Eletromagnetismo

$$\vec{\nabla}\cdot\vec{D}=\rho$$

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

$$\vec{\nabla}\cdot\vec{B}=0$$

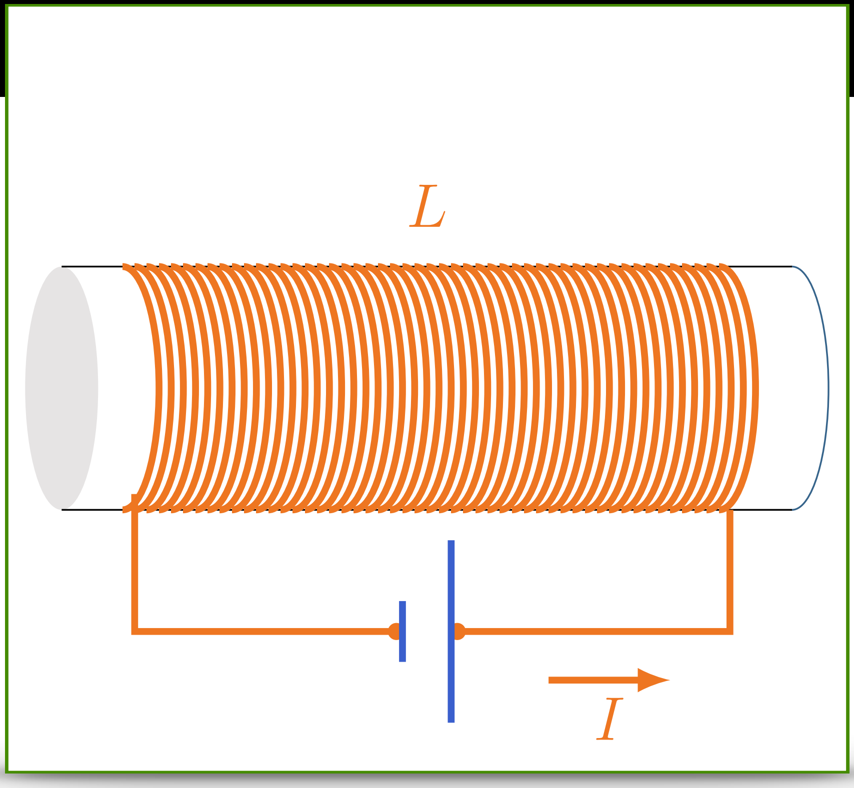
$$\vec{\nabla}\times\vec{H}=\vec{j}+\frac{\partial\vec{D}}{\partial t}$$

21 de julho de 2021

Eletrodinâmica

Pratique o que aprendeu

$$\mathcal{E} = -L\frac{\mathrm{d}I}{\mathrm{d}t}$$



$$B = \mu_0 \frac{N}{\ell} I$$

$$\phi_{1 \text{ espira}} = \mu_0 \frac{N}{\ell} I \mathcal{A}$$

COMO VISTO EM 19 DE JULHO

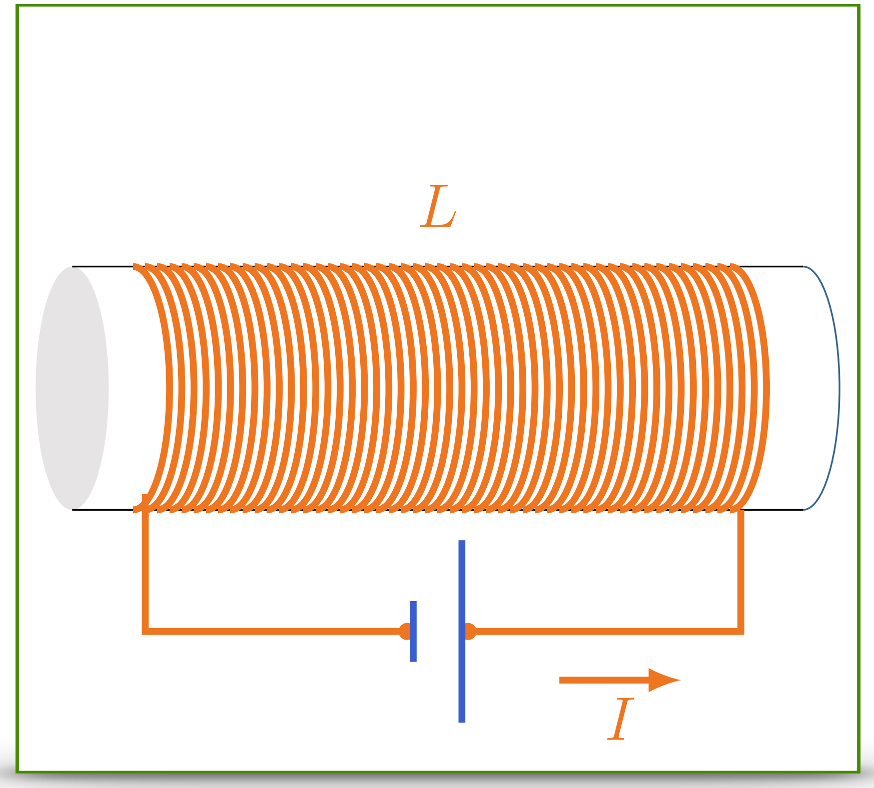
$$\phi = \mu_0 \frac{N^2}{\ell} I \mathcal{A}$$

$$\mathcal{E} = -\mu_0 \frac{N^2}{\ell} \mathcal{A} \frac{\mathrm{d}I}{\mathrm{d}t} \qquad \Rightarrow \quad L = \mu_0 \left(\frac{N}{\ell}\right)^2 \mathcal{V}$$

Energia no campo magnético

$$B = \mu_0 \frac{N}{\ell} I$$

$$L = \mu_0 \left(\frac{N}{\ell}\right)^2 \mathcal{V}$$



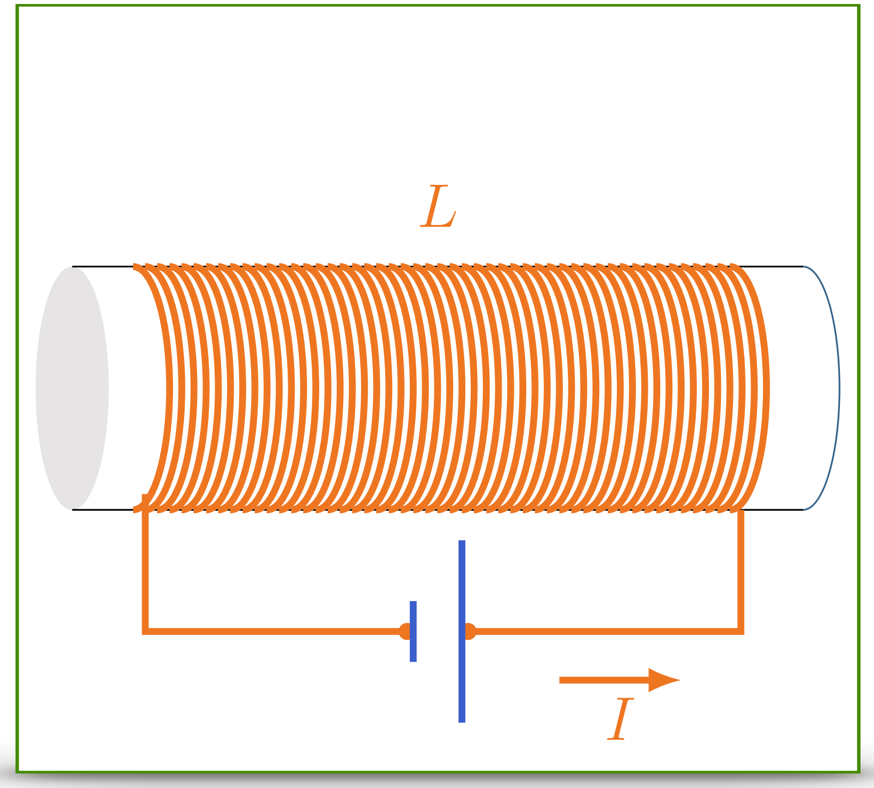
Energia no campo magnético

$$B = \mu_0 \frac{N}{\ell} I$$

$$L = \mu_0 \left(\frac{N}{\ell}\right)^2 \mathcal{V}$$

$$\mathcal{E} = -L \frac{\mathrm{d}I}{\mathrm{d}t}$$

DIFERENÇA DE POTENCIAL ENTRE OS TERMINAIS DO INDUTOR



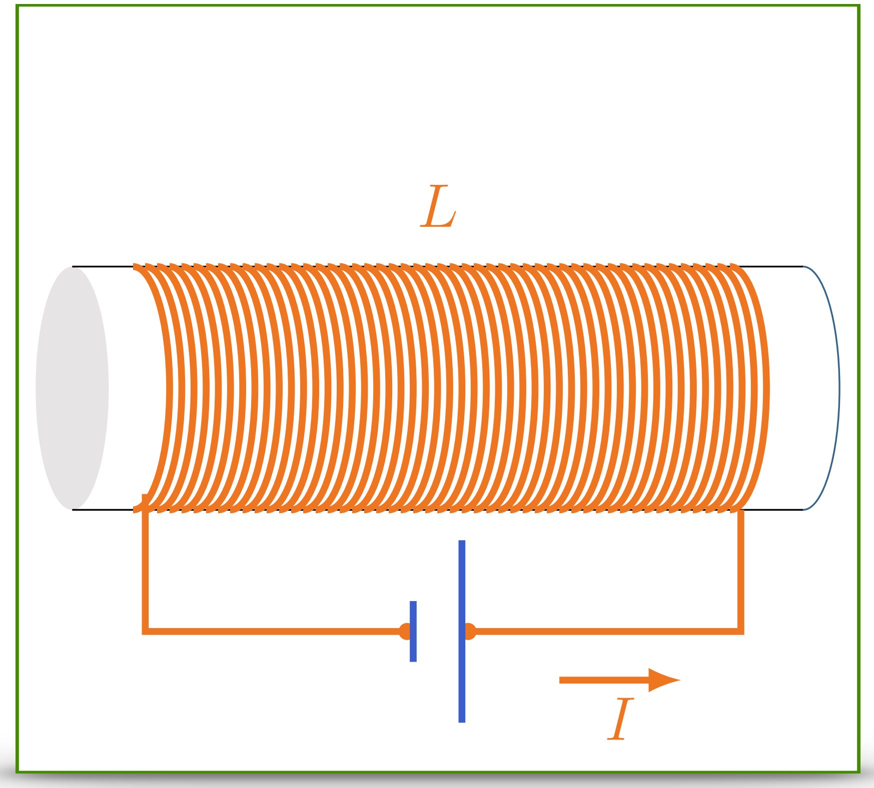
Energia no campo magnético

$$B = \mu_0 \frac{N}{\ell} I$$

$$L = \mu_0 \left(\frac{N}{\ell}\right)^2 \mathcal{V}$$

$$\mathcal{E} = -L \frac{\mathrm{d}I}{\mathrm{d}t}$$

$$P = \mathcal{E} I$$ → POTÊNCIA DISPENDIDA PELA BATERIA
É
GANHA PELO INDUTOR



Energia no campo magnético

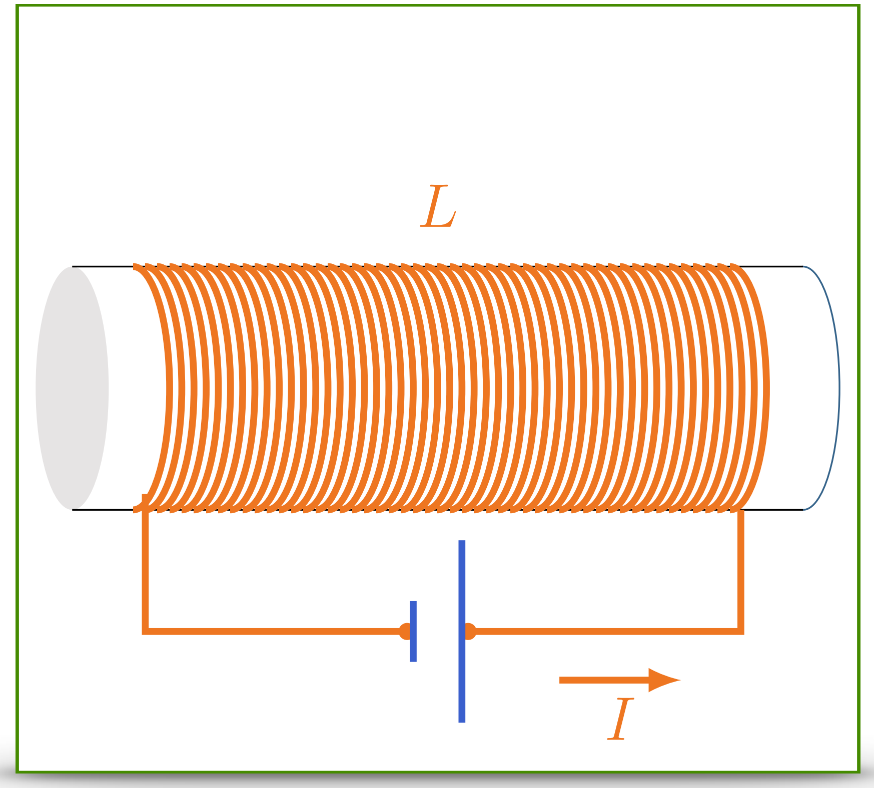
$$B = \mu_0 \frac{N}{\ell} I$$

$$L = \mu_0 \left(\frac{N}{\ell}\right)^2 \mathcal{V}$$

$$\mathcal{E} = -L\frac{\mathrm{d}I}{\mathrm{d}t}$$

$$P = \mathcal{E} I$$

$$P = -LI\frac{\mathrm{d}I}{\mathrm{d}t}$$



INDUTOR ESTÁ GANHANDO ENERGIA

SINAL NEGATIVO SOB ÓPTICA DA BATERIA

POTÊNCIA NEGATIVA QUANDO I CRESCE $\left(\frac{dI}{dt} > 0\right)$

POTÊNCIA POSITIVA QUANDO I DIMINUI $\left(\frac{dI}{dt} < 0\right)$

INDUTOR ESTÁ PERDENDO

Energia no campo magnético

$$B = \mu_0 \frac{N}{\ell} I$$

$$L = \mu_0 \left(\frac{N}{\ell}\right)^2 \mathcal{V}$$

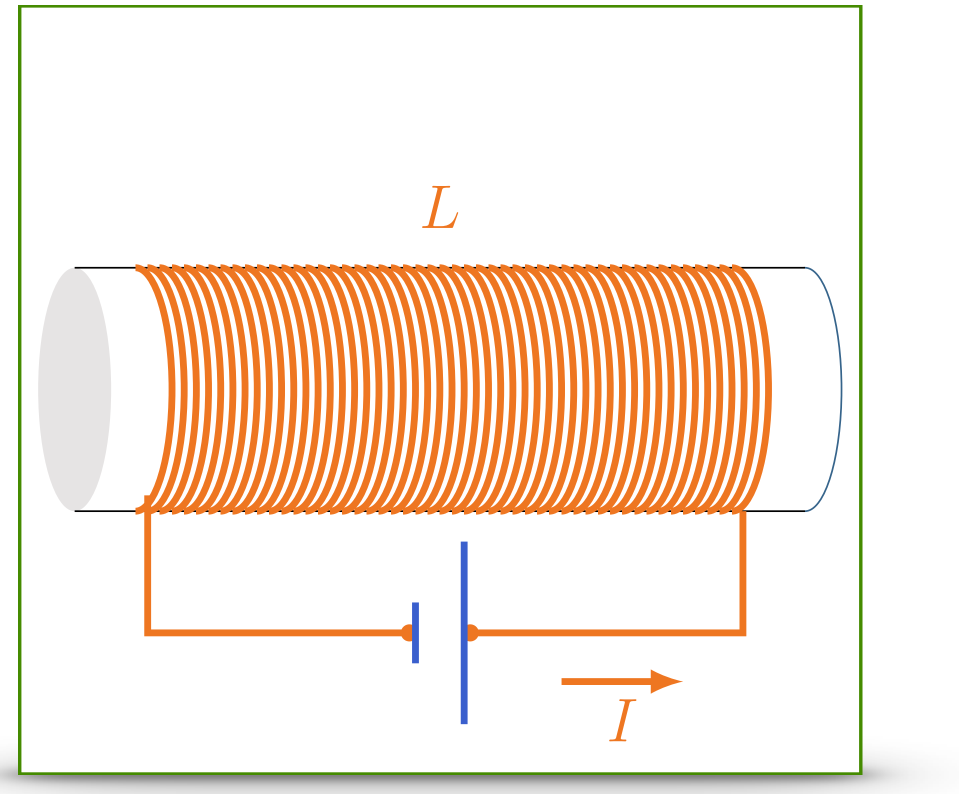
$$\mathcal{E} = -L\frac{\mathrm{d}I}{\mathrm{d}t}$$

$$P = \mathcal{E} I$$

$$P = -LI\frac{\mathrm{d}I}{\mathrm{d}t}$$

$$W = -\int_0^{t_f} LI\frac{\mathrm{d}I}{\mathrm{d}t}\,\mathrm{d}t$$

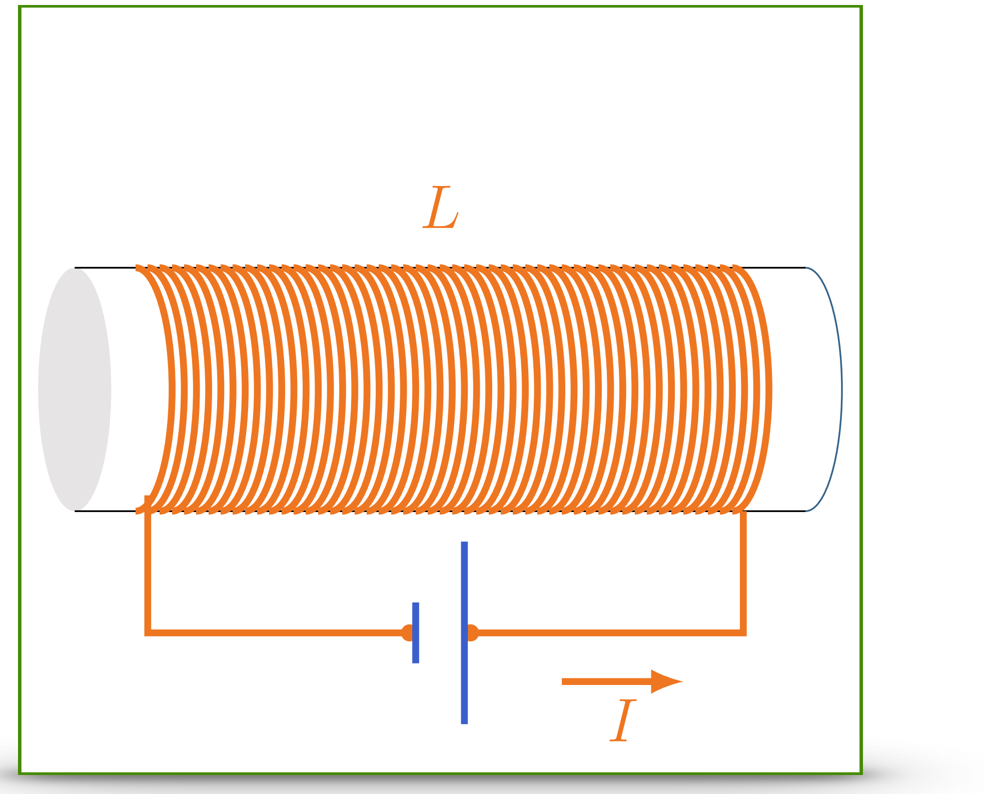
TRABALHO QUE BATERIA PRECISA FAZER PARA ELEVAR CORRENTE NO INDUTOR DE 0 A $I(t_f)$



Energia no campo magnético

$$B = \mu_0 \frac{N}{\ell} I$$

$$L = \mu_0 \left(\frac{N}{\ell}\right)^2 \mathcal{V}$$



$$\mathcal{E} = -L\frac{\mathrm{d}I}{\mathrm{d}t}$$

$$P = \mathcal{E} I$$

$$P = -LI\frac{\mathrm{d}I}{\mathrm{d}t}$$

$$W = -\int_0^{t_f} LI \underbrace{\frac{\mathrm{d}I}{\mathrm{d}t}\,\mathrm{d}t}_{dI}$$

$$U = L\frac{I_f^2}{2}$$

ENERGIA ARMAZENADA NO INDUTOR

Energia no campo magnético

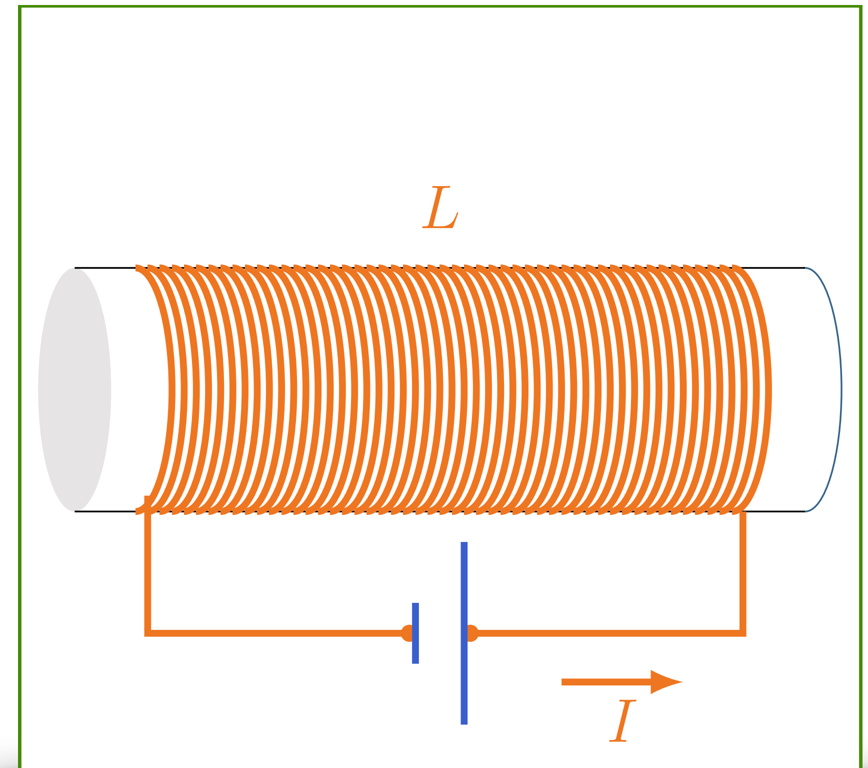
$$B = \mu_0 \frac{N}{\ell} I$$

$$L = \mu_0 \left(\frac{N}{\ell}\right)^2 \mathcal{V}$$

$$U = L\frac{I_f^2}{2}$$

$$U = \mu_0 \left(\frac{N}{\ell}\right)^2 \frac{I^2}{2} \mathcal{V}$$

$$\frac{U}{\mathcal{V}} = \frac{1}{2\mu_0} B^2$$



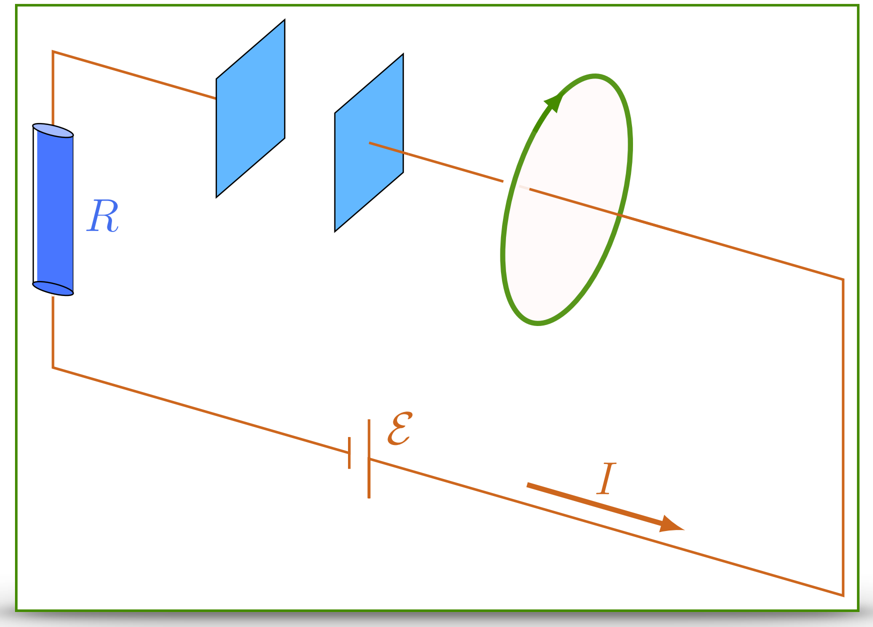
ENERGIA POR UNIDADE DE VOLUME

COMPARE COM CAMPO ELÉTRICO:

$$\frac{u}{v} = \frac{\epsilon_0 E^2}{2}$$

Correção na lei de Ampère

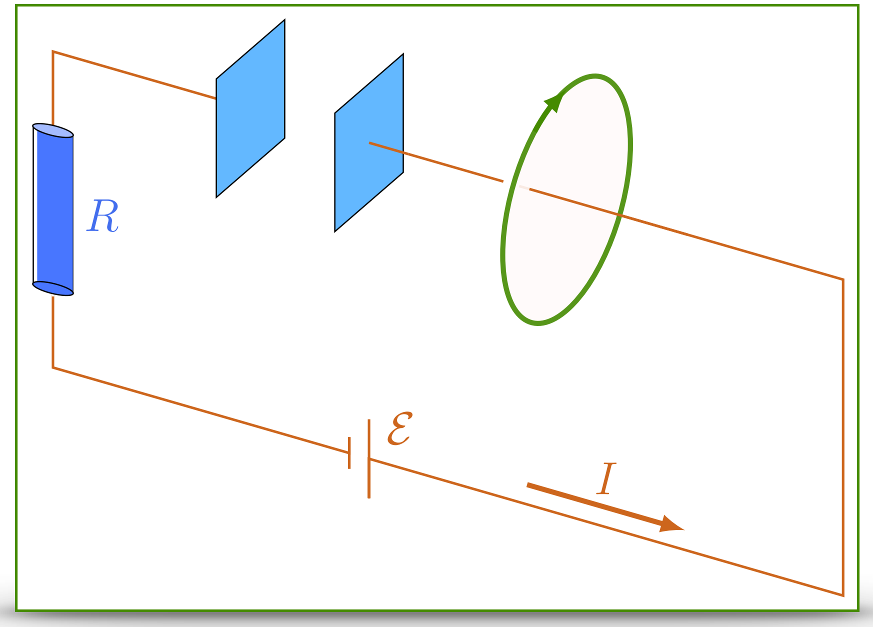
$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$



Correção na lei de Ampère

$$\vec{\boldsymbol{\nabla}} \times \vec{B} = \mu_0 \vec{J}$$

$$\vec{\boldsymbol{\nabla}} \cdot \vec{\boldsymbol{\nabla}} \times \vec{B} = \mu_0 \vec{\boldsymbol{\nabla}} \cdot \vec{J}$$



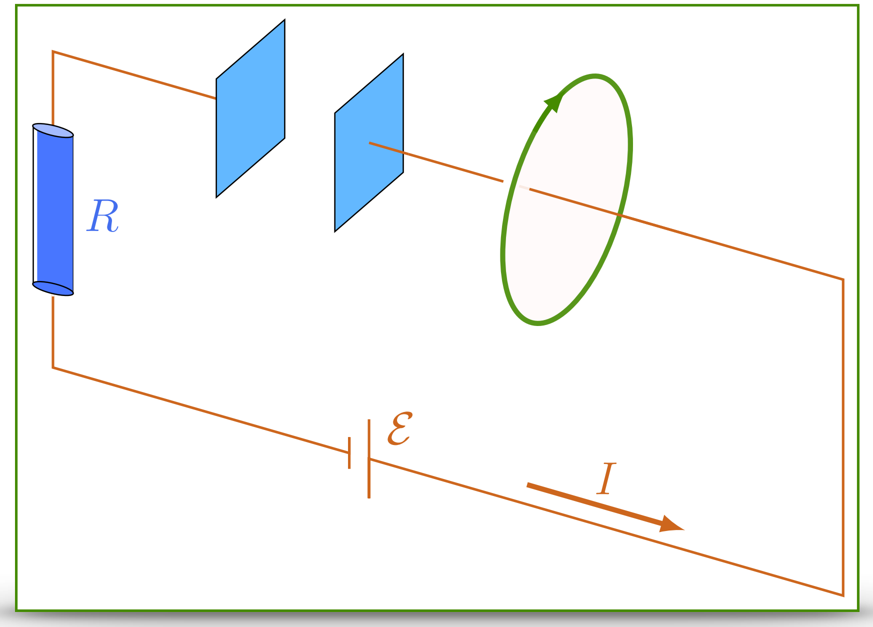
Correção na lei de Ampère

$$\vec{\boldsymbol{\nabla}} \times \vec{B} = \mu_0 \vec{J}$$

$$\vec{\boldsymbol{\nabla}} \cdot \vec{\boldsymbol{\nabla}} \times \vec{B} = \mu_0 \vec{\boldsymbol{\nabla}} \cdot \vec{J}$$

$$0 = \mu_0 \left(- \frac{\partial \rho}{\partial t} \right)$$

ABSURDO, PORQUE NADA IMPEDE ρ DE AUMENTAR OU DIMINUIR

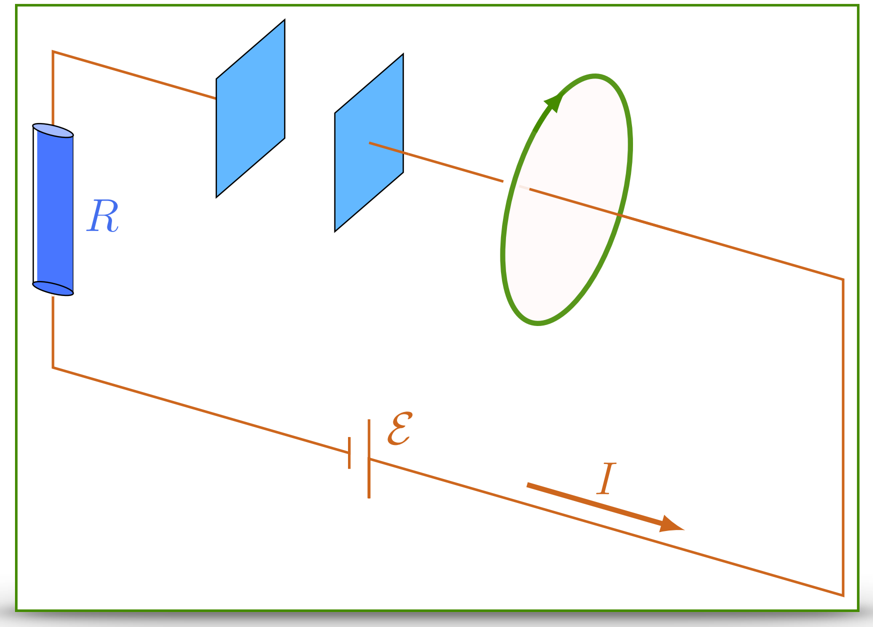


Correção na lei de Ampère

$$\vec{\boldsymbol{\nabla}} \times \vec{B} = \mu_0 \vec{J}$$

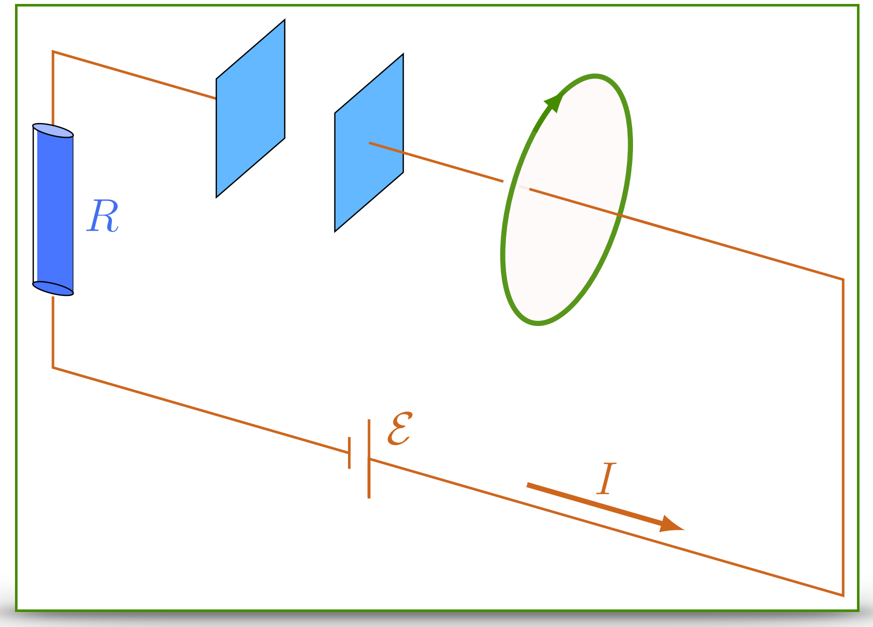
$$\vec{\boldsymbol{\nabla}} \cdot \vec{\boldsymbol{\nabla}} \times \vec{B} = \mu_0 \vec{\boldsymbol{\nabla}} \cdot \vec{J}$$

¿ $0 = \mu_0 \Big(-\dfrac{\partial \rho}{\partial t} \Big)$?



Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$

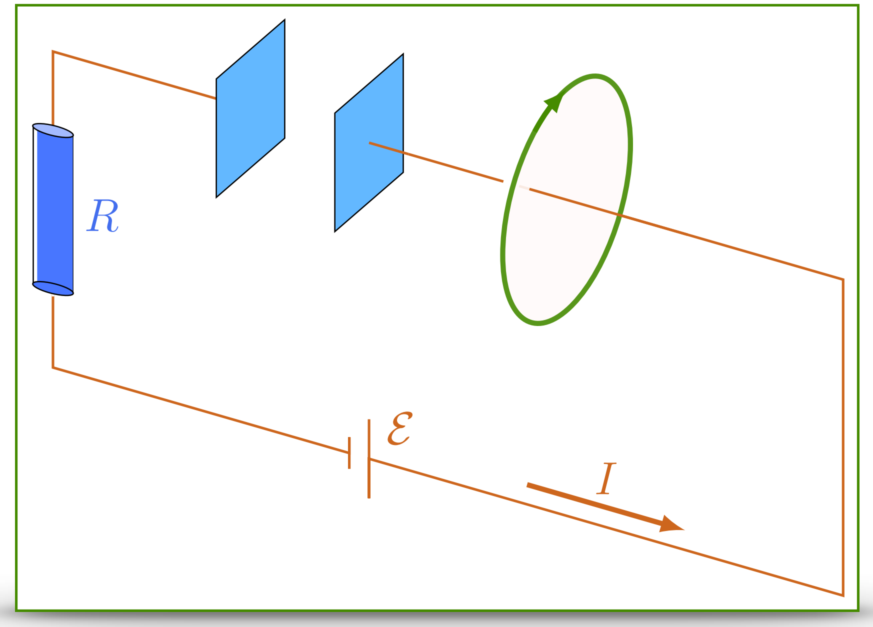


Correção na lei de Ampère

$$\vec{\boldsymbol{\nabla}} \times \vec{B} = \mu_0 \vec{J}$$

$$\vec{\boldsymbol{\nabla}} \times \vec{B} = \mu_0 (\vec{J} + \vec{X})$$

A DETERMINAR

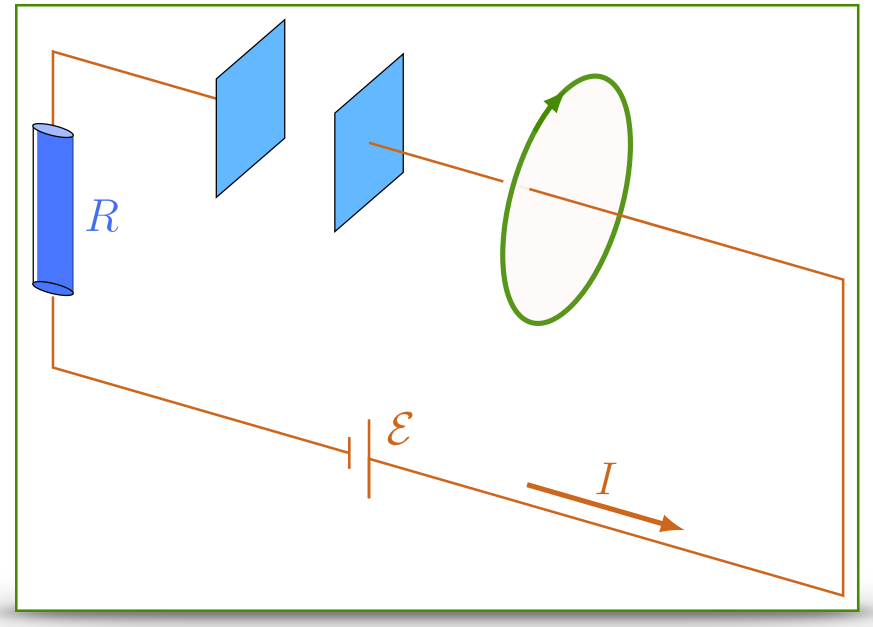


Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$

$$\vec{\nabla} \times \vec{B} = \mu_0 (\vec{J} + \vec{X})$$

$$\vec{\nabla} \cdot \vec{\nabla} \times \vec{B} = \mu_0 (\vec{\nabla} \cdot \vec{J} + \vec{\nabla} \cdot \vec{X})$$



Correção na lei de Ampère

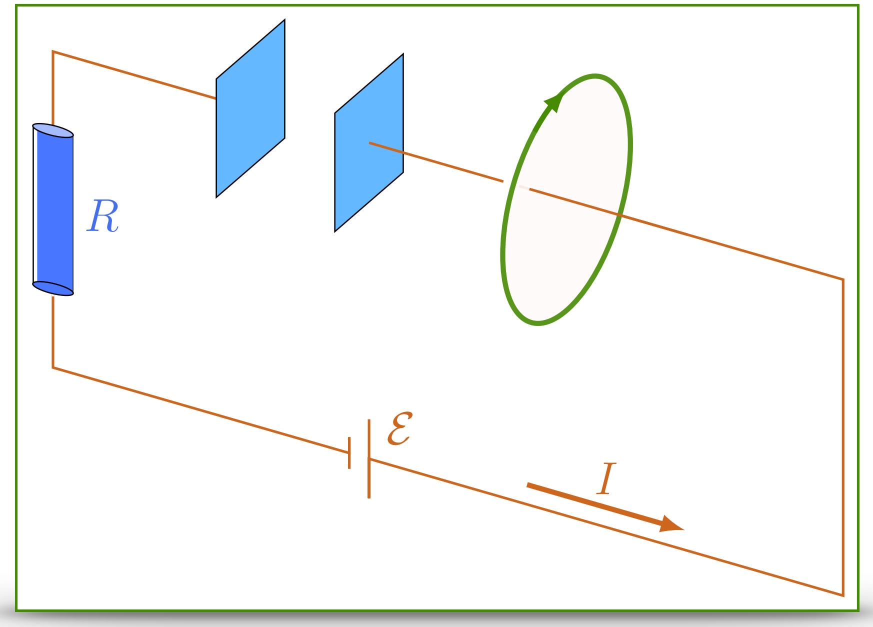
$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$

$$\vec{\nabla} \times \vec{B} = \mu_0 (\vec{J} + \vec{X})$$

$$\vec{\nabla} \cdot \vec{\nabla} \times \vec{B} = \mu_0 (\vec{\nabla} \cdot \vec{J} + \vec{\nabla} \cdot \vec{X})$$

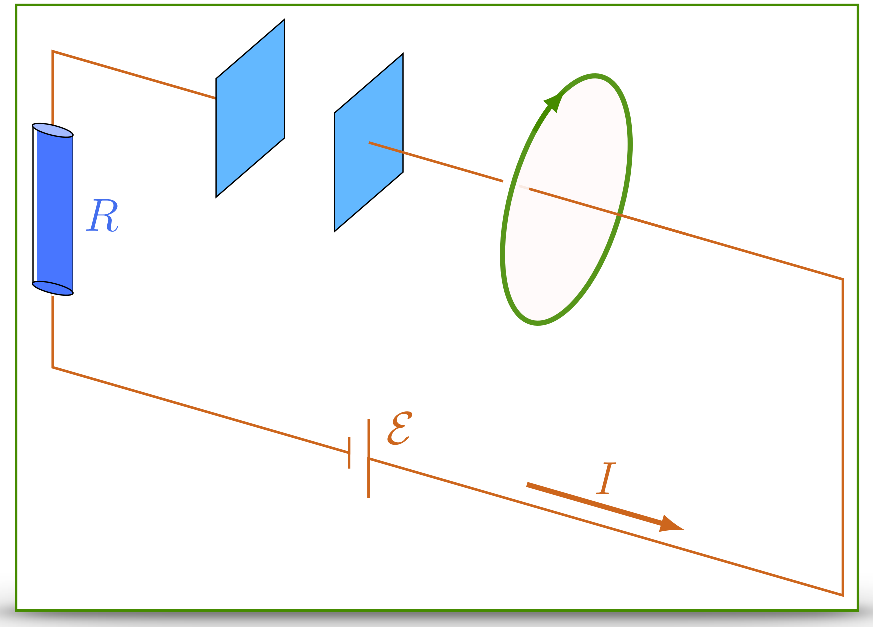
$$0 = -\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{X}$$

(EM LUGAR DE $\frac{\partial \rho}{\partial t} = 0$)



Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$



$$\vec{\nabla} \times \vec{B} = \mu_0 (\vec{J} + \vec{X})$$

$$\vec{\nabla} \cdot \vec{\nabla} \times \vec{B} = \mu_0 (\vec{\nabla} \cdot \vec{J} + \vec{\nabla} \cdot \vec{X})$$

$$0 = -\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{X}$$

$$\frac{\rho}{\epsilon_0} = \vec{\nabla} \cdot \vec{E} \Rightarrow \frac{\partial \rho}{\partial t} = \epsilon_0 \vec{\nabla} \cdot \frac{\partial \vec{E}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{X} = \epsilon_0 \frac{\partial \vec{\nabla} \cdot \vec{E}}{\partial t}$$

Correção na lei de Ampère

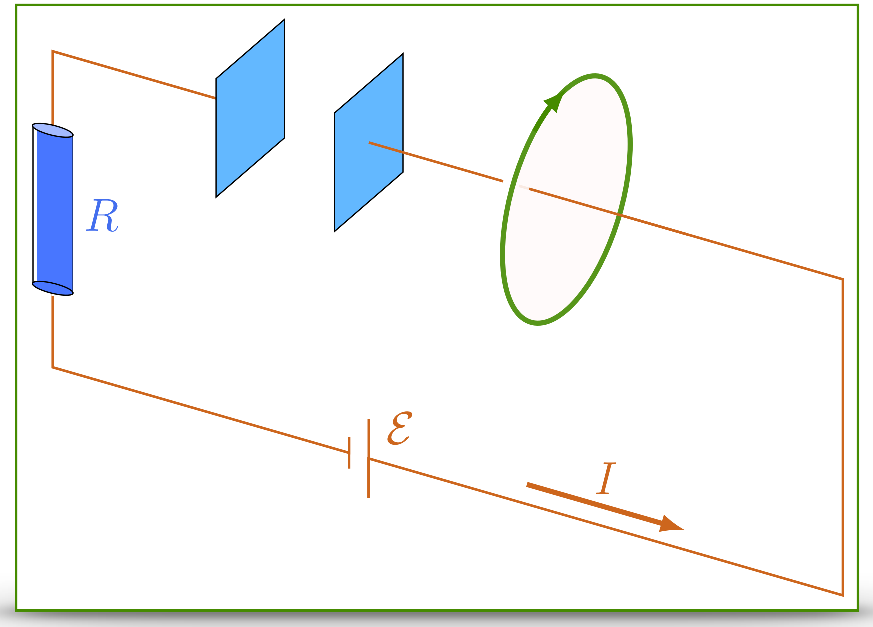
$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$

$$\vec{\nabla} \times \vec{B} = \mu_0 (\vec{J} + \vec{X})$$

$$\vec{\nabla} \cdot \vec{\nabla} \times \vec{B} = \mu_0 (\vec{\nabla} \cdot \vec{J} + \vec{\nabla} \cdot \vec{X})$$

$$0 = -\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{X}$$

$$\vec{\nabla} \cdot \vec{X} = \epsilon_0 \frac{\partial \vec{\nabla} \cdot \vec{E}}{\partial t}$$

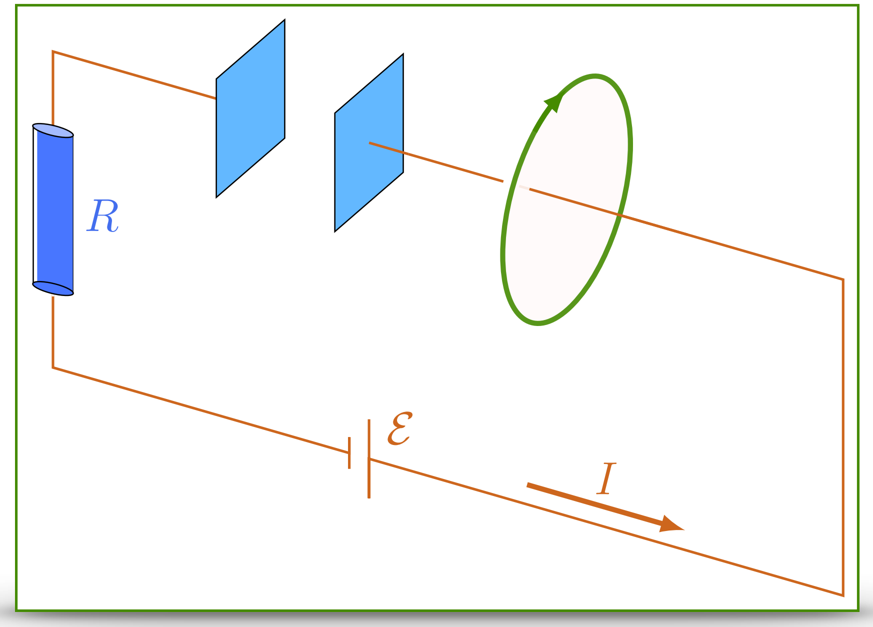


$$\boxed{\vec{\nabla} \times \vec{B} = \mu_0 \left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right)}$$

EQ. AMPÈRE
CORRIGIDA

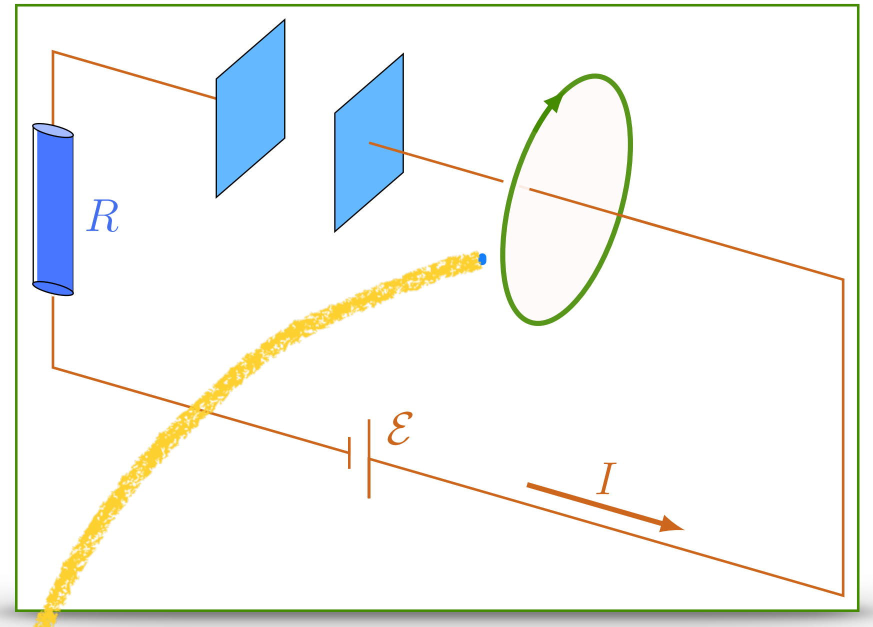
Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0 \left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right)$$



Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0 \left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right)$$



Kirchoff

$$-\frac{q}{C} - RI + \mathcal{E} = 0$$

NA BATERIA

NO RESISTOR

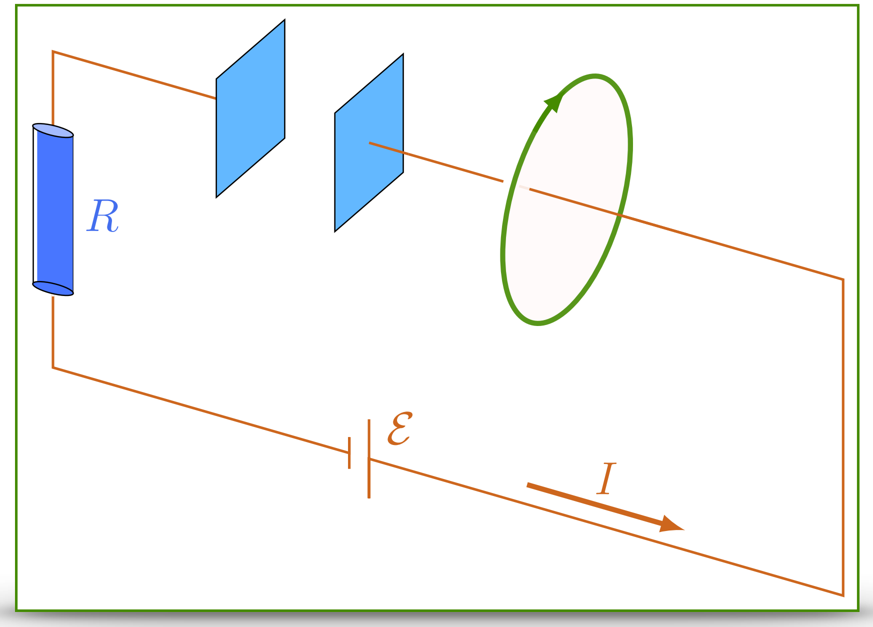
NO CAPACITOR

QUEREMOS CAMPO MAGNÉTICO AQUI.

PARA ISSO, PRECISAMOS DA CORRENTE NO CIRCUITO

Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0 \left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right)$$



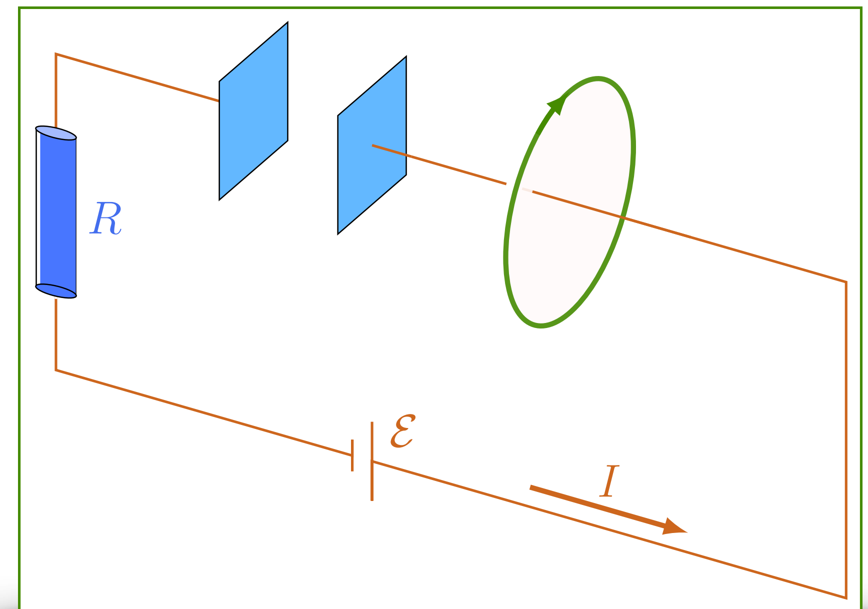
Kirchoff

$$-\frac{q}{C} - RI + \mathcal{E} = 0$$

$$R\frac{\mathrm{d}q}{\mathrm{d}t} + \frac{q}{C} = \mathcal{E}$$

Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0\left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t}\right)$$



Kirchoff

$$-\frac{q}{C} - RI + \mathcal{E} = 0$$

$$R\frac{\mathrm{d}q}{\mathrm{d}t} + \frac{q}{C} = \mathcal{E}$$

EDO

CONDIÇÃO INICIAL: $q(0)=0$

SOL. EQ. Ñ HOMOGÊNEA:

- $q = C\mathcal{E}$

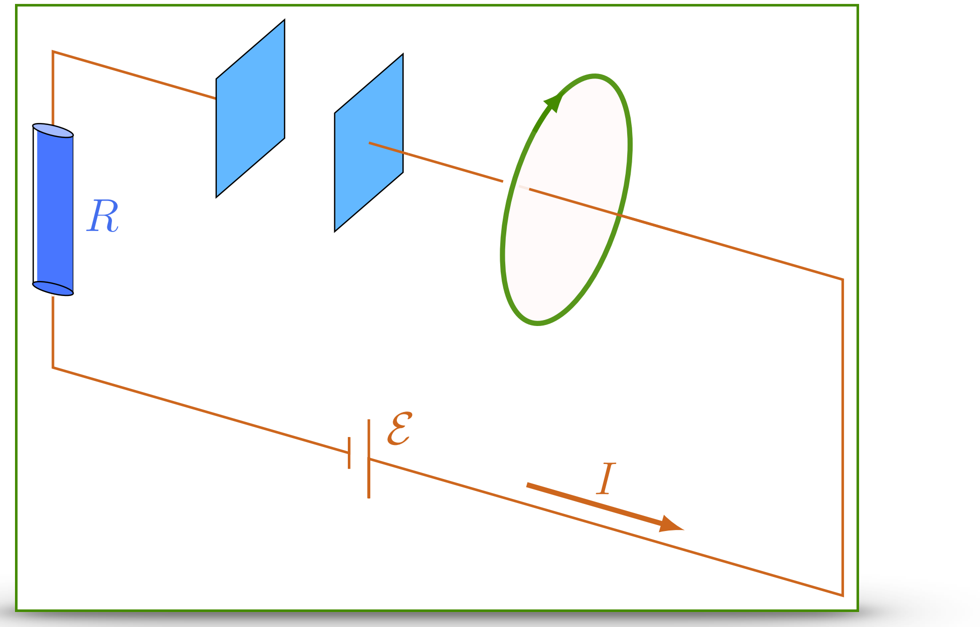
SOL. EQ. HOMOGÊNEA

- $q = \alpha e^{-t/RC}$

$$q(t) = \mathcal{E}C\left(1 - e^{\frac{-t}{RC}}\right)$$

Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0\left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t}\right)$$



Kirchoff

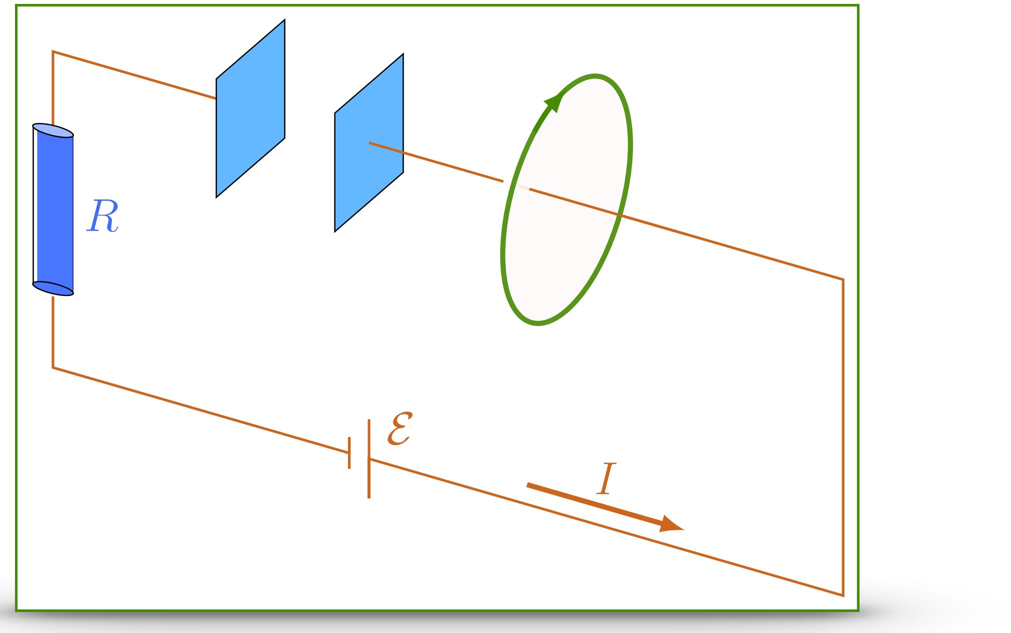
$$-\frac{q}{C} - RI + \mathcal{E} = 0$$

$$R\frac{\mathrm{d}q}{\mathrm{d}t} + \frac{q}{C} = \mathcal{E}$$

$$q(t) = \mathcal{E}C\left(1 - e^{\frac{-t}{RC}}\right) \Longrightarrow I(t) = \frac{\mathcal{E}}{R}e^{\frac{-t}{RC}}$$

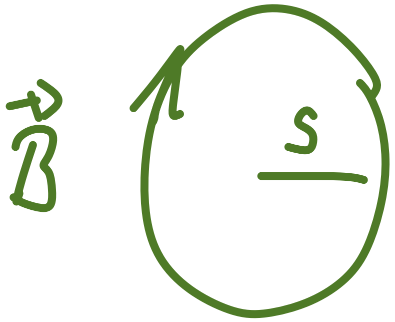
Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0 \left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right)$$



$$q(t) = \mathcal{E} C \left(1 - e^{\frac{-t}{RC}} \right)$$

$$I(t) = \frac{\mathcal{E}}{R} e^{\frac{-t}{RC}}$$



$$\int \vec{B} \cdot d\vec{\ell} = \mu_0 I$$

$$\Downarrow$$

$$B \, 2\pi s = \mu_0 I \implies \boxed{B(t) = \frac{\mu_0}{2\pi s} \frac{\mathcal{E}}{R} e^{-t/RC}}$$

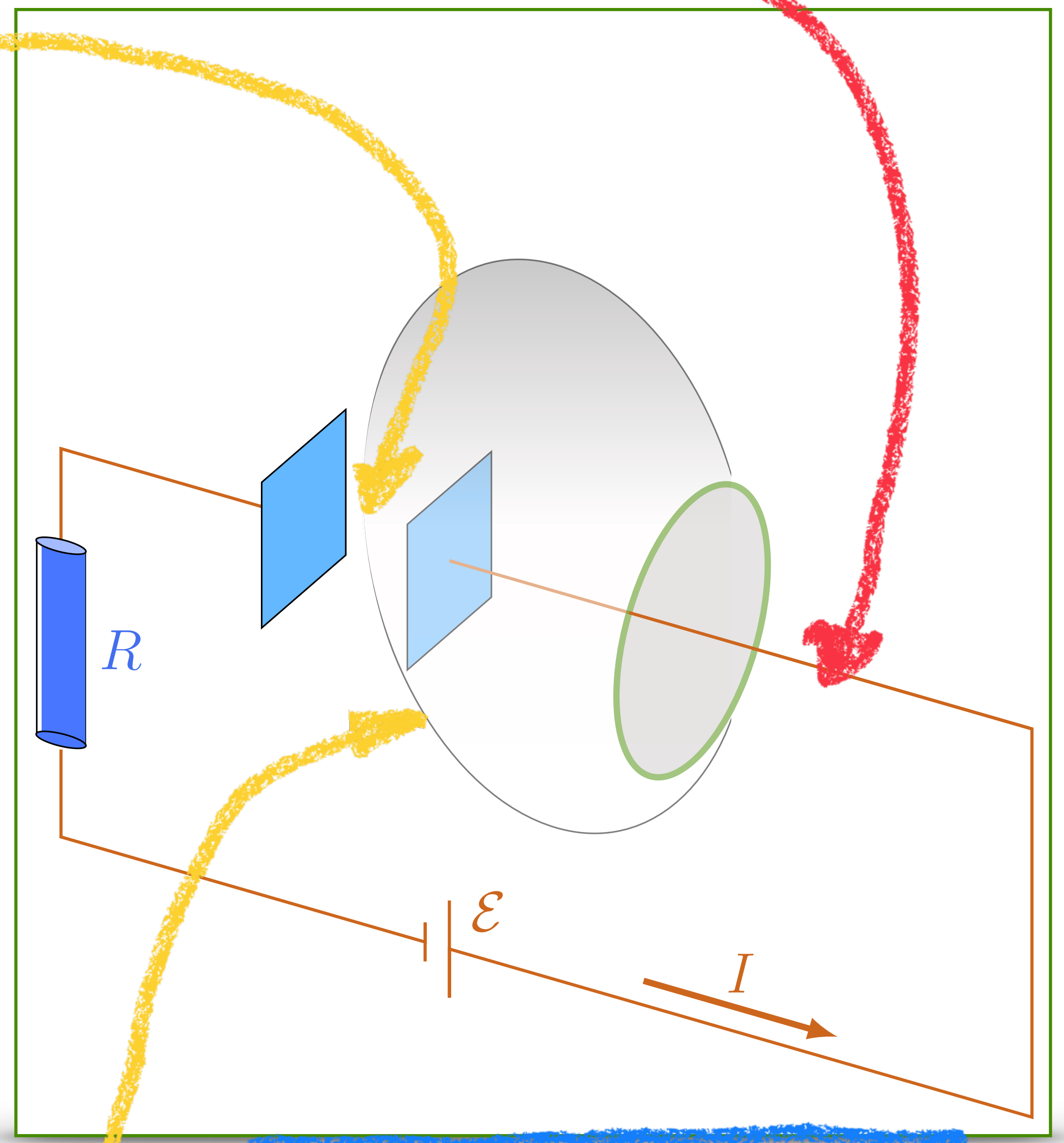
Correção na lei de Ampère

$$\vec{\nabla} \times \vec{B} = \mu_0\left(\vec{J} + \epsilon_0 \frac{\partial \vec{E}}{\partial t}\right)$$

$$q(t) = \mathcal{E}C\left(1 - e^{\frac{-t}{RC}}\right)$$

$$I(t) = \frac{\mathcal{E}}{R} e^{\frac{-t}{RC}}$$

$$\int \vec{B} \cdot d\vec{\ell} = \int \vec{J} \cdot \hat{n}\, da$$



STOKES PERMITE INTEGRAR SOBRE BOLHA

FIO NÃO CRUZA BOLHA, MAS $\frac{\partial \vec{E}}{\partial t}$ CRUZA