Eletromagnetismo

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

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

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

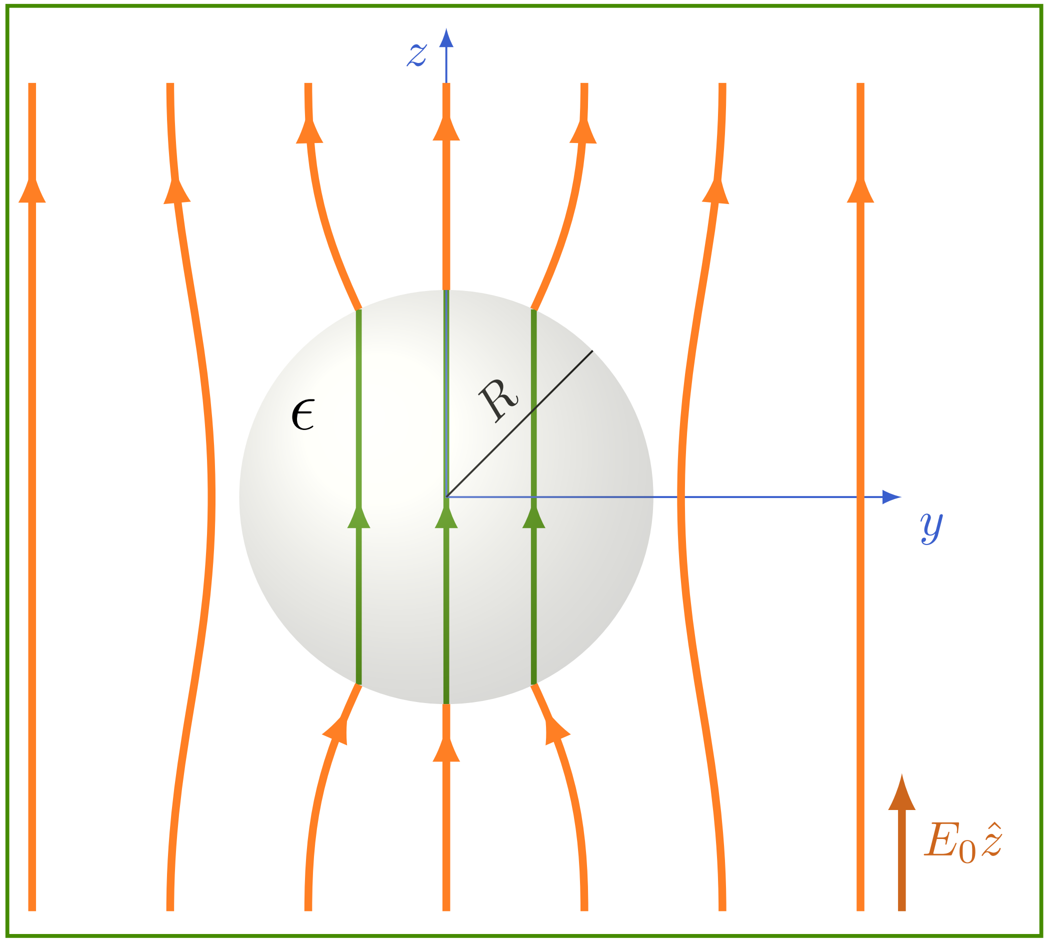
$$\vec{\nabla} \times \vec{H} = \vec{j} + \epsilon_0 \frac{\partial \vec{D}}{\partial t}$$

21 de junho de 2021

Dielétricos

Pratique o que aprendeu

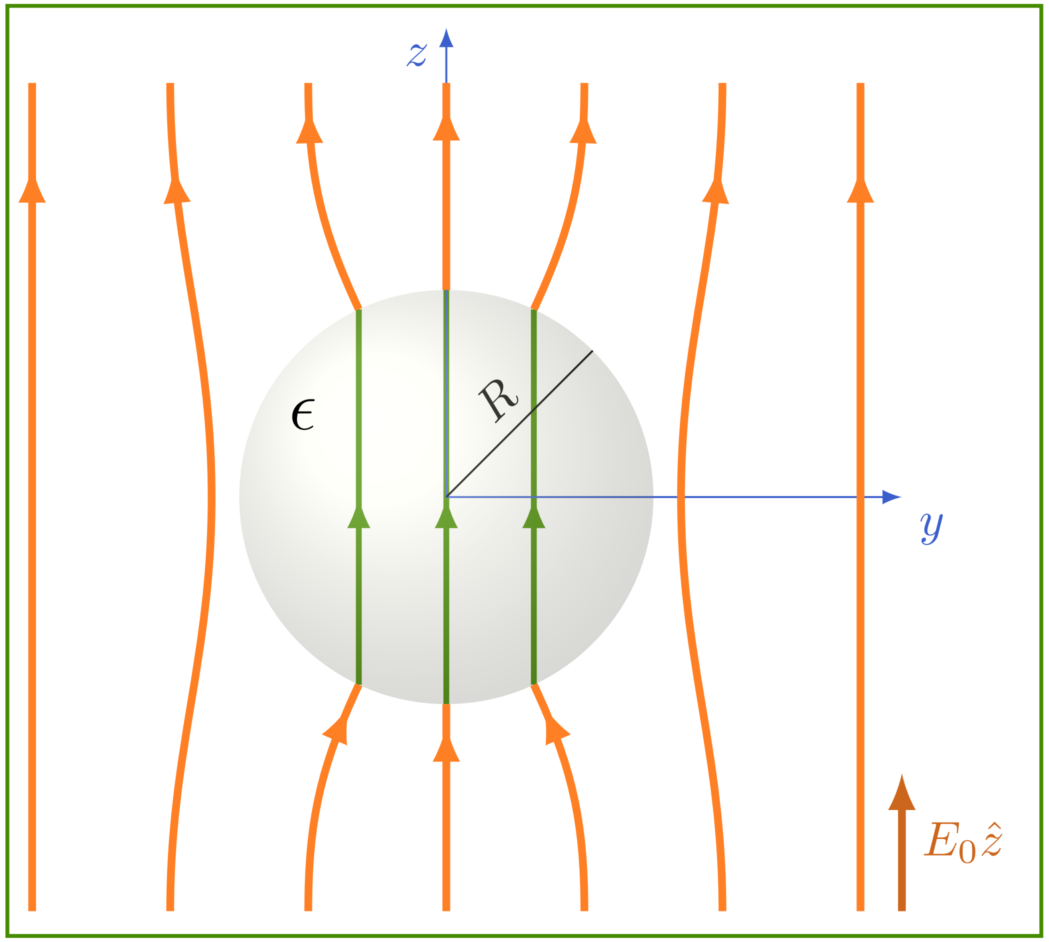
$$\epsilon_b \frac{\partial V_b}{\partial n} = \epsilon_a \frac{\partial V_a}{\partial n} \qquad V_b = V_a$$



Pratique o que aprendeu

$$\epsilon_b \frac{\partial V_b}{\partial n} = \epsilon_a \frac{\partial V_a}{\partial n} \qquad V_b = V_a$$

Condições de contorno



Pratique o que aprendeu

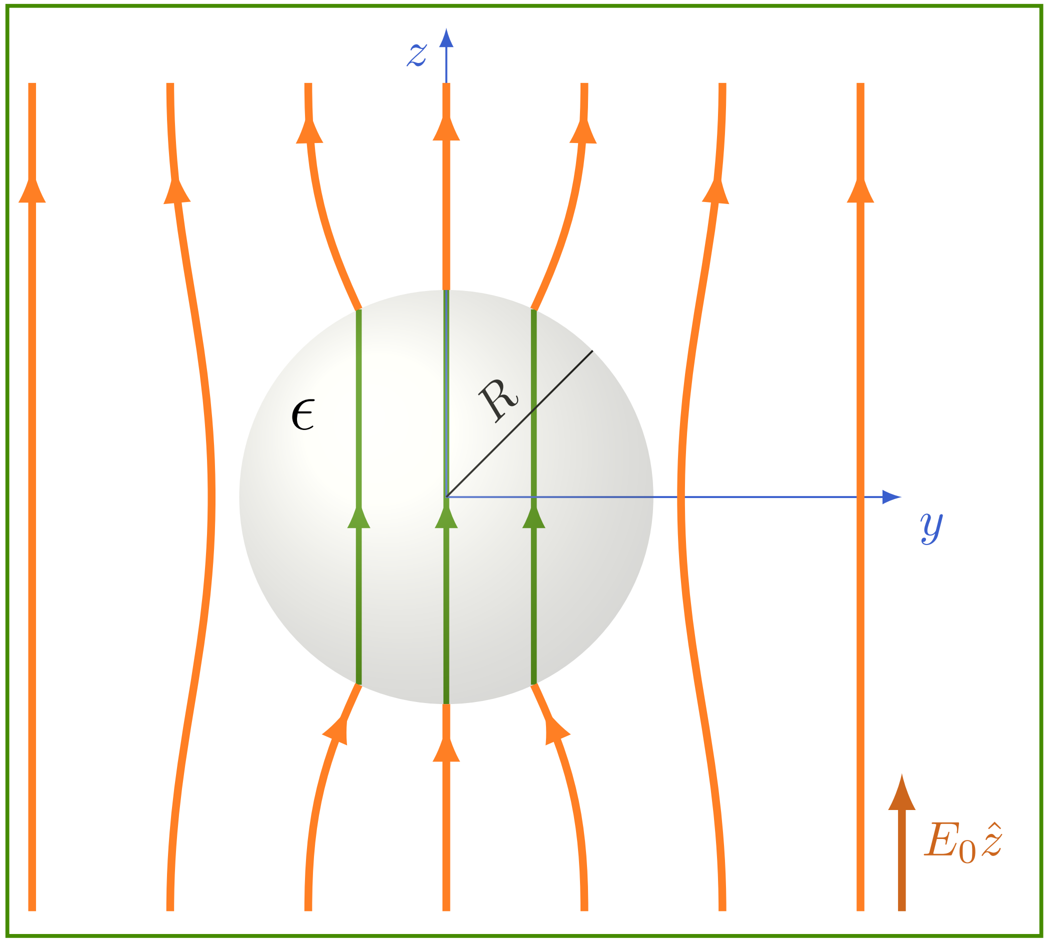
$$\epsilon_b \frac{\partial V_b}{\partial n} = \epsilon_a \frac{\partial V_a}{\partial n} \qquad V_b = V_a$$

Condições de contorno

$$V(r \to \infty) = -E_0 r \cos\theta$$

$$V_d(R) = V_f(R)$$

$$\epsilon \frac{\partial V_d}{\partial n}\Big|_R = \epsilon_0 \frac{\partial V_f}{\partial n}\Big|_R$$



Pratique o que aprendeu

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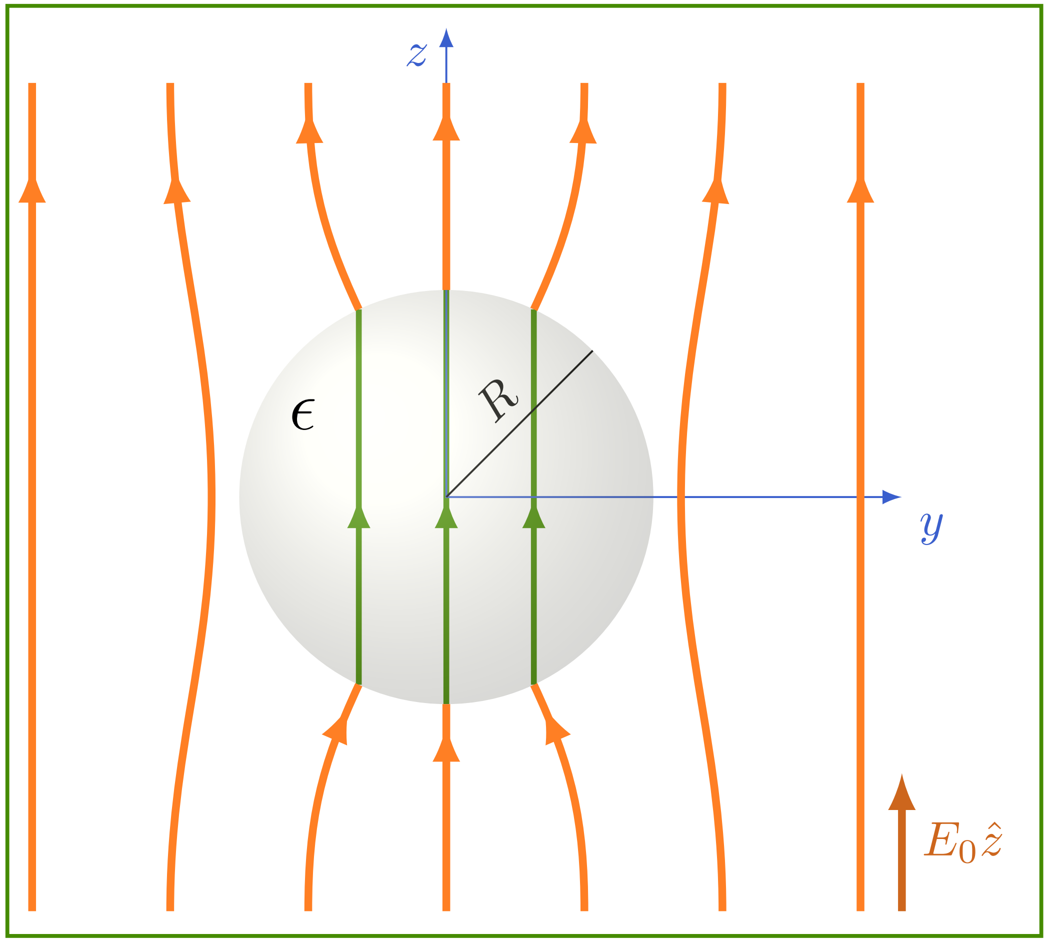


Pratique o que aprendeu

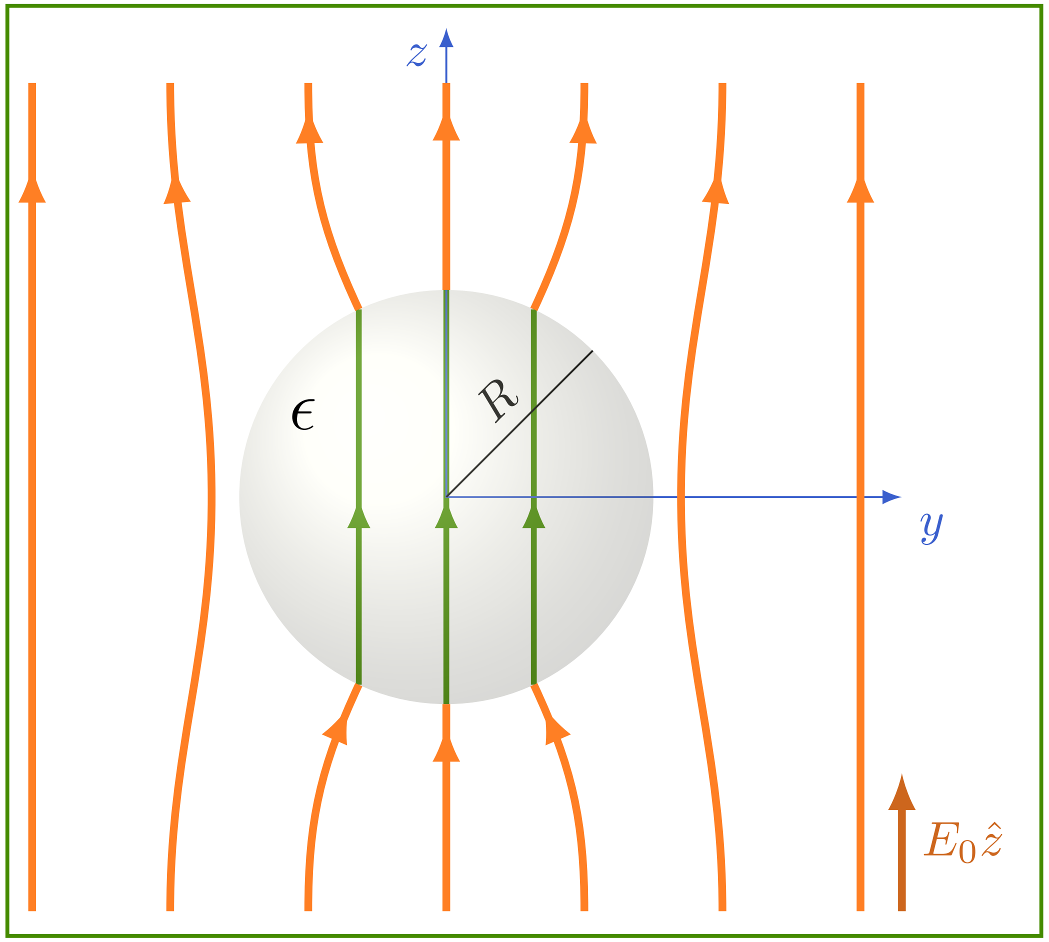
$$\epsilon_b \frac{\partial V_b}{\partial n} = \epsilon_a \frac{\partial V_a}{\partial n} \qquad V_b = V_a$$

Condições de contorno

$$V(r \to \infty) = -E_0 r \cos\theta$$

$$V_d(R) = V_f(R)$$

$$\epsilon \frac{\partial V_d}{\partial n}\bigg|_R = \epsilon_0 \frac{\partial V_f}{\partial n}\bigg|_R$$



$$V(r) = \sum_\ell \left(A_\ell r^\ell + \frac{B_\ell}{r^{\ell+1}}\right) P_\ell(\cos\theta)$$

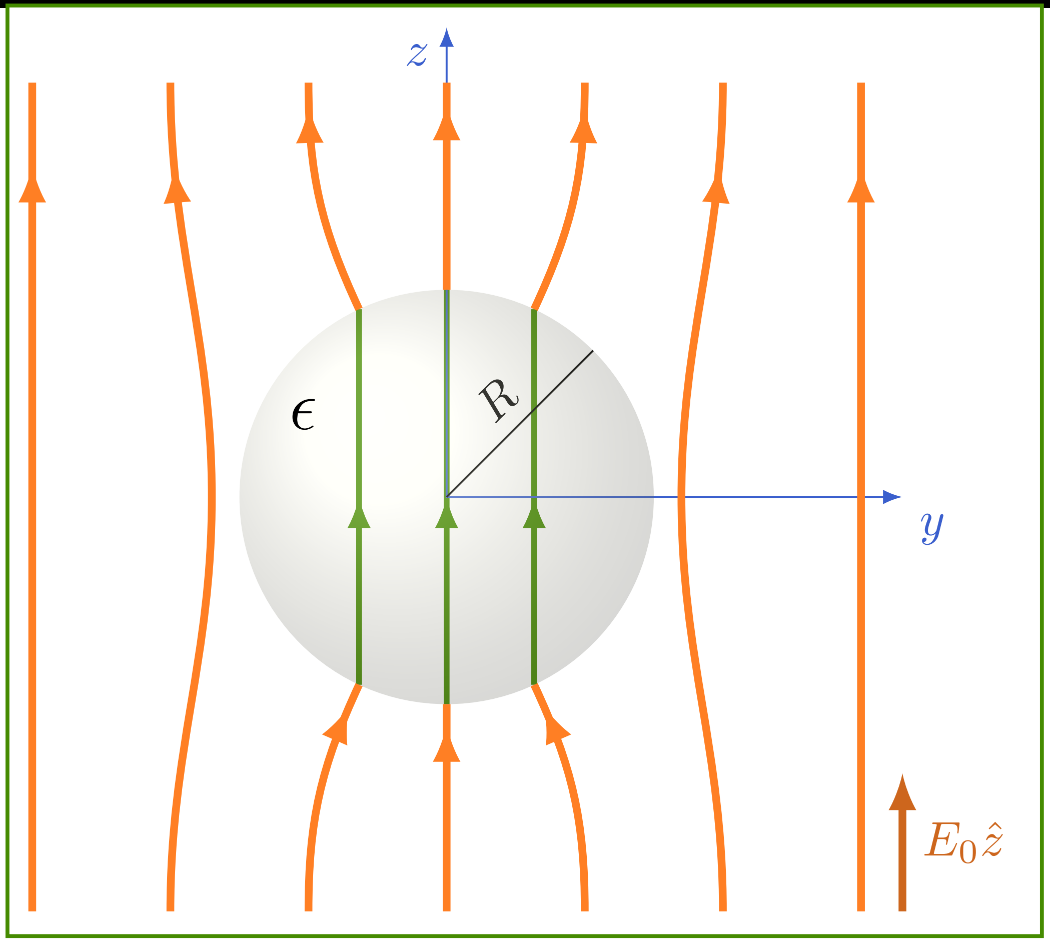
$$r \to \infty \quad \Rightarrow \quad V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

Pratique o que aprendeu

$$V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

$$V_d(R) = V_f(R)$$

$$\epsilon \frac{\partial V_d}{\partial n}\bigg|_R = \epsilon_0 \frac{\partial V_f}{\partial n}\bigg|_R$$



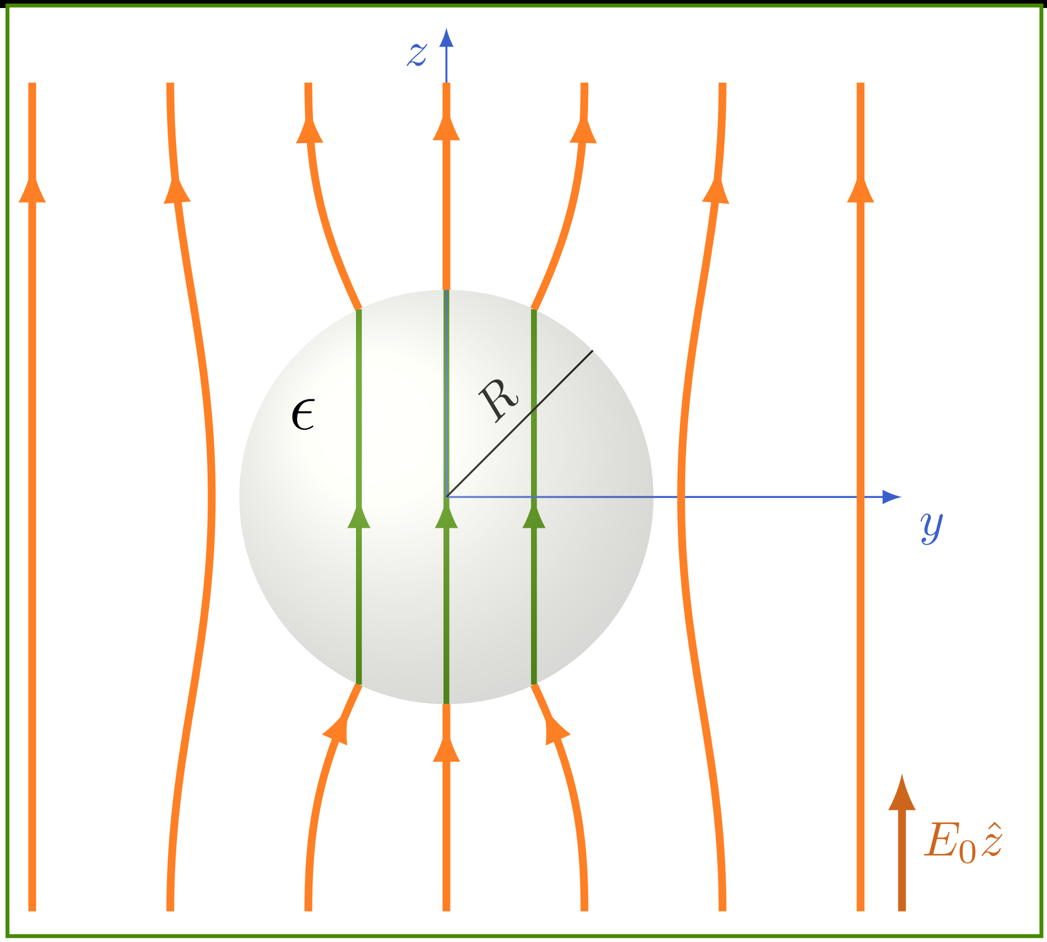
Pratique o que aprendeu

$$V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

$$V_d(R) = V_f(R)$$

$$\epsilon \frac{\partial V_d}{\partial n}\bigg|_R = \epsilon_0 \frac{\partial V_f}{\partial n}\bigg|_R$$

$$V_d(r) = \sum_\ell A_\ell r^\ell P_\ell(\cos\theta)$$

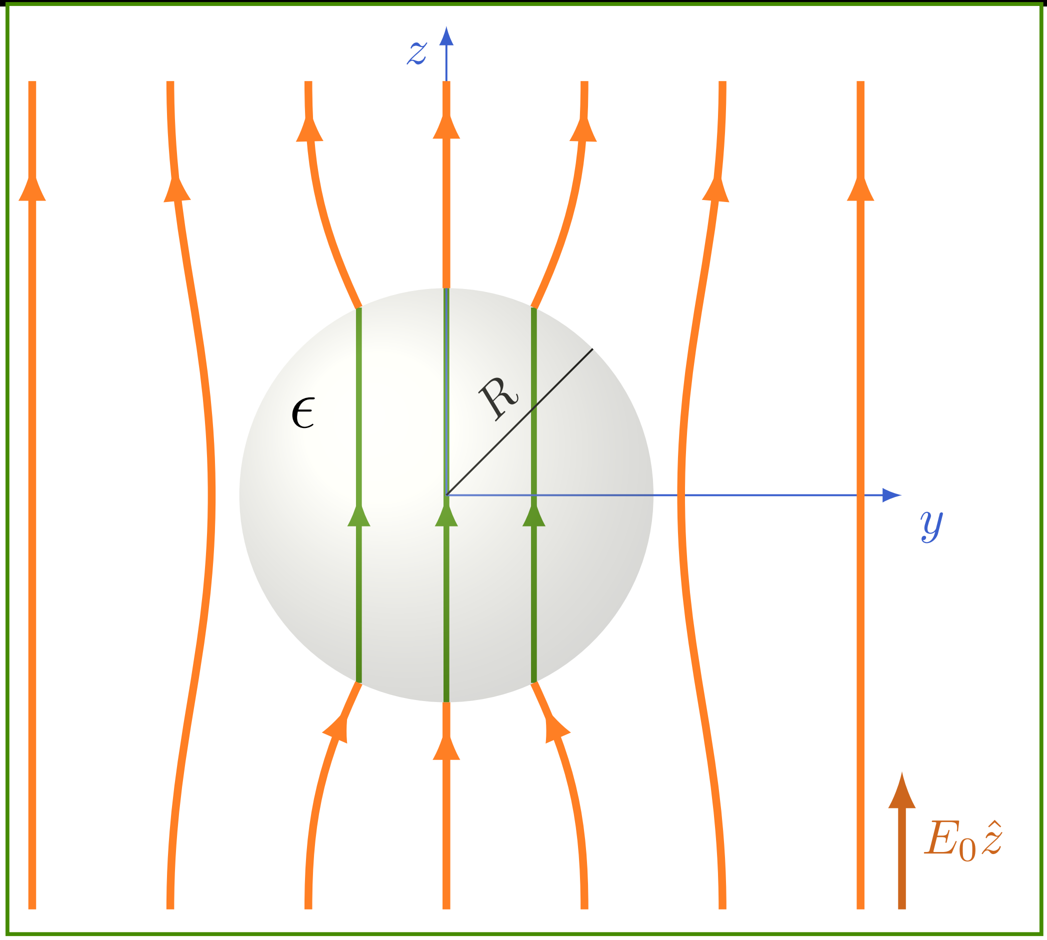


Pratique o que aprendeu

$$V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

$$V_d(R) = V_f(R)$$

$$\epsilon \frac{\partial V_d}{\partial n}\bigg|_R = \epsilon_0 \frac{\partial V_f}{\partial n}\bigg|_R$$



$$V_d(r) = \sum_\ell A_\ell r^\ell P_\ell(\cos\theta)$$

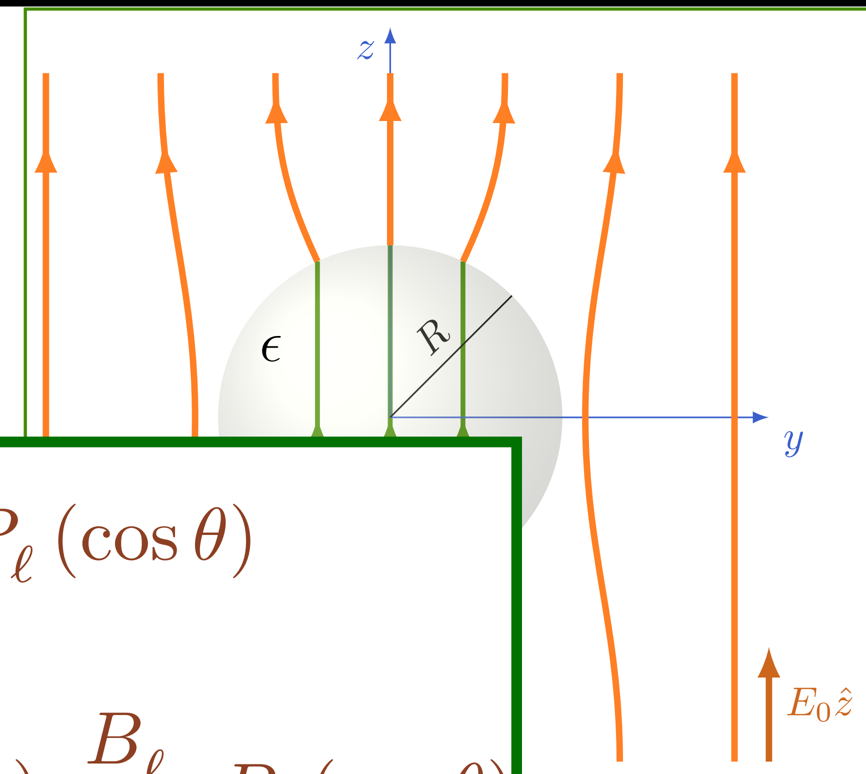
$$r = R \Rightarrow \quad \sum_\ell A_\ell R^\ell P_\ell(\cos\theta) = -E_0 R\cos\theta + \sum_\ell \frac{B_\ell}{R^{\ell+1}} P_\ell(\cos\theta)$$

$$\epsilon_r \sum_\ell \ell A_\ell R^{\ell-1} P_\ell(\cos\theta) = -E_0\cos\theta - \sum_\ell (\ell+1)\frac{B_\ell}{R^{\ell+2}} P_\ell(\cos\theta)$$

Pratique o que aprendeu

$$V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

$$V_d(r) = \sum_\ell A_\ell r^\ell P_\ell(\cos\theta)$$



$$\sum_\ell A_\ell R^\ell P_\ell(\cos\theta) = -E_0 R\cos\theta + \sum_\ell \frac{B_\ell}{R^{\ell+1}} P_\ell(\cos\theta)$$

$$\epsilon_r \sum_\ell \ell A_\ell R^{\ell-1} P_\ell(\cos\theta) = -E_0\cos\theta - \sum_\ell (\ell+1)\frac{B_\ell}{R^{\ell+2}} P_\ell(\cos\theta)$$

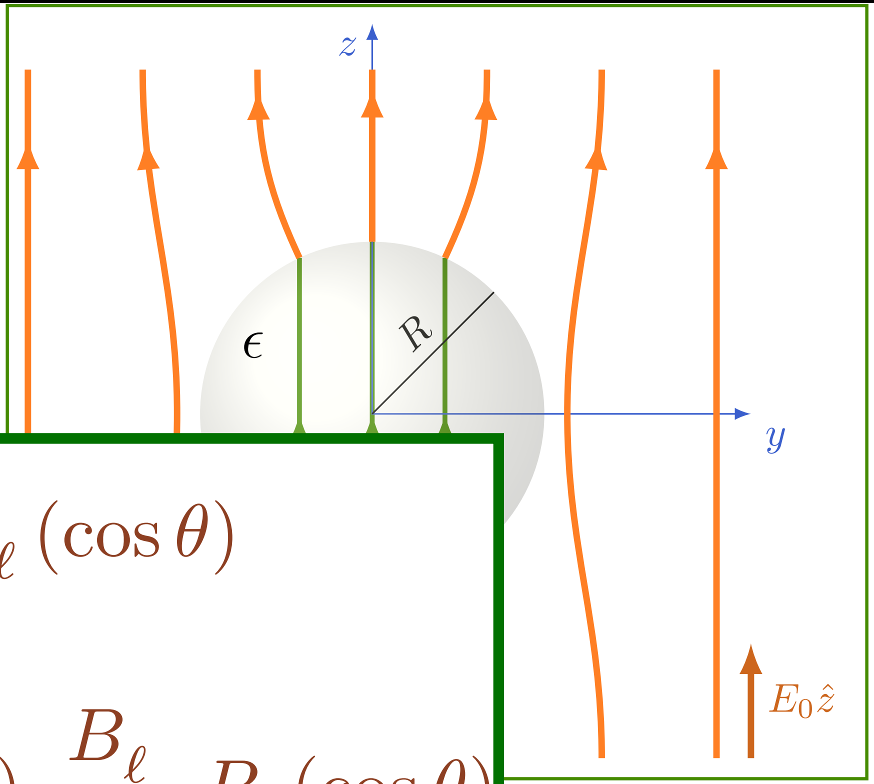
$$\ell = 1 \quad \Rightarrow \quad A_1 R = -E_0 R + \frac{B_1}{R^2}$$

$$\epsilon_r A_1 = -E_0 - 2\frac{B_1}{R^3}$$

$$\Rightarrow \quad A_1 = -\frac{3}{\epsilon_r + 2} E_0$$

$$B_1 = \frac{\epsilon_r - 1}{\epsilon_r + 2} R^3 E_0$$

Pratique o que aprendeu



$$V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

$$V_d(r) = \sum_\ell A_\ell r^\ell P_\ell(\cos\theta)$$

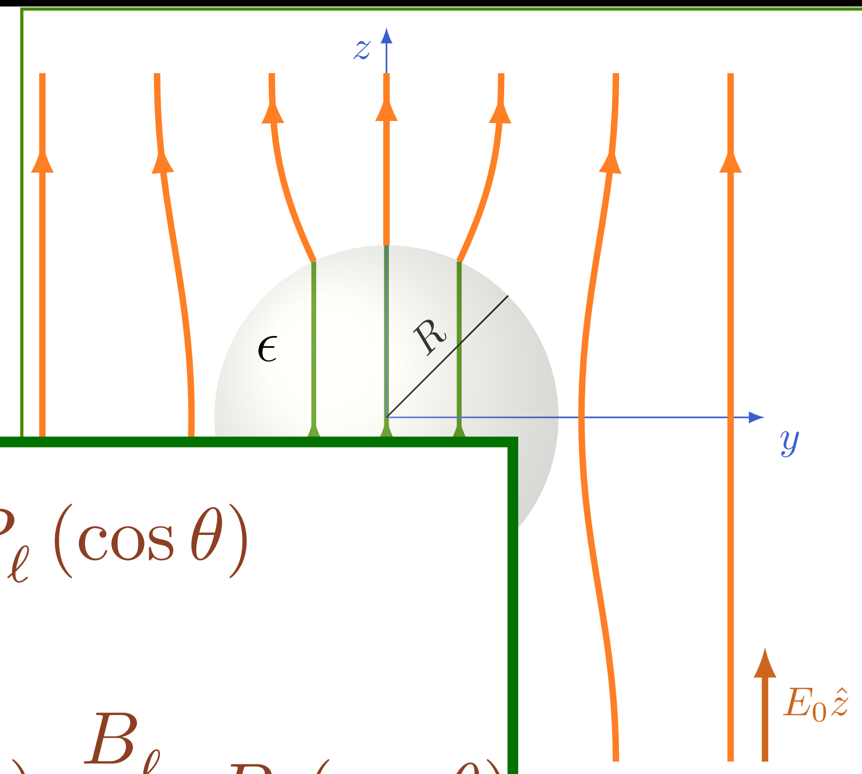
$$\sum_\ell A_\ell R^\ell P_\ell(\cos\theta) = -E_0 R\cos\theta + \sum_\ell \frac{B_\ell}{R^{\ell+1}} P_\ell(\cos\theta)$$

$$\epsilon_r \sum_\ell \ell A_\ell R^{\ell-1} P_\ell(\cos\theta) = -E_0\cos\theta - \sum_\ell (\ell+1)\frac{B_\ell}{R^{\ell+2}} P_\ell(\cos\theta)$$

$$\ell \neq 1 \quad \Rightarrow \quad A_\ell R^\ell = \frac{B_\ell}{R^{\ell+2}}$$

$$\epsilon_r \ell A_\ell R^{\ell-1} = -(\ell+1)\frac{B_\ell}{R^{\ell+2}}$$

Pratique o que aprendeu



$$V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

$$V_d(r) = \sum_\ell A_\ell r^\ell P_\ell(\cos\theta)$$

$$\sum_\ell A_\ell R^\ell P_\ell(\cos\theta) = -E_0 R\cos\theta + \sum_\ell \frac{B_\ell}{R^{\ell+1}} P_\ell(\cos\theta)$$

$$\epsilon_r \sum_\ell \ell A_\ell R^{\ell-1} P_\ell(\cos\theta) = -E_0\cos\theta - \sum_\ell (\ell+1)\frac{B_\ell}{R^{\ell+2}} P_\ell(\cos\theta)$$

$$\ell \neq 1 \quad \Rightarrow \quad A_\ell R^\ell = \frac{B_\ell}{R^{\ell+2}}$$

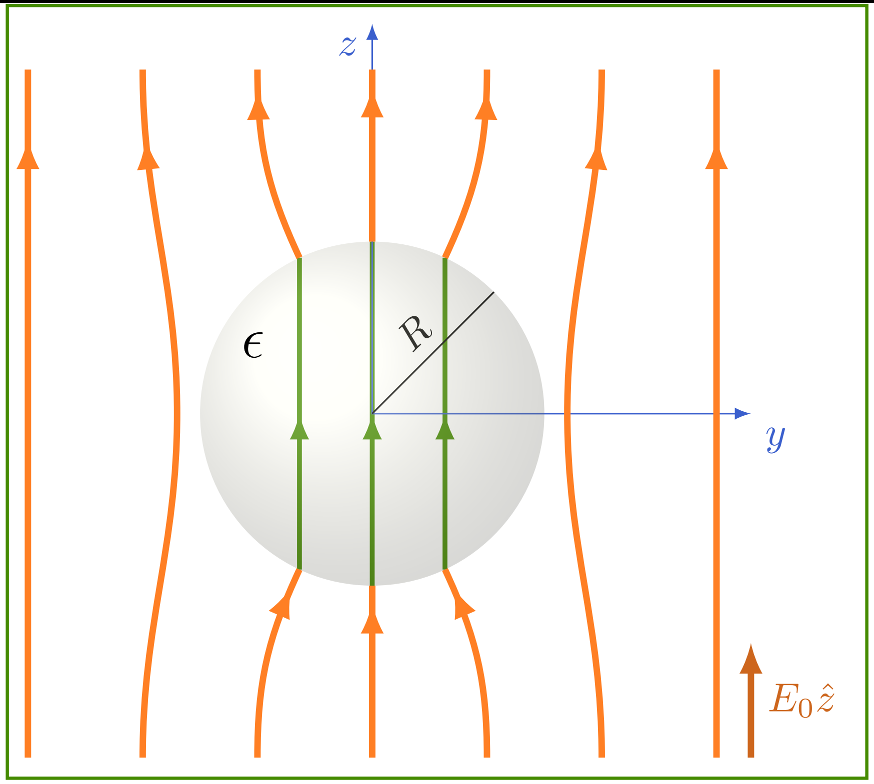
$$\epsilon_r \ell A_\ell R^{\ell-1} = -(\ell+1)\frac{B_\ell}{R^{\ell+2}}$$

$$\Rightarrow \quad A_\ell = B_\ell = 0$$

Pratique o que aprendeu

$$V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

$$V_d(r) = \sum_\ell A_\ell r^\ell P_\ell(\cos\theta)$$



$$\Rightarrow \quad A_1 = -\frac{3}{\epsilon_r + 2} E_0$$

$$B_1 = \frac{\epsilon_r - 1}{\epsilon_r + 2} R^3 E_0$$

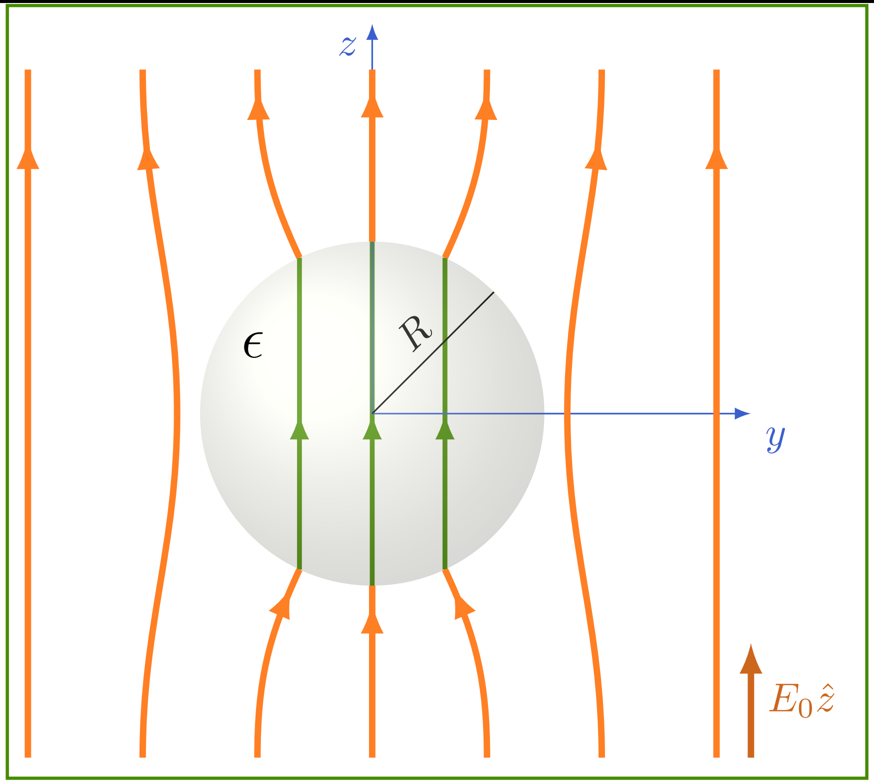
$$\Rightarrow \quad A_\ell = B_\ell = 0$$

$$V_d(r) = -\frac{3}{\epsilon_r + 2} E_0 r\cos\theta = -\frac{3}{\epsilon_r + 2} E_0 z$$

Pratique o que aprendeu

$$V_f(r) = -E_0 r\cos\theta + \sum_\ell \frac{B_\ell}{r^{\ell+1}} P_\ell(\cos\theta)$$

$$V_d(r) = \sum_\ell A_\ell r^\ell P_\ell(\cos\theta)$$



$\Rightarrow$ $A_\ell = B_\ell = 0$

$\Rightarrow$

$$A_1 = -\frac{3}{\epsilon_r + 2} E_0$$

$$B_1 = \frac{\epsilon_r - 1}{\epsilon_r + 2} R^3 E_0$$

$$V_f(r) = -E_0 r\cos\theta + \frac{\epsilon_r - 1}{\epsilon_r + 2}\frac{E_0 R^3\cos\theta}{r^2}$$

Eletromagnetismo

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

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

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

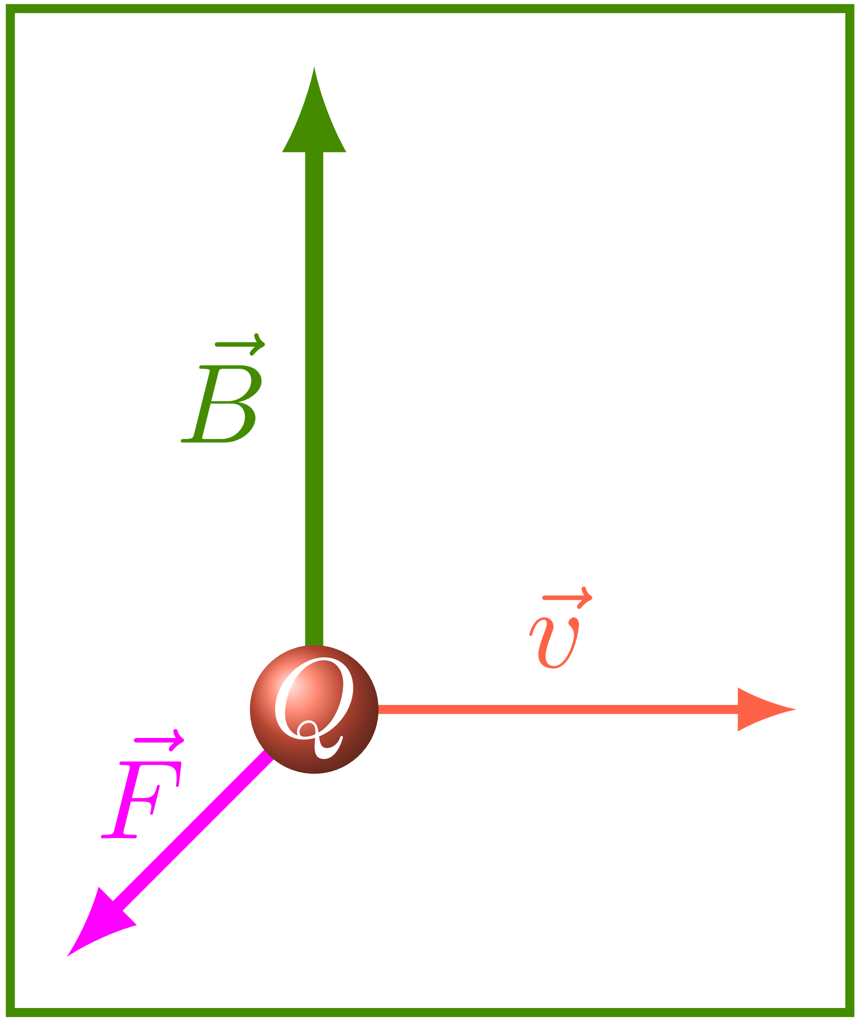
$$\vec{\nabla} \times \vec{H} = \vec{j} + \epsilon_0 \frac{\partial \vec{D}}{\partial t}$$

21 de junho de 2021

Magnetismo

Força de Lorentz

$$\vec{F} = Q(\vec{E} + \vec{v} \times \vec{B})$$



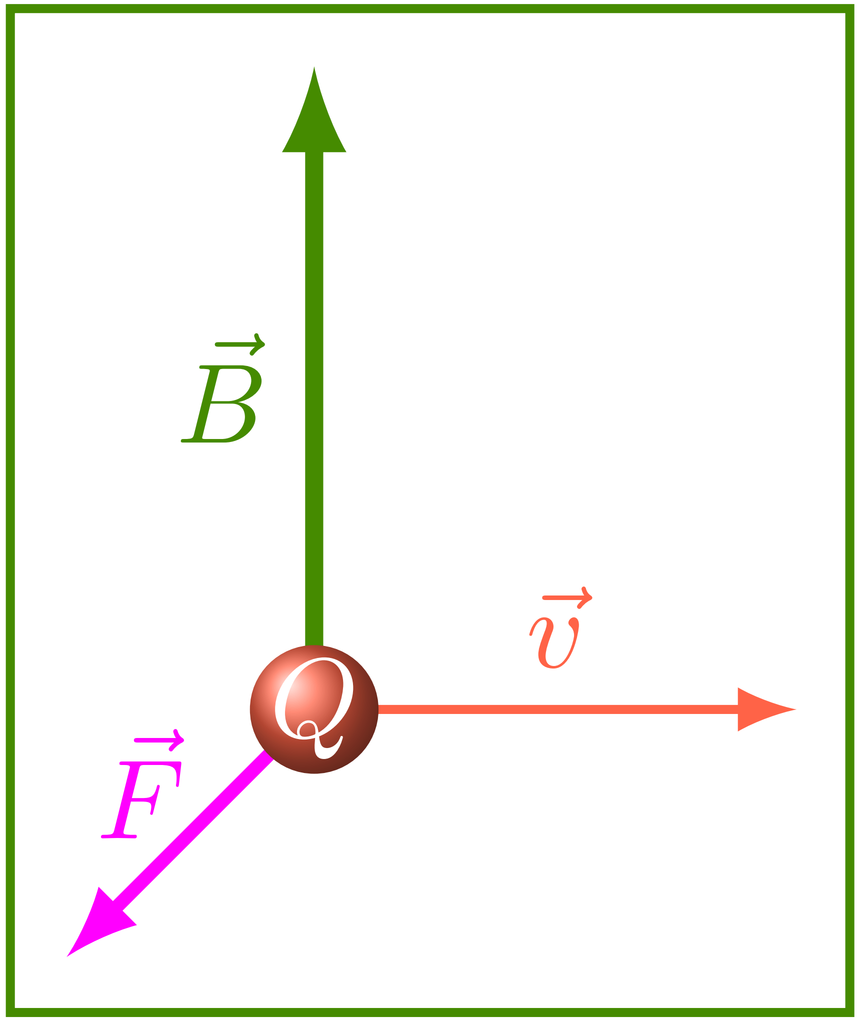
REGRA
DA MÃO DIREITA

Força de Lorentz

$$\vec{F} = Q(\vec{E} + \vec{v} \times \vec{B})$$

Força magnética não realiza trabalho

ÀS VEZES, PARECE REALIZAR



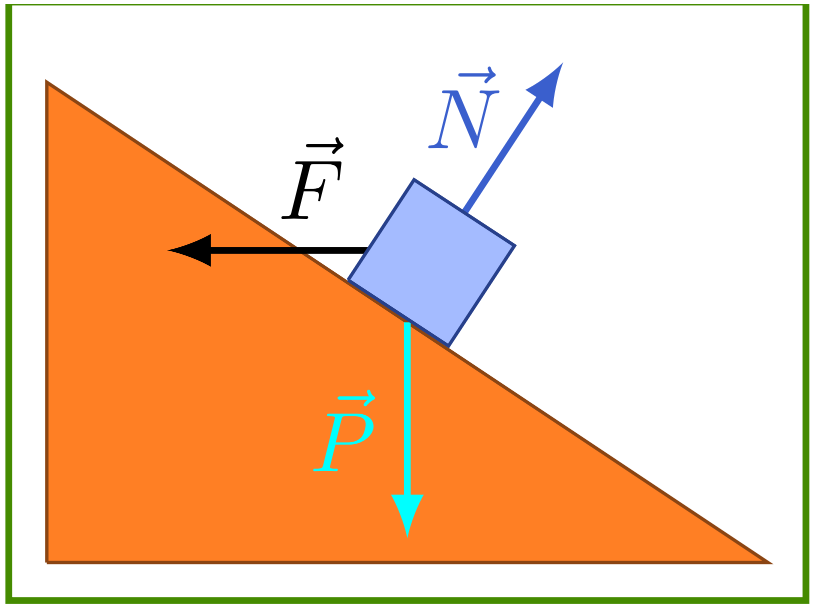
Força de Lorentz

$$\vec{F} = Q(\vec{E} + \vec{v} \times \vec{B})$$

ANALOGIA

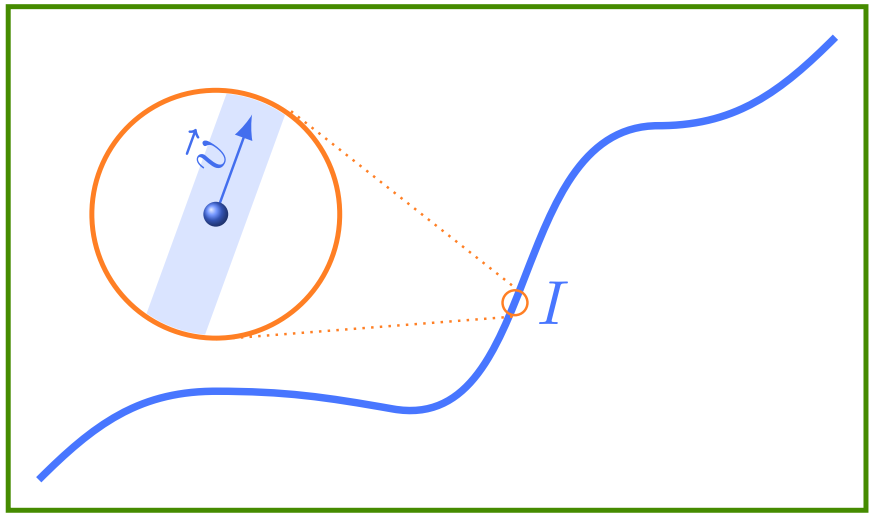
Força normal não realiza trabalho,

MAS PARECE REALIZAR



QUEM EMPURRA O BLOCO PARA CIMA É A NORMAL, MAS QUEM REALIZA TRABALHO É A FORÇA $\vec{F}$

Corrente elétrica



$$\vec{I} = \lambda \vec{v}$$

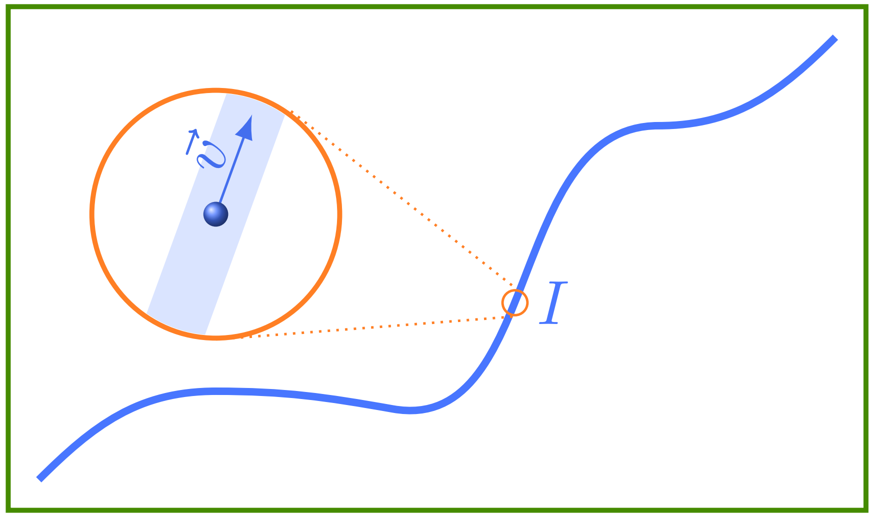
↳ VETOR CORRENTE

Corrente elétrica

$$\vec{I} = \lambda \overrightarrow{v}$$

$$\vec{F} = \int \vec{v} \times \vec{B}\ \mathrm{d}q$$

$dq = \lambda d\ell$



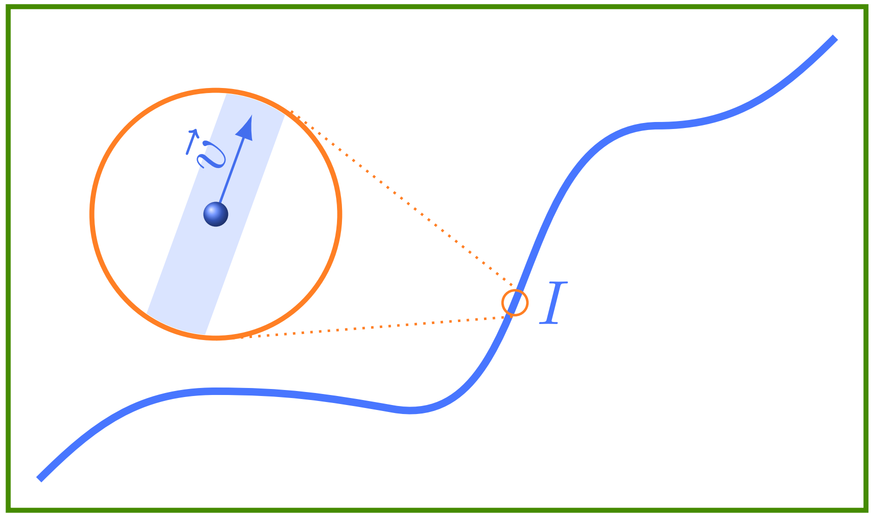
Corrente elétrica

$$\vec{I} = \lambda \overrightarrow{v}$$

$$\vec{F} = \int \vec{v} \times \vec{B} \, \mathrm{d}q$$

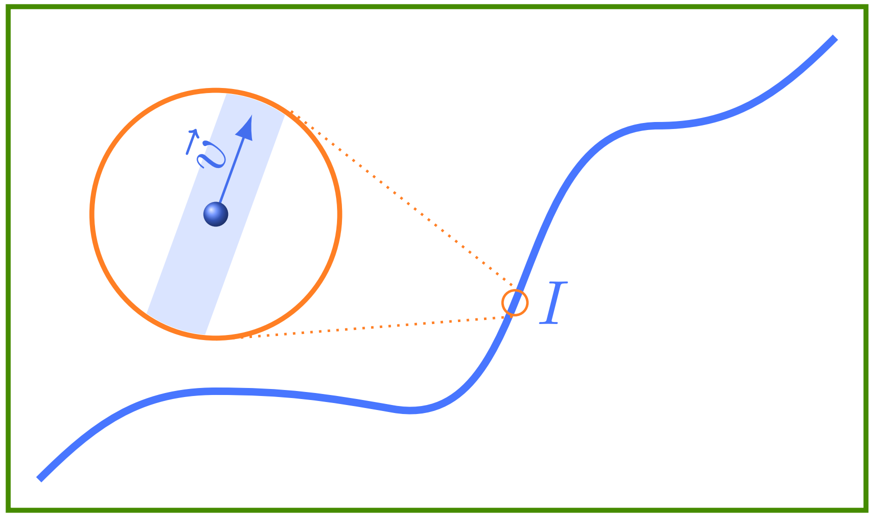
$$\vec{F} = \int \vec{v} \times \vec{B} \, \lambda \, \mathrm{d}\ell$$

$\longrightarrow \vec{I}$



Corrente elétrica

$$\vec{I} = \lambda \vec{v}$$



$$\vec{F} = \int \vec{v} \times \vec{B} \, \mathrm{d}q$$

$$\vec{F} = \int \vec{v} \times \vec{B} \, \lambda \, \mathrm{d}\ell$$

$$\vec{F} = \int \vec{I} \times \vec{B} \, \mathrm{d}\ell$$

$\longrightarrow \vec{I} \, d\vec{\ell}$

Corrente elétrica

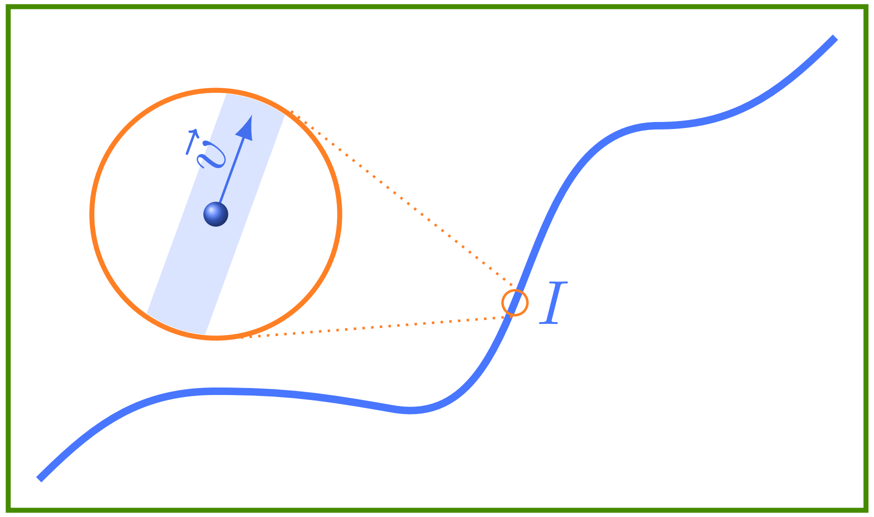
$$\vec{I} = \lambda \overrightarrow{v}$$

$$\vec{F} = \int \vec{v} \times \vec{B} \, \mathrm{d}q$$

$$\vec{F} = \int \vec{v} \times \vec{B} \, \lambda \, \mathrm{d}\ell$$

$$\vec{F} = \int \vec{I} \times \vec{B} \, \mathrm{d}\ell$$

$$\vec{F} = I \int \mathrm{d}\vec{\ell} \times \vec{B}$$



Pratique o que aprendeu

$$\vec{F} = I\int \mathrm{d}\vec{\ell}\times\vec{B}$$

Qual a corrente I que equilibra o peso?

$$\Delta\vec{\ell}\times\vec{B} = aB\,(\hat{x}\times -\hat{z}) = aB\,\hat{y}$$

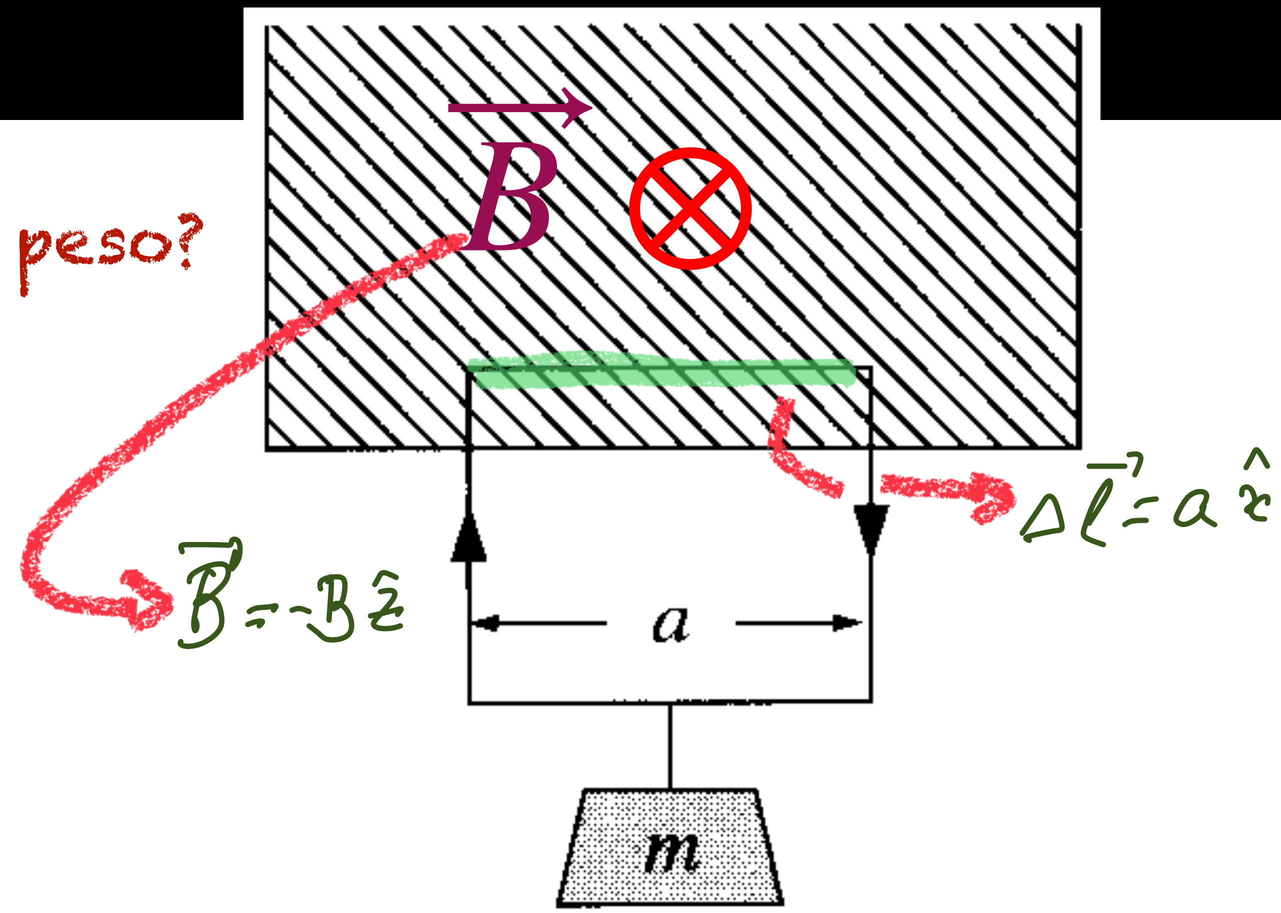
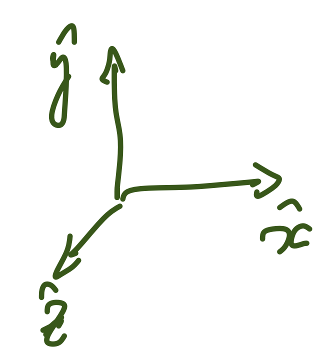


Figure 5.10



Pratique o que aprendeu

$$\vec{F} = I \int \mathrm{d}\vec{\ell} \times \vec{B}$$

Qual a corrente I que equilibra o peso?

$$F = IaB \qquad \left(\vec{F} = Iab\,\hat{y}\right)$$

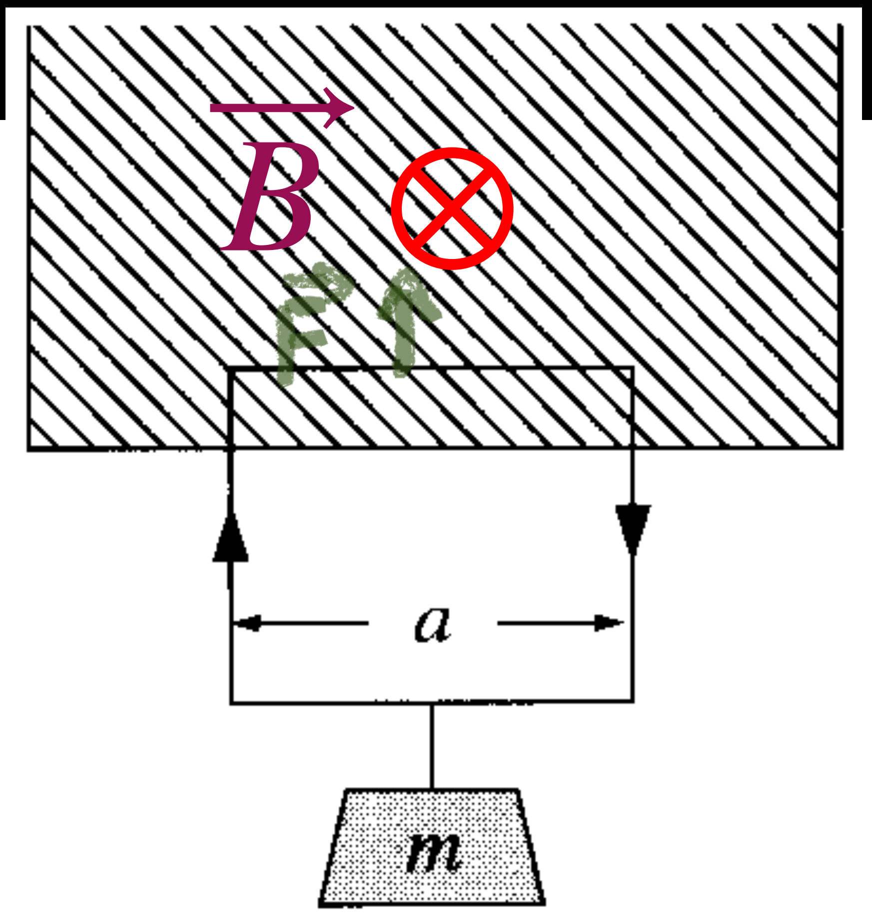
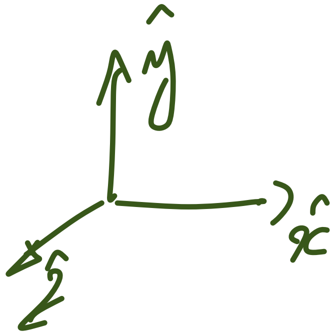


Figure 5.10



Pratique o que aprendeu

$$\vec{F} = I \int \mathrm{d}\vec{\ell} \times \vec{B}$$

Qual a corrente I que equilibra o peso?

$$F = IaB$$

$$F = mg$$

$$I = \frac{mg}{aB}$$

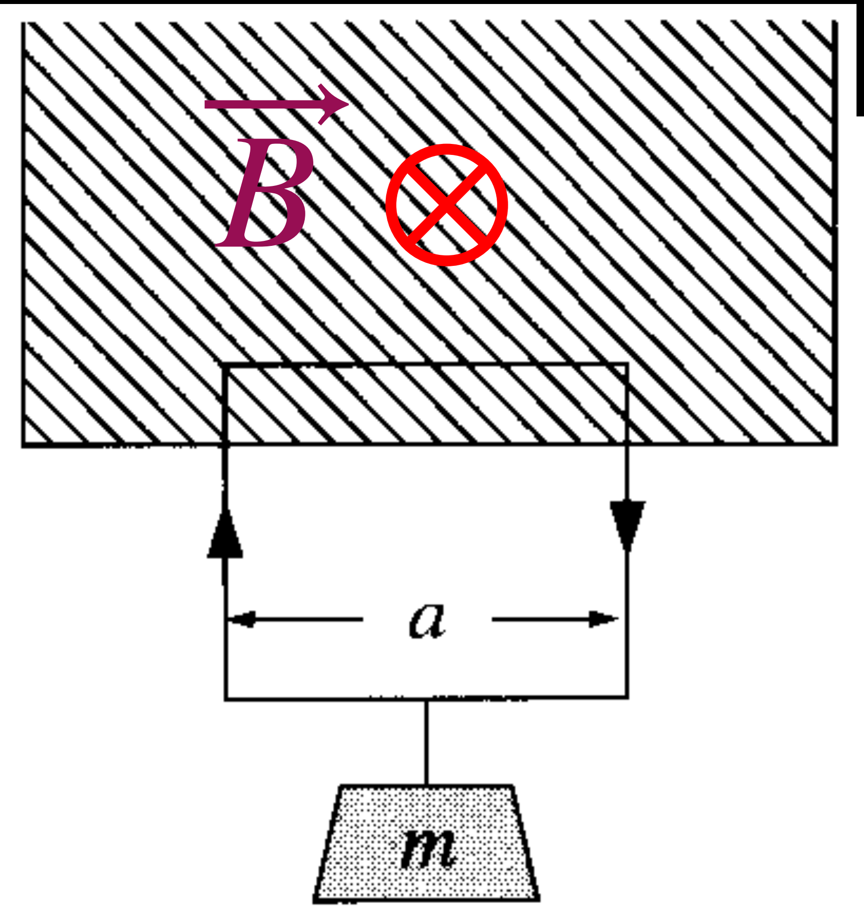


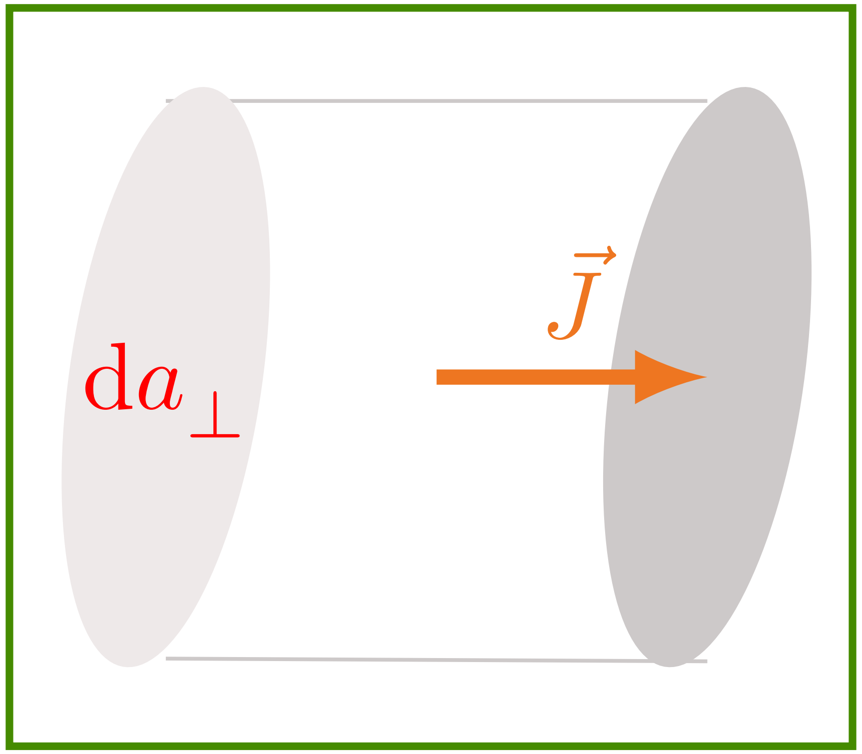
Figure 5.10

Densidade de corrente

$$\vec{J} = \frac{\mathrm{d}\vec{I}}{\mathrm{d}a_{\perp}}$$

$$\vec{J} = \rho\vec{v}$$

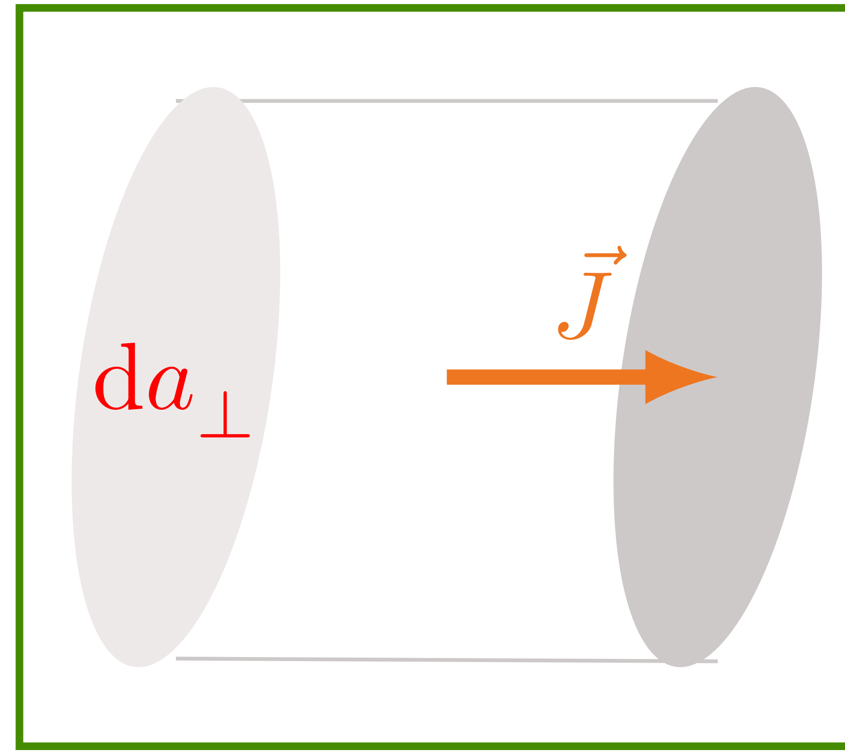
Força no fio



Densidade de corrente

$$\vec{J} = \frac{\mathrm{d}\vec{I}}{\mathrm{d}a_\perp}$$

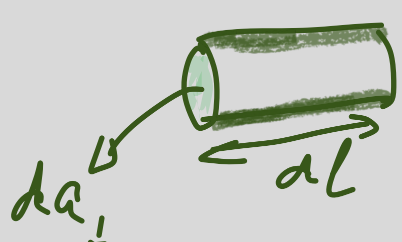
$$\vec{J} = \rho\vec{v}$$



Força no fio

$$\vec{F} = \int \vec{I} \times \vec{B}\,\mathrm{d}\ell$$

$$d\ell\, da_\perp = d\tau$$



$$\vec{I}\,d\ell = \vec{J}\,d\tau$$

Densidade de corrente

$$\vec{J} = \frac{\mathrm{d}\vec{I}}{\mathrm{d}a_{\perp}}$$

$$\vec{J} = \rho\vec{v}$$

Força no fio

$$\vec{F} = \int \vec{I} \times \vec{B}\ \mathrm{d}\ell$$

$$\vec{F} = \int \vec{J} \times \vec{B}\ \mathrm{d}\tau$$