Lenz
1804 - 1865



Fluxo magnético

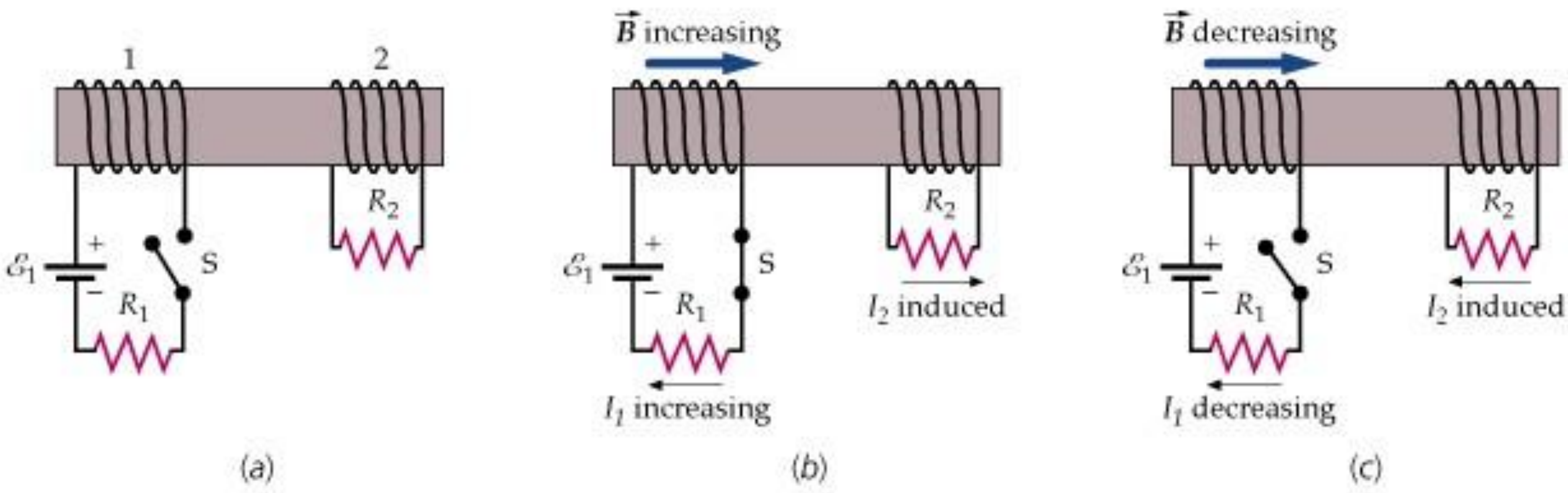


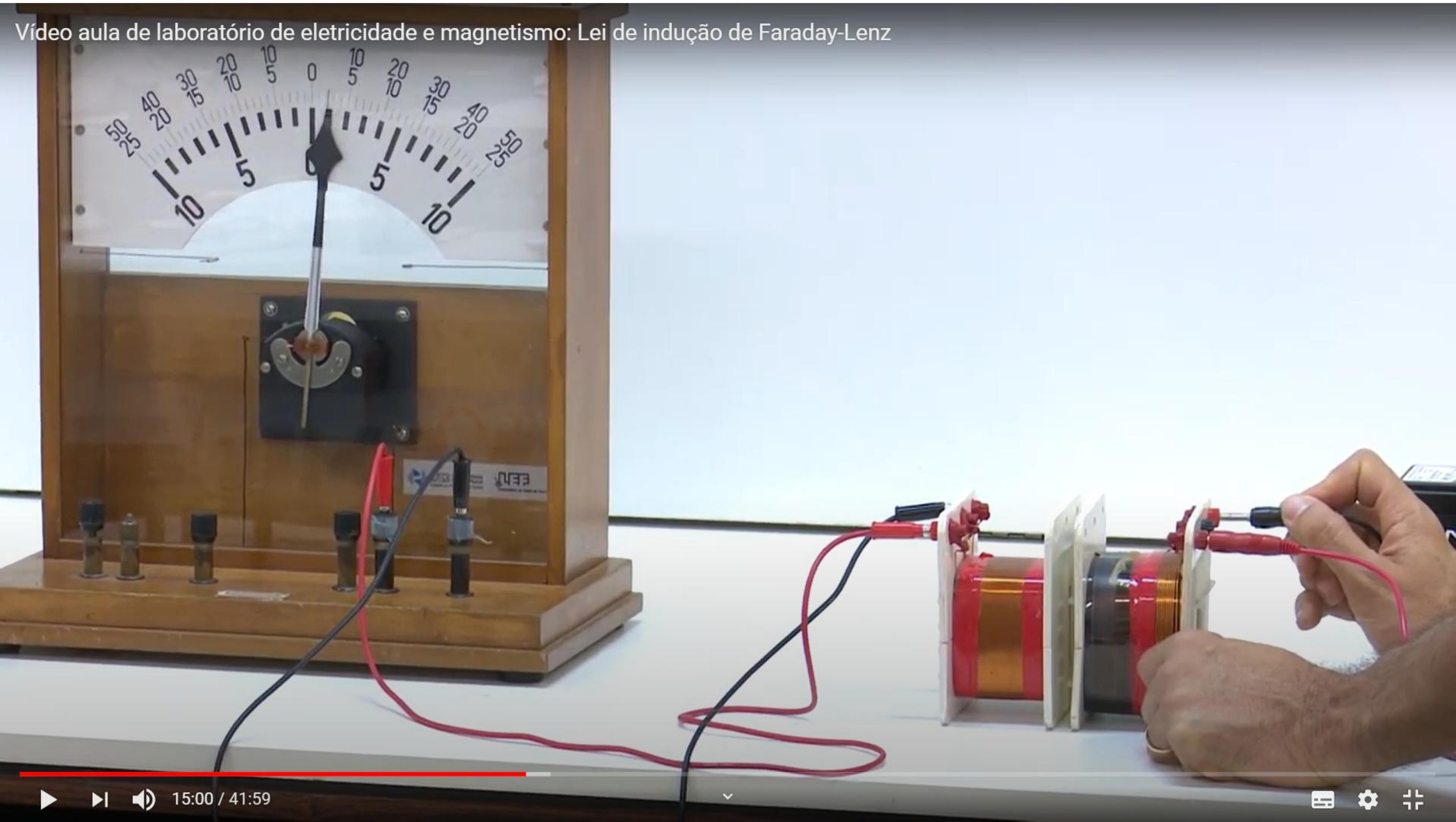


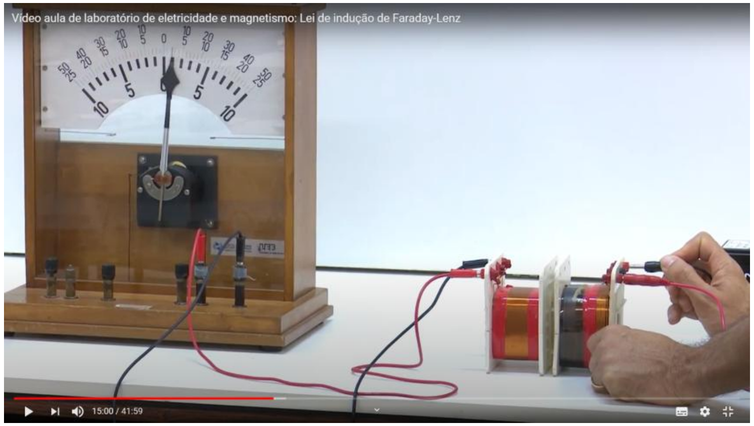


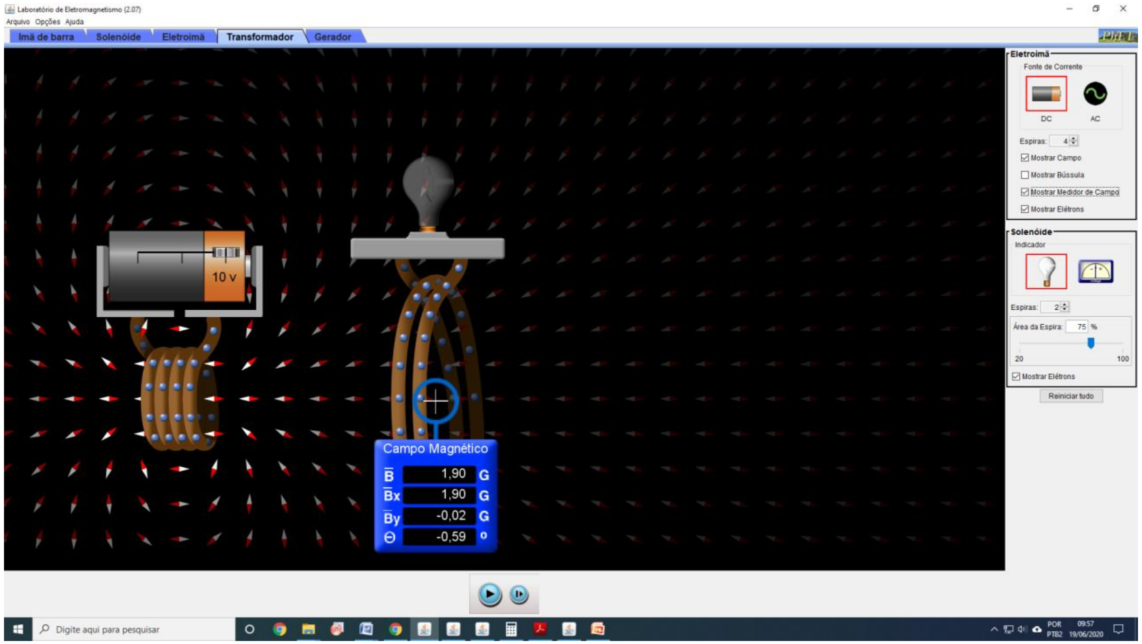
O fluxo total na superfície fechada é NULO

Demonstração da Indução usando duas bobinas (ou solenoides)



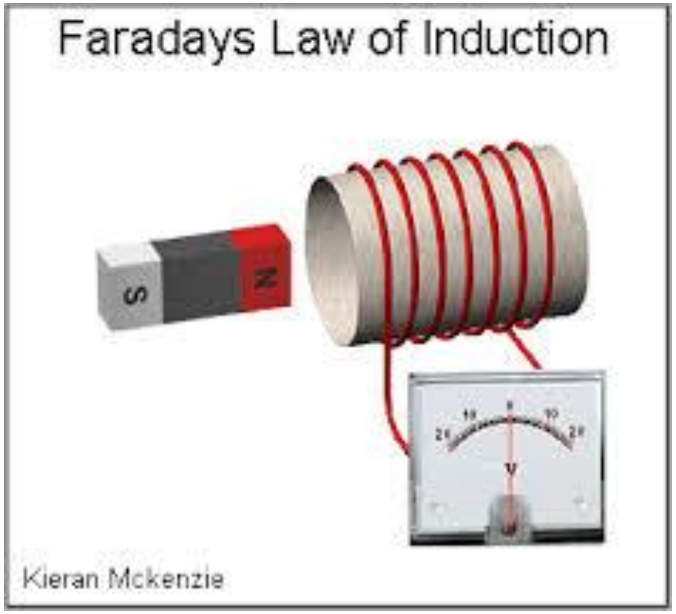

Vídeo aula de laboratório de eletricidade e magnetismo: Lei de indução de Faraday-Lenz
15:00 / 41:59

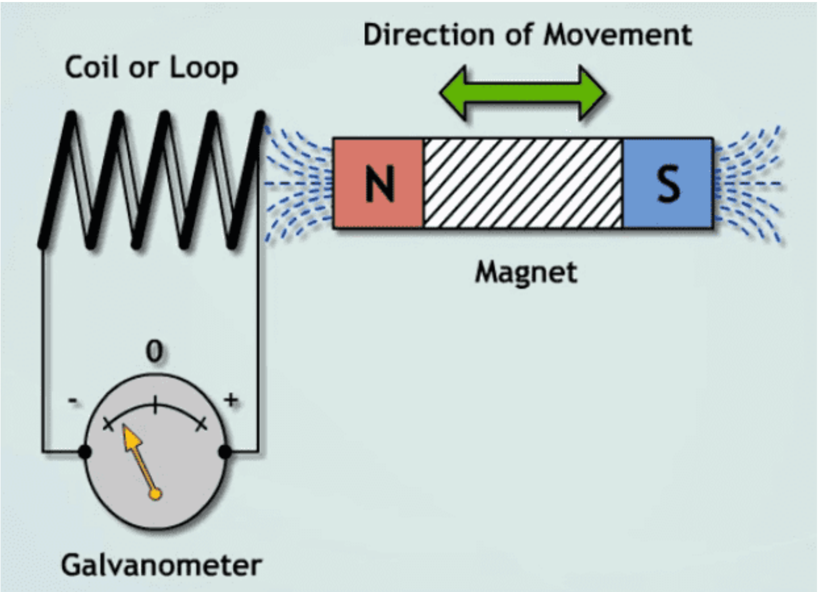


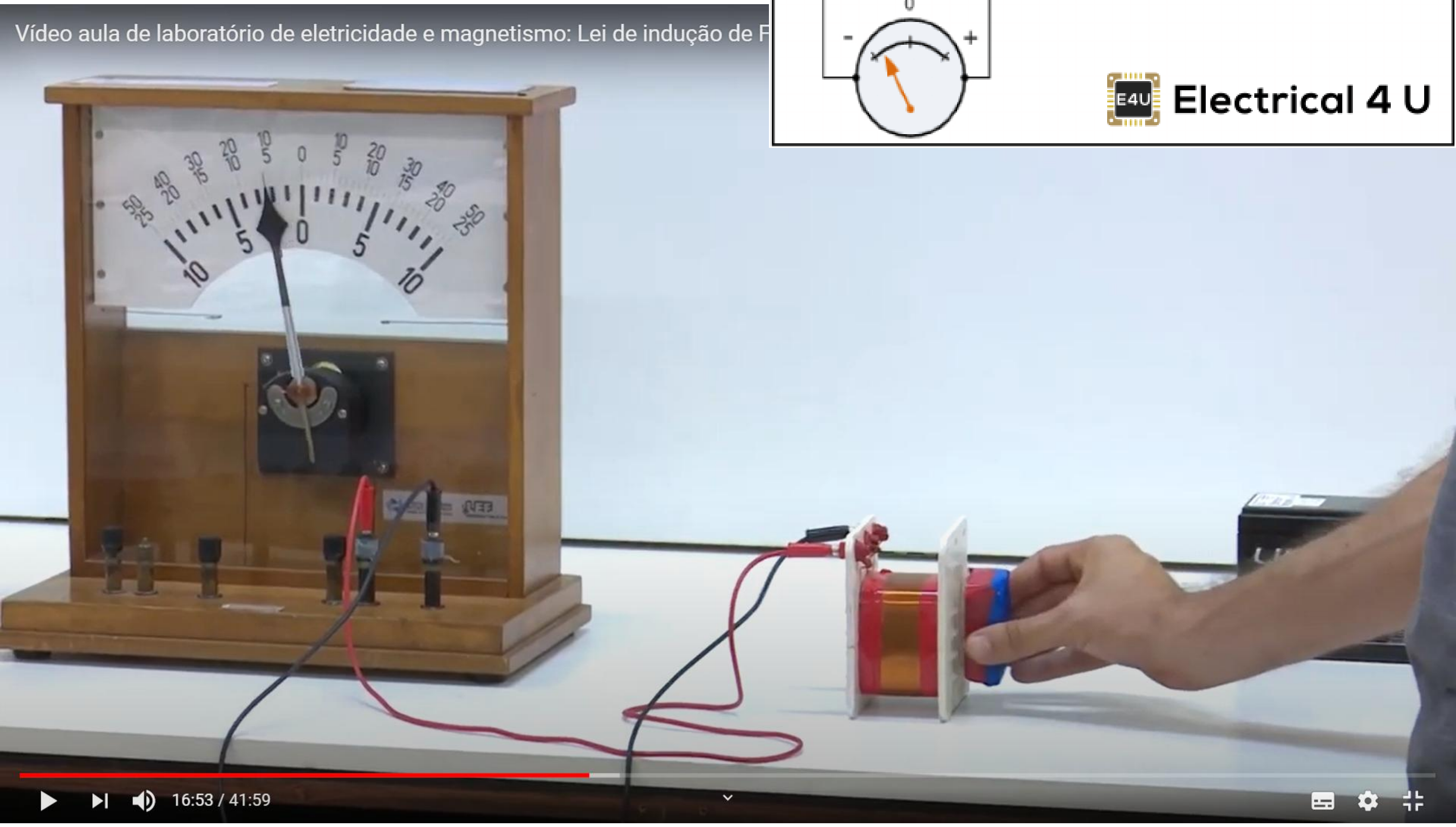


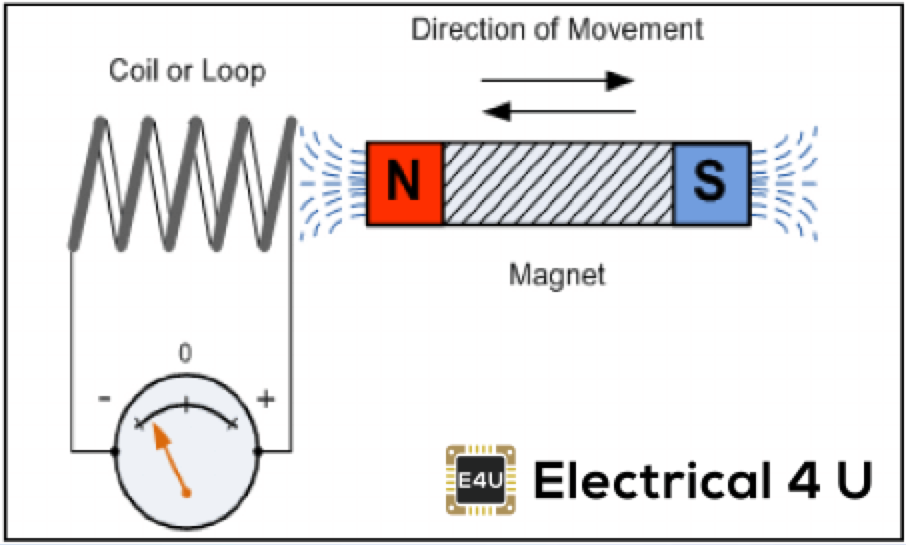
Esta demonstração pode ser simulada no PhET usando a aba Transformador

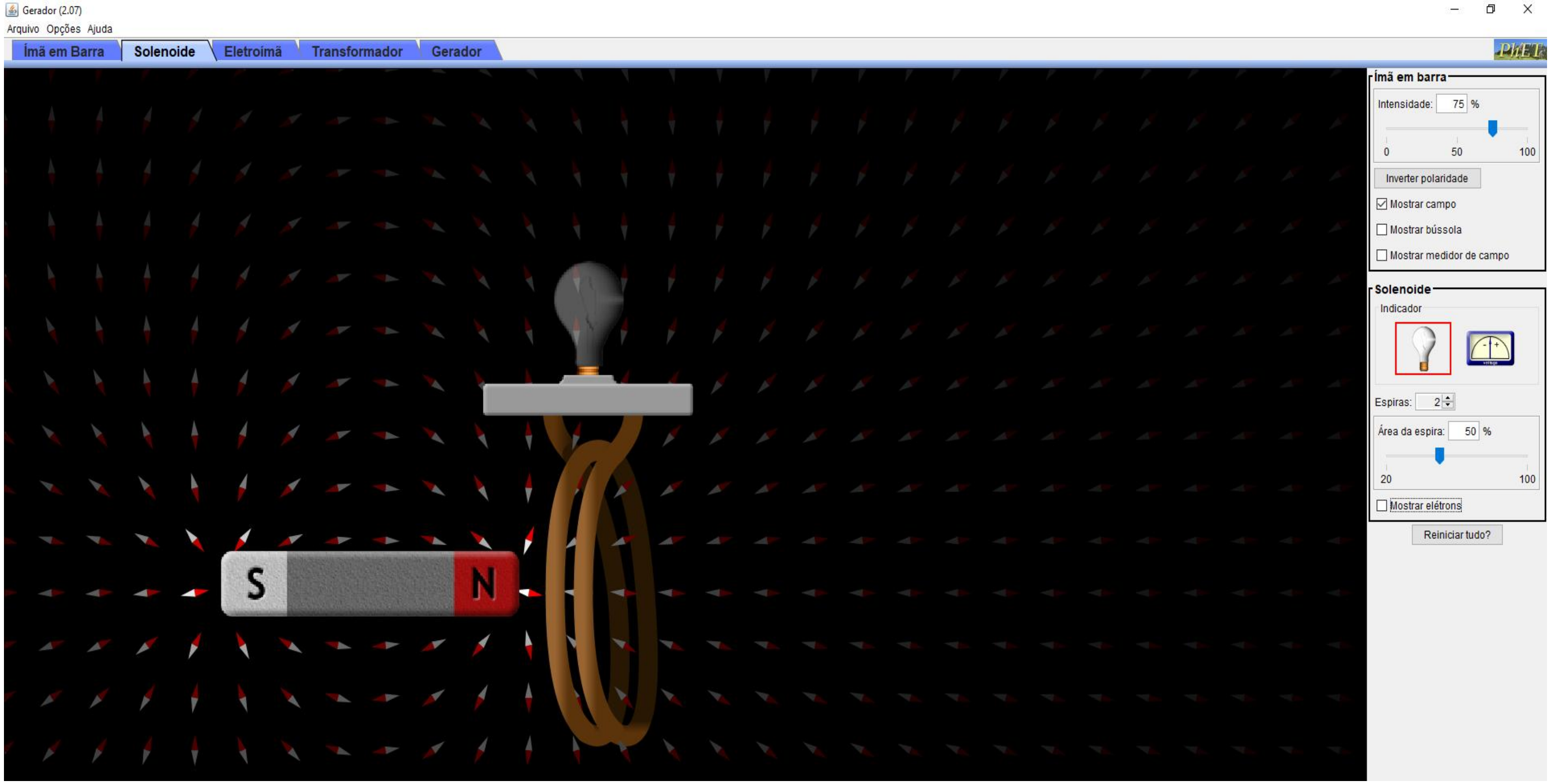
Demonstração: corrente induzida por um imã permanente



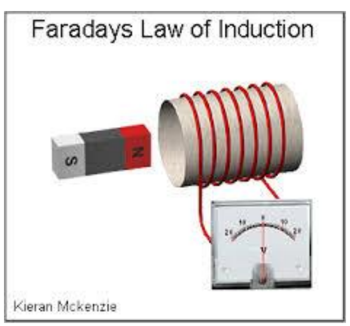


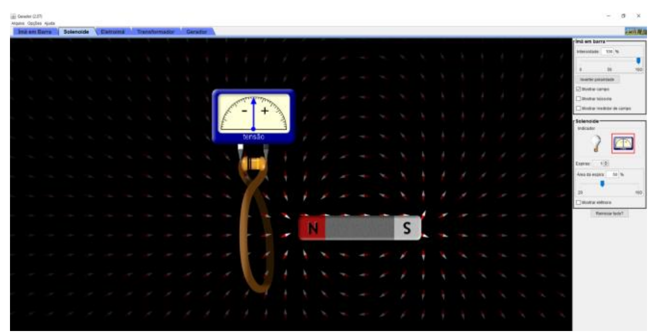

Vídeo aula de laboratório de eletricidade e magnetismo: Lei de indução de
16:53 / 41:59


Direction of Movement
Coil or Loop
N
S
Magnet
0
-
+
E4U
Electrical 4 U

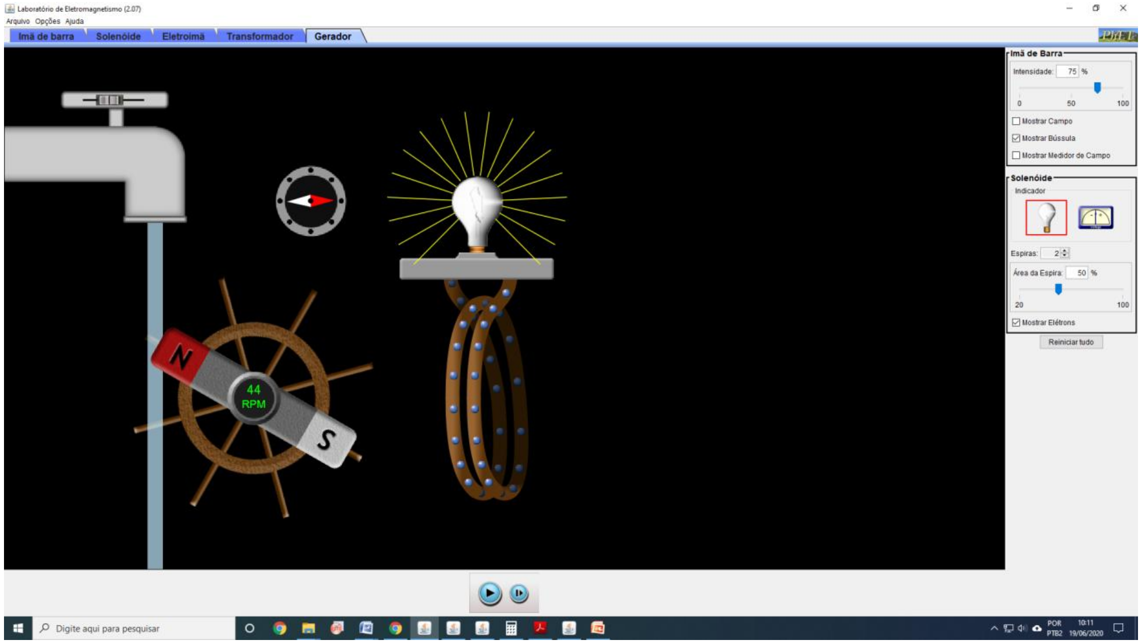


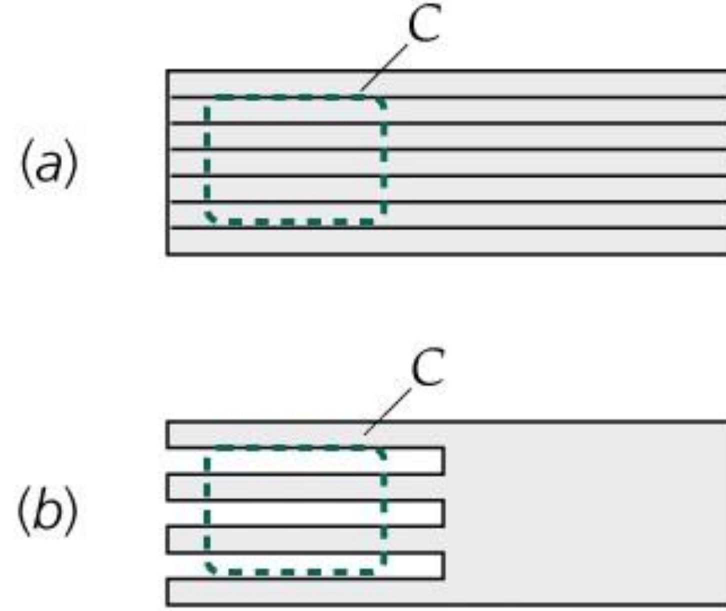
Explorar no PhET

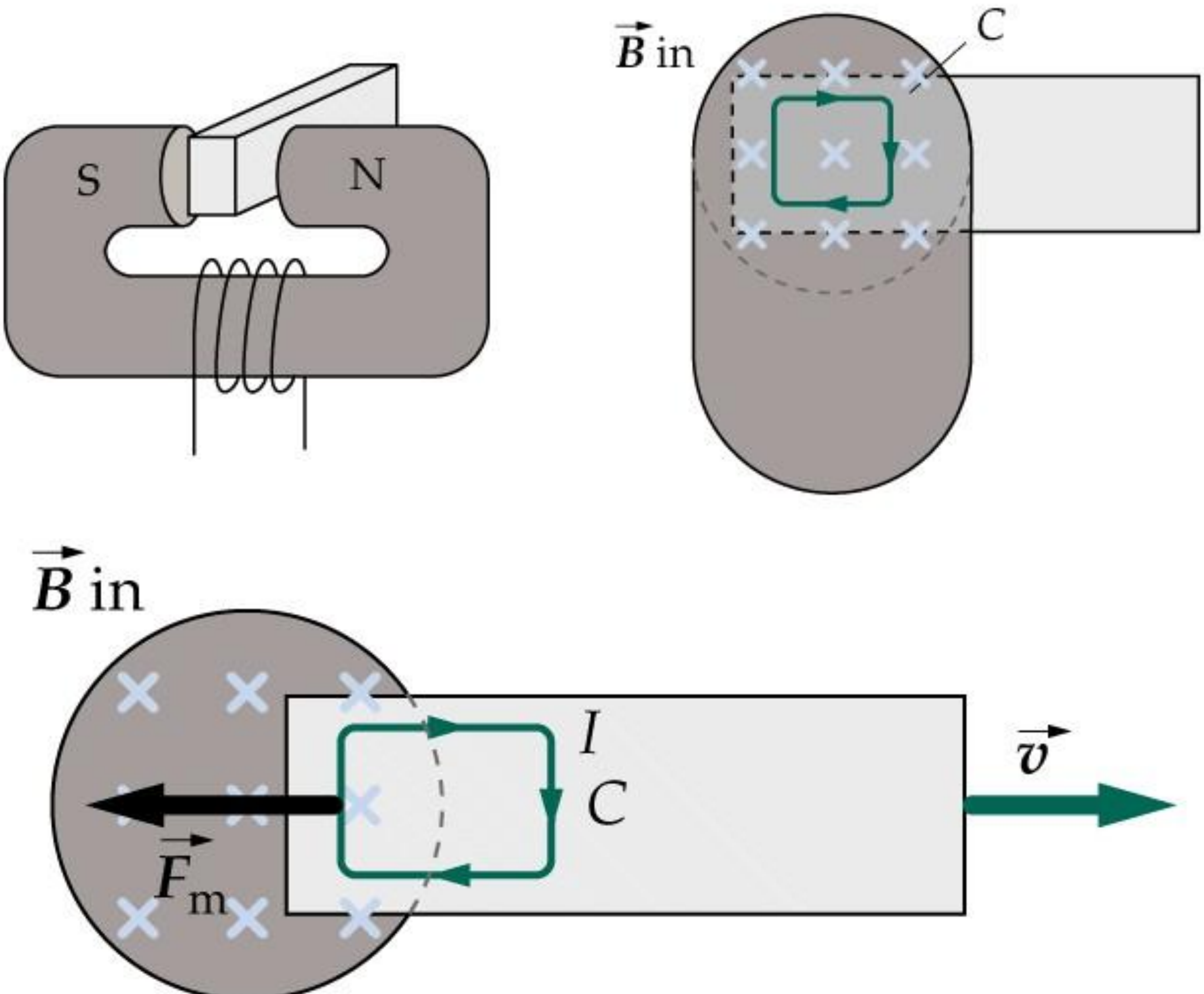


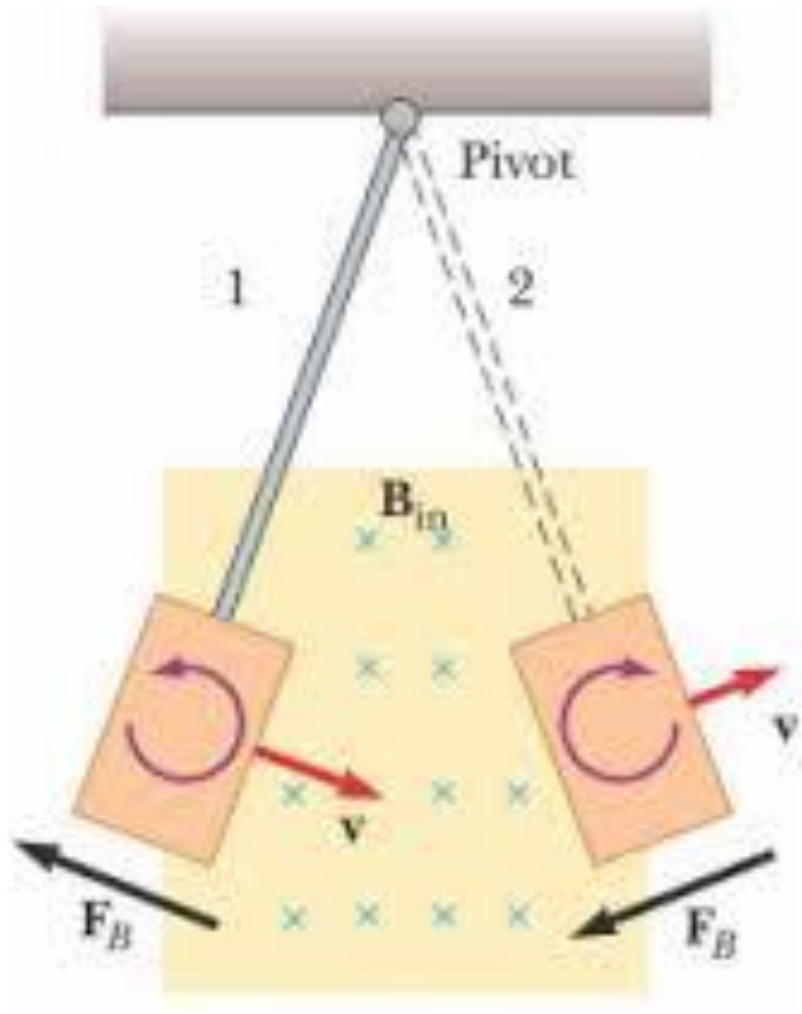


Gerador Elétrico

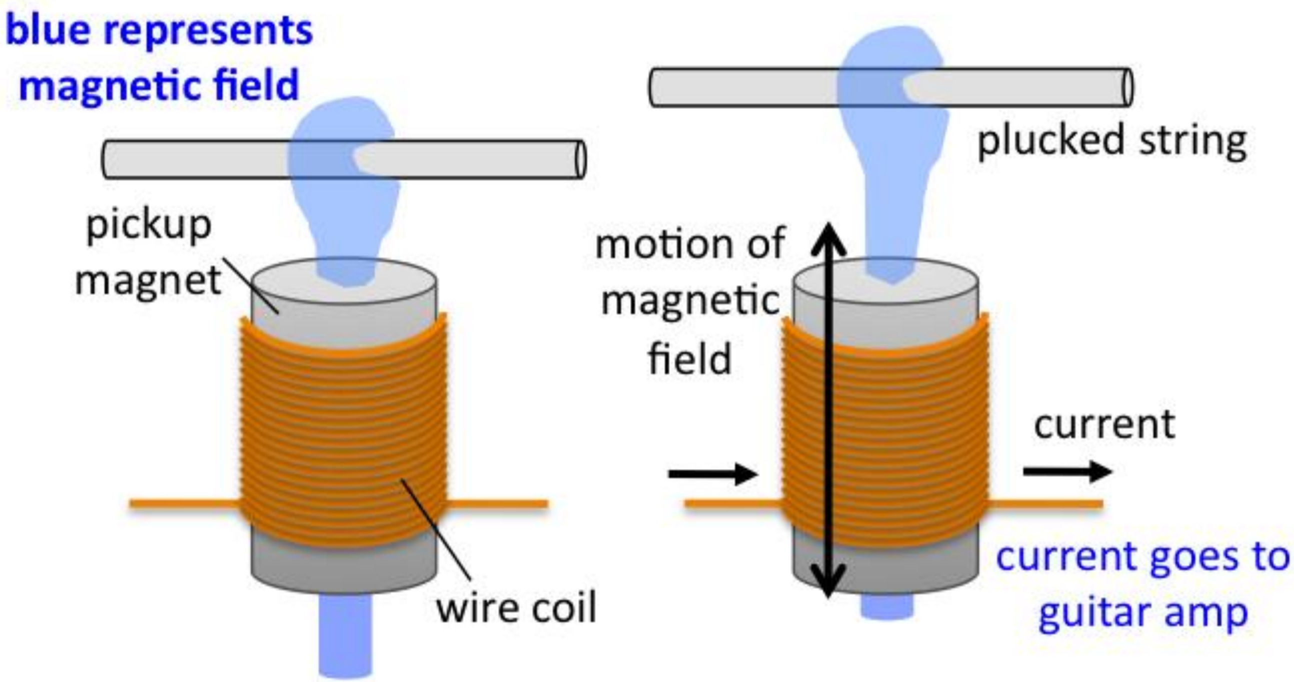


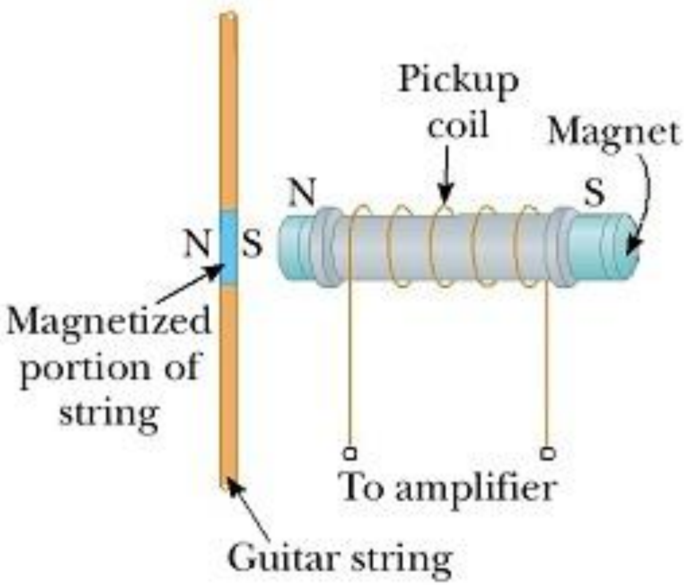

C
(a)
C
(b)


S
N
B in
C
B in
I
C
v
F m


Pivot
1
2
B_{in}
v
v
F_B
F_B

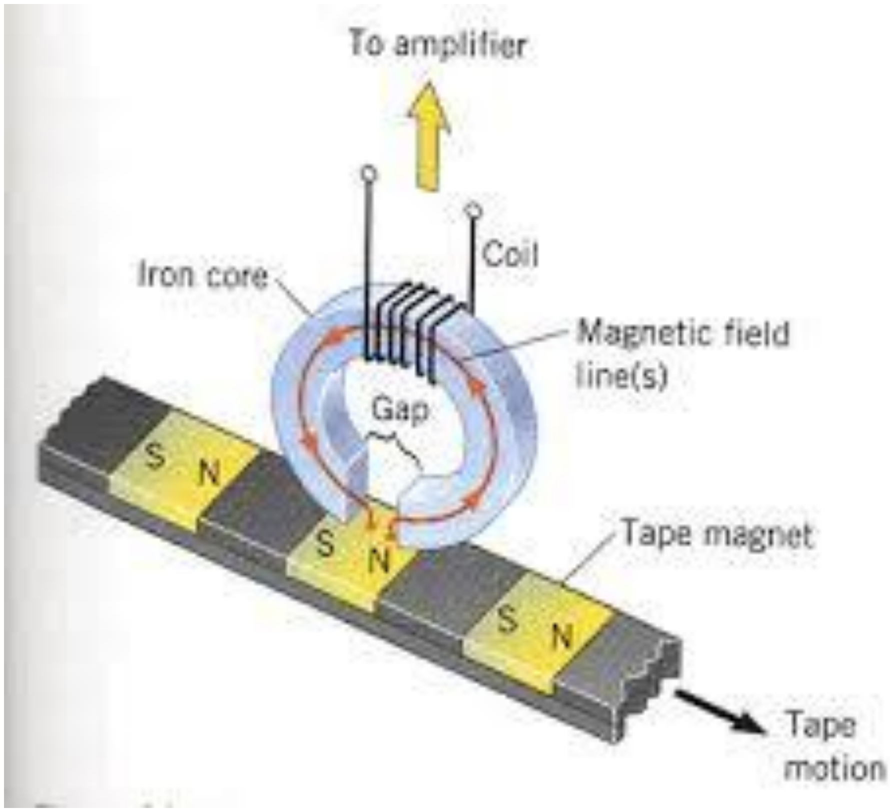
Electric Guitar Strings

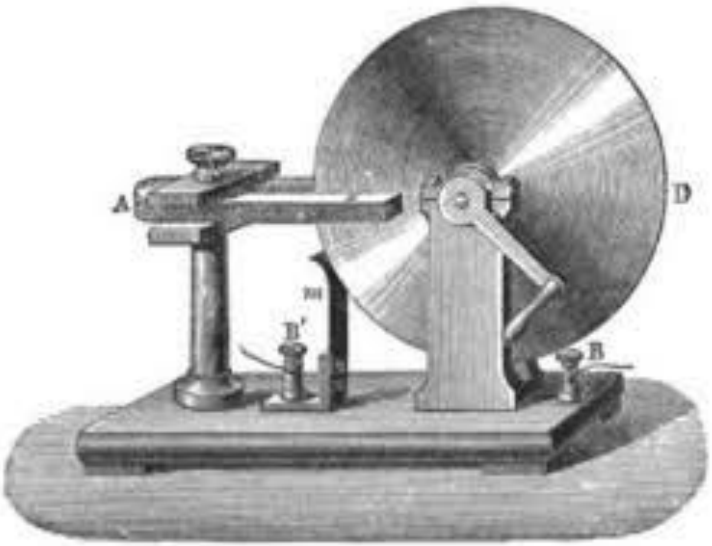


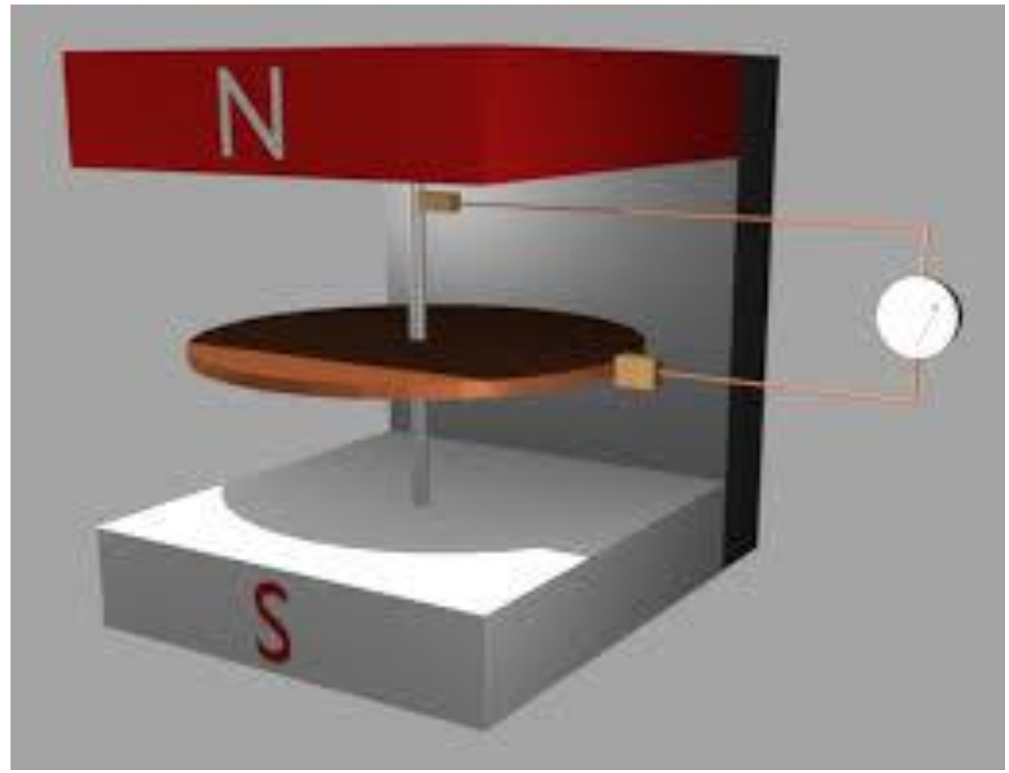

Pickup
coil
Magnet
N
S
N
S
Magnetized
portion of
string
To amplifier
Guitar string

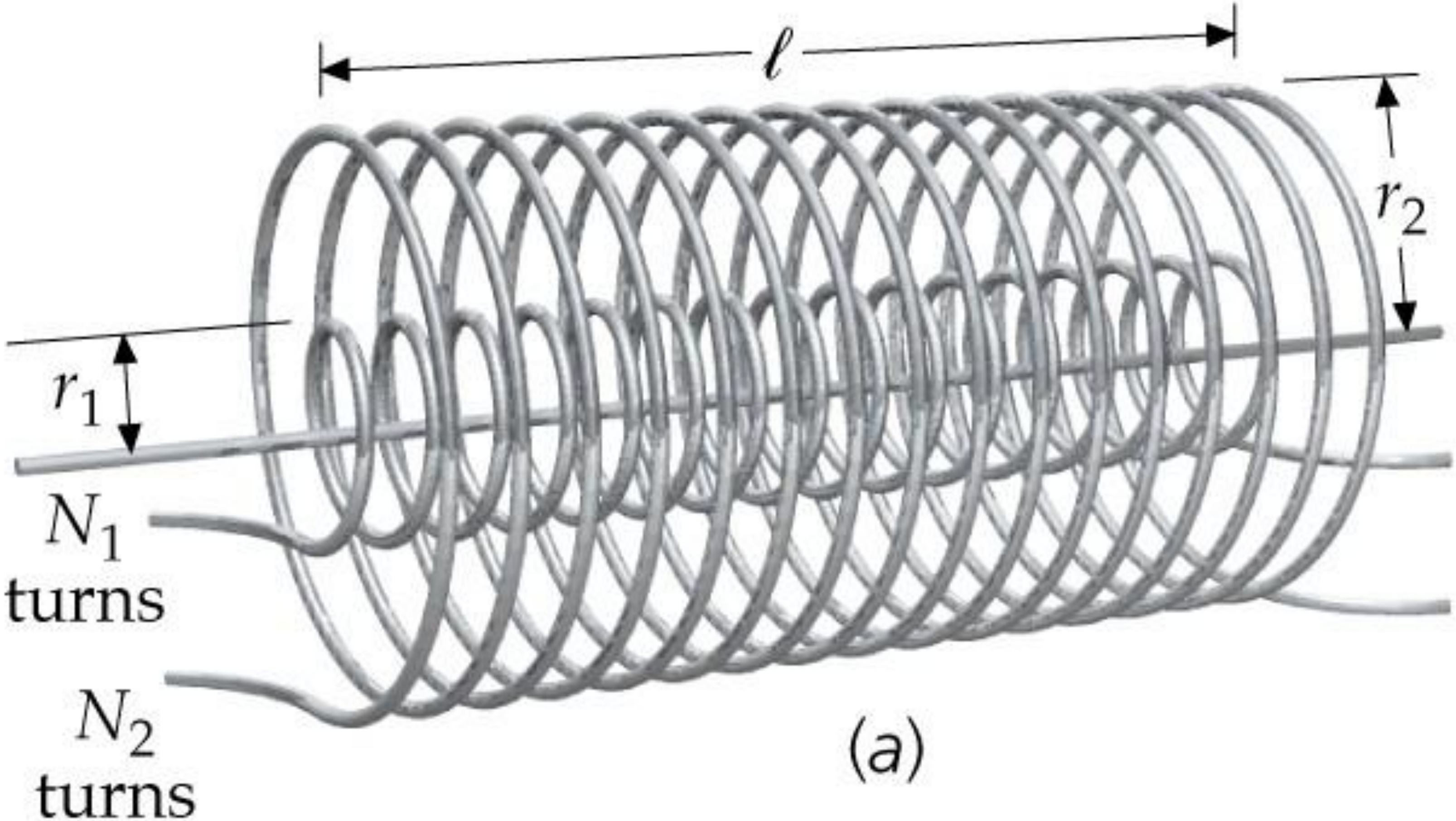
(a)

(b)

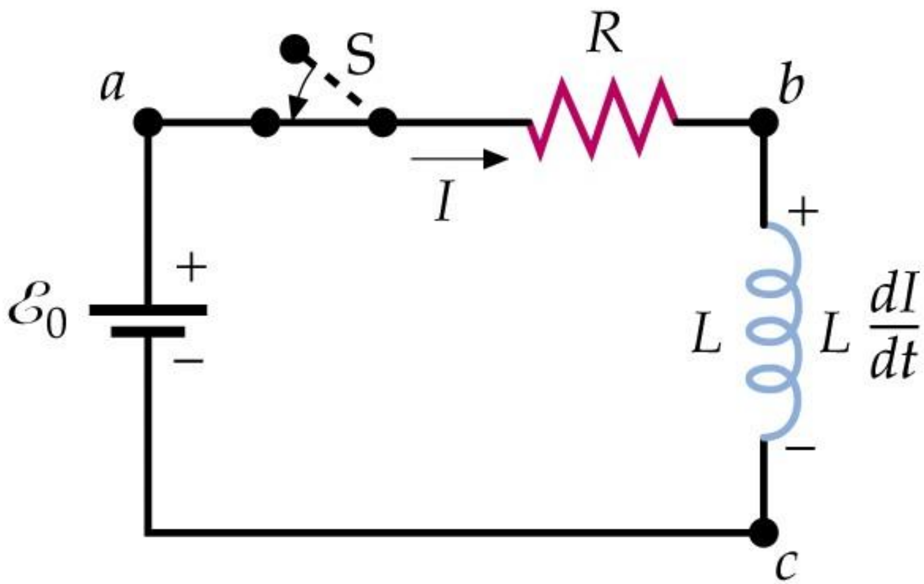

To amplifier
Coil
Iron core
Magnetic field line(s)
Gap
S
N
S
N
S
N
Tape magnet
Tape motion


A
D
m
B'
B

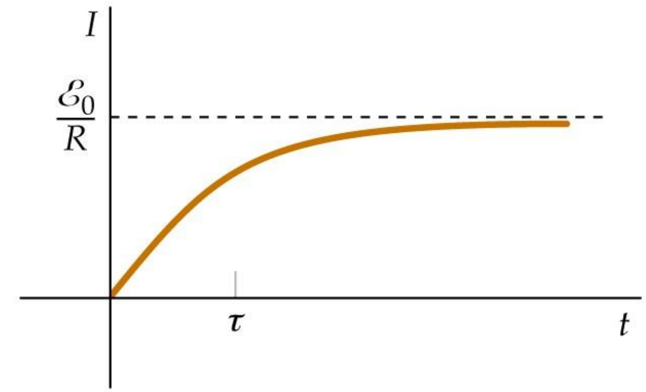

N
S



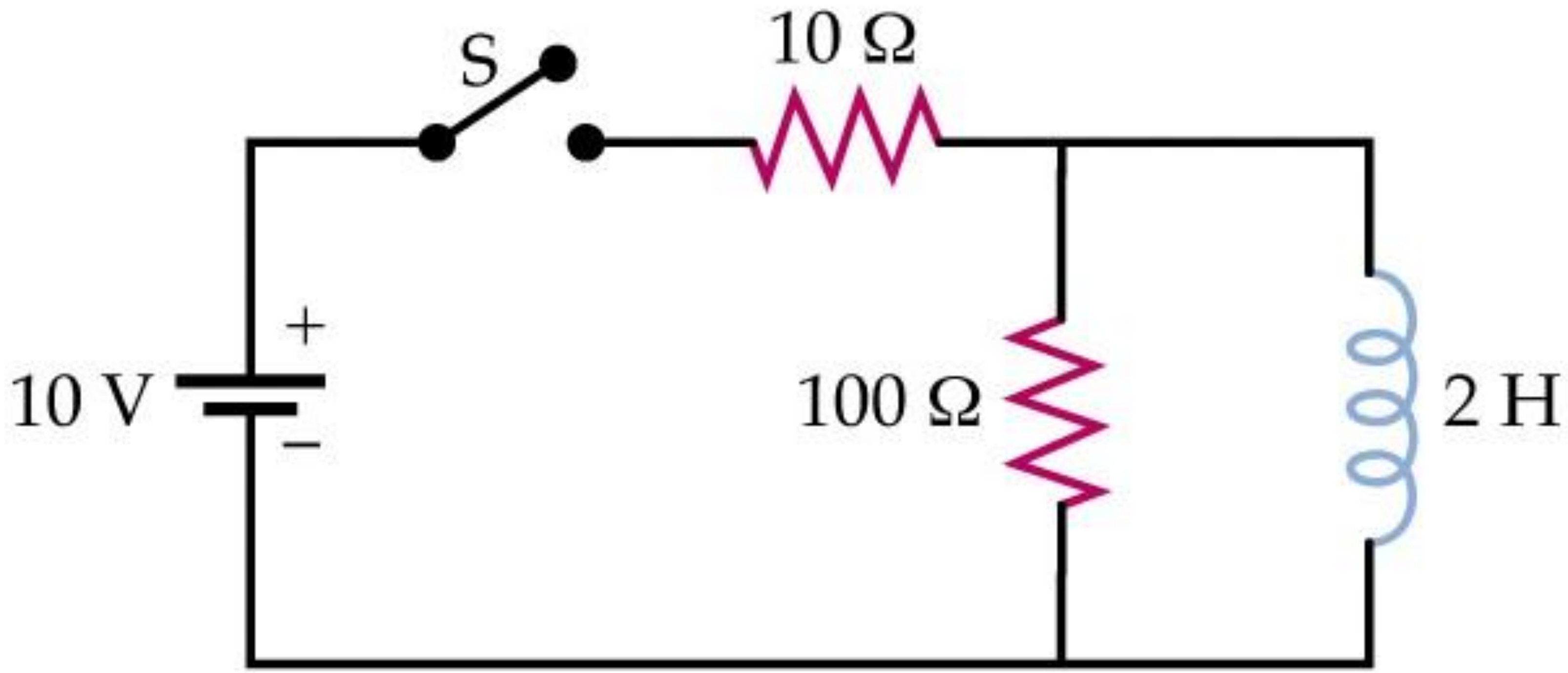
(a)



S
R
a
b
I
+
$\mathcal{E}_0$
−
+
L
$L\,\frac{dI}{dt}$
−
c



I
$\frac{\mathcal{E}_0}{R}$
τ
t



S
10 Ω
10 V
+
−
100 Ω
2 H