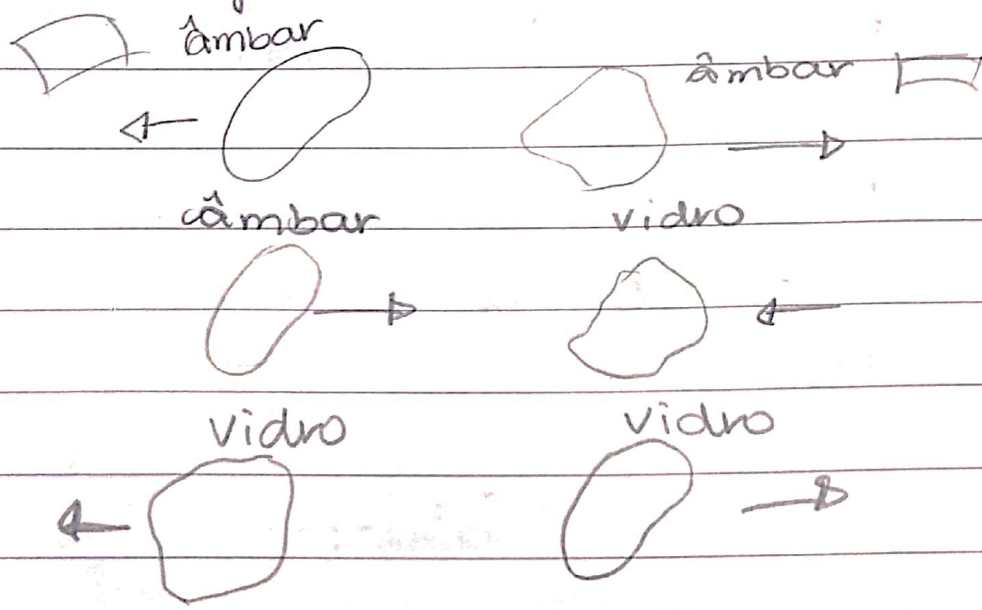
ELETROMAGNETISMO

• Carga elétrica



✓ Propriedades + e −

(+) → ← (−) atrai

← (+) (+) → repele

← (−) (−) → repele

Obs: Materiais condutores: alguns eletrons da camada mais externa facilmente "caminham" entre os átomos

Materiais isolantes: os eletrons não possuem facilidade para "caminhar" entre os átomos.

ATT: Polarização → não deixa de estar neutro!

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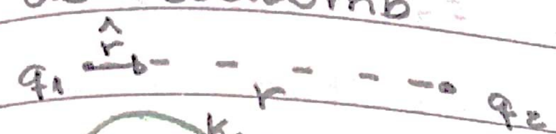
• Lei de Coulomb



$$F_{1(2)} = -\underbrace{\frac{1}{4\pi\varepsilon_0}}_{k}\frac{q_1 q_2}{r^2} = -k\frac{q_1 q_2}{r^2}$$

↳ constante eletrostática

$k = 8{,}99 \cdot 10^{9}\ \frac{Nm^2}{C^2}$

$$F_{2(1)} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$[q] = C$

$\varepsilon_0 \cong 8{,}85 \cdot 10^{-12}\ \frac{C^2}{Nm^2}$

↳ permissividade do vácuo

1º caso: $q_1 > 0$ e $q_2 < 0$ ou $q_1 < 0$ e $q_2 > 0$

$F_{1(2)} = -k\frac{q_1 q_2}{r^2}$?

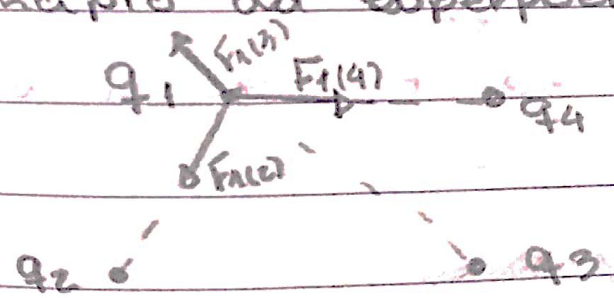
$F_{2(1)} = k\frac{q_1 q_2}{r^2}$?

2º caso: $q_1 > 0$ e $q_2 > 0$ ou $q_1 < 0$ e $q_2 < 0$

$F_{1(2)} = k\frac{q_1 q_2}{r^2}$?

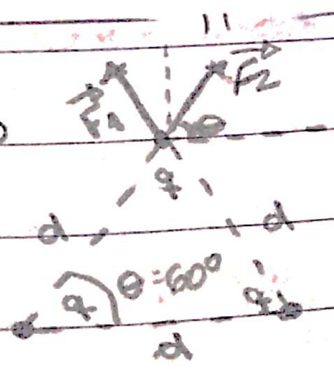
$F_{2(1)} = -k\frac{q_1 q_2}{r^2}$?

• Princípio da superposição



$$F_{r1} = F_{1(2)} + F_{1(3)} + F_{1(4)}$$
$$= \sum_{i=2}^{4} F_{1(i)}$$

Obs. triângulo equiláteto



$F_1 = F_{1x}\hat{i} + F_{1y}\hat{j}$

$F_2 = F_{2x}\hat{i} + F_{2y}\hat{j}$

$F_r = F_1 + F_2 = (F_{1x} + F_{2x})\hat{i} + (F_{1y} + F_{2y})\hat{j}$

$$|F_1| = |F_2| = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2} = F$$

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$F_{2x} = F \cdot \cos 60°$ $\qquad$ $F_{2y} = F \cdot \text{sen } 60°$

$F_{1x} = -F \cdot \cos 60°$ $\qquad$ $F_{1y} = F \cdot \text{sen } 60°$

$= F \cdot \cos 120°$

$$\vec{F} = \left(\vec{F} \cdot \frac{1}{2} - \vec{F}\frac{1}{2}\right)\hat{i} + \left(F\frac{\sqrt{3}}{2} + F\frac{\sqrt{3}}{2}\right)\hat{j}$$

$$\vec{F} = F\sqrt{3}\,\hat{j} = \frac{\sqrt{3}}{4\pi\varepsilon_0} \cdot \frac{q^2}{d^2}\,\hat{j}$$

— // — // —

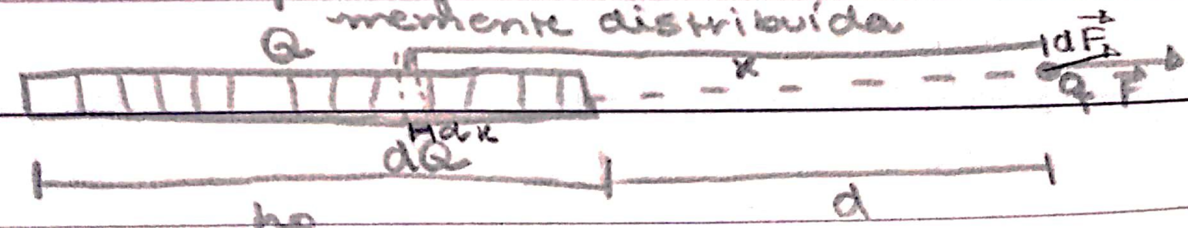
→ carga elétrica

$\boxed{Q = n.e}$, $n = 0, \pm 1, \pm 2$

$|e| = 1,602171 \cdot 10^{-19}$ C

→ carga elétrica uniformemente distribuída

Ex.



$$\frac{}{4\pi\varepsilon_0}\;\frac{}{d^2}$$

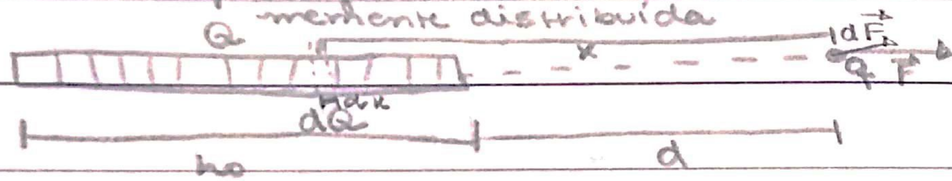
p/ carga elétrica

$$\boxed{Q = n\,e}\,,\quad n = 0, \pm 1, \pm 2$$

$$|e| = 1{,}602171 \cdot 10^{-19}\,C$$

p/ carga elétrica uniformemente distribuída

Ex.



$$\sum_i dF = \sum_i \frac{1}{4\pi\varepsilon_0}\,\frac{dQ \cdot q}{x^2}$$

$$\int dF = \int \frac{q}{4\pi\varepsilon_0} \cdot \frac{dQ}{x^2} \Rightarrow F = \frac{q}{4\pi\varepsilon_0} \int \frac{dQ}{x^2}$$

* Densidade de carga linear

$$\lambda = \frac{Q}{L} = \frac{dQ}{dx} \quad \therefore \quad \boxed{dQ = \lambda\,dx}$$

$$F = \frac{q}{4\pi\varepsilon_0} \cdot \int_d^{d+L_0} \frac{\lambda}{x^2}\,dx = \frac{q\lambda}{4\pi\varepsilon_0} \int \frac{1}{x^2}\,dx$$

$$F = \frac{\lambda q}{4\pi\varepsilon_0}\,\frac{x^{-2+1}}{-2+1}\Bigg|_d^{d+L_0}$$

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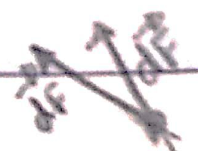
$$F = -\frac{\lambda q}{4\pi\varepsilon_0} x^{-1} \Big|_{d}^{d+L_0} = -\frac{\lambda q}{4\pi\varepsilon_0}\left[\frac{1}{d+L_0} - \frac{1}{d}\right]$$

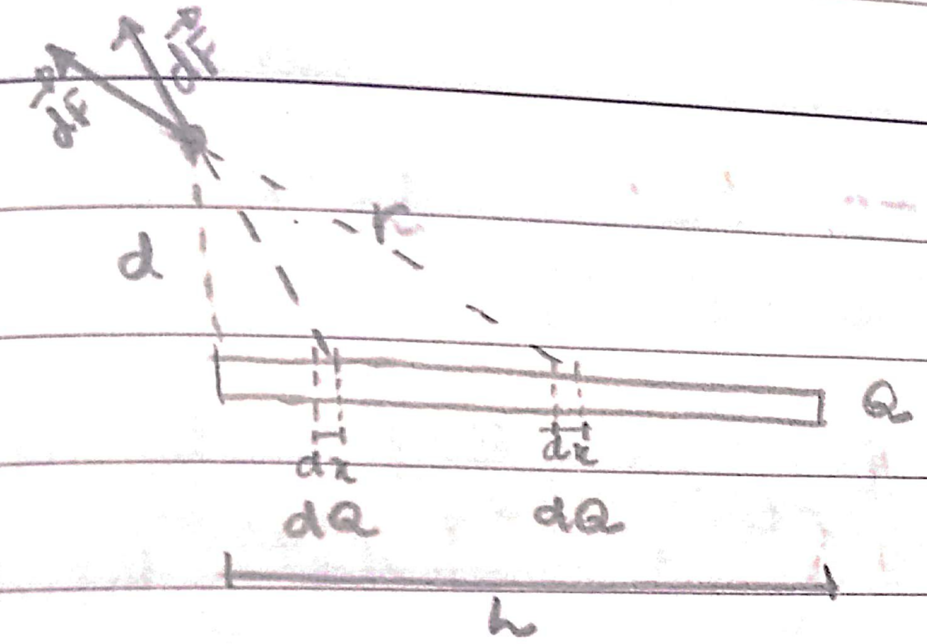
$$F = \frac{\lambda q}{4\pi\varepsilon_0}\left[\frac{1}{d} - \frac{1}{d+L_0}\right] = \frac{Qq}{4\pi\varepsilon_0 \cdot L}\left[\frac{1}{d} - \frac{1}{d+L_0}\right]$$

$$F = \frac{1}{4\pi\varepsilon_0}\frac{Q\,q}{L_0}\left[\frac{d+L_0-d}{d(d+L_0)}\right] = \frac{1}{4\pi\varepsilon_0}\frac{Q.q}{\cancel{L_0}}\frac{\cancel{L_0}}{d(d+L_0)} ;$$

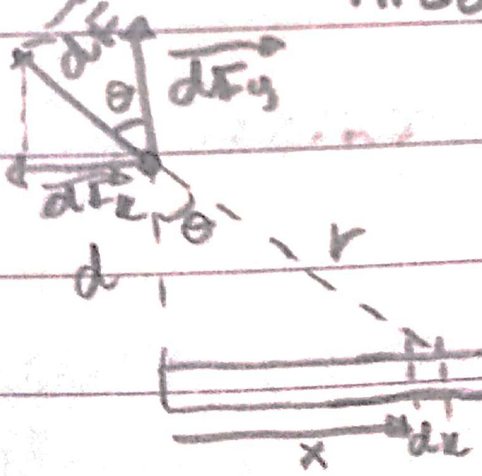
$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q.Q}{d(d+L_0)}$$



EX2:



$$dF = \frac{1}{4\pi\varepsilon_0}\,\frac{q\,dQ}{r^2}$$



$dF_y = dF \cdot \cos\theta$

$dF_x = dF \cdot \operatorname{sen}\theta$

$F_y = \int dF \cos\theta$

$F_x = -\int dF \cdot \operatorname{sen}\theta$

$$F_y = \int \frac{1}{4\pi\varepsilon_0} \cdot \frac{q\, dQ}{r^2} \cos\theta$$

$$\lambda = \frac{Q}{L} = \frac{dQ}{dx} \Rightarrow dQ = \lambda\, dx$$

$$r^2 = d^2 + x^2$$

$$r = \sqrt{d^2 + x^2}$$

$$\cos\theta = \frac{d}{r} = \frac{d}{\sqrt{d^2+x^2}}$$

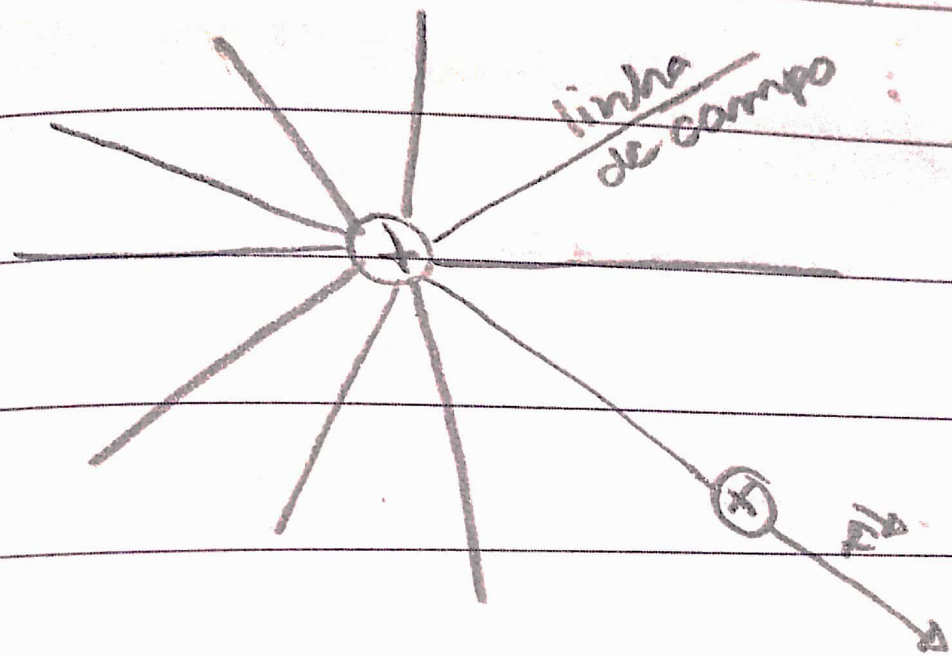
$$F_y = \int_0^L \frac{1}{4\pi\varepsilon_0} \frac{q\lambda\, dx}{(x^2+d^2)} \cdot \frac{d}{\sqrt{x^2+d^2}}$$

$$F_y = \int_0^L \frac{q\lambda}{4\pi\varepsilon_0} \frac{1}{(x^2+d^2)^{3/2}} dx$$

$$F_y = \frac{q\lambda}{4\pi\varepsilon_0} \int_0^L \frac{1}{(x^2+d^2)^{3/2}} dx \quad \begin{cases} u = d\,tg\,x \\ \frac{du}{d\theta} = d\sec^2\theta \end{cases}$$

Faz a mesma coisa p/ F_x

• Campo elétrico ($\vec{E}$)



- É a capacidade de gerar força

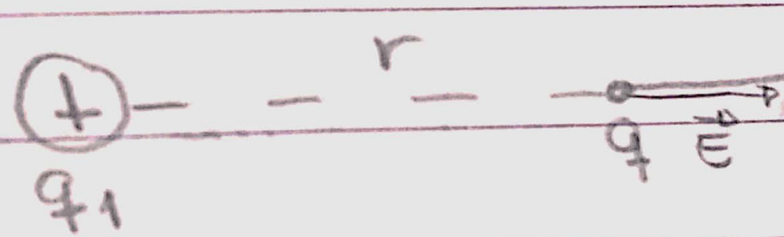
$$\vec{E} = \frac{\vec{F}}{q} \quad \therefore \quad \boxed{\vec{F} = q\,\vec{E}}$$

Por outro lado:

$$\vec{F} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 \cdot q}{r^2}$$

$$\cancel{q} \cdot \vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 \cancel{q}}{r^2}$$

$$\boxed{\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1}{r^2}}$$



$\vec{F} = q \cdot \vec{E}$

Se coloco uma carga q

$$\vec{F} = q\,E = q \cdot \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r^2}$$

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$$\vec{F} = \underbrace{\frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q}{r^2}}_{\vec{E}_{q_1}} = \underbrace{\frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}}_{\vec{E}_q} q_1$$

$$\vec{E} = \frac{\vec{F}}{q} = \frac{\frac{1}{4\pi\varepsilon_0} \frac{Qq}{r^2}}{q}$$

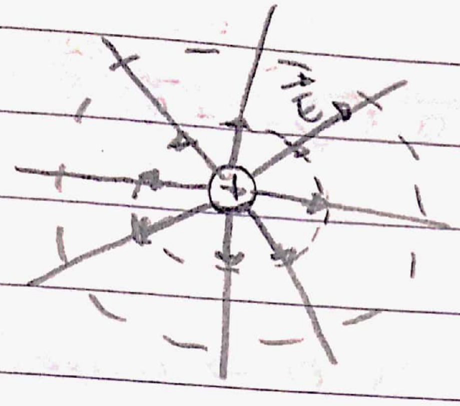
$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^2}$$

Att.: como não depende de q, cargas com distâncias radiais iguais possuem campo elétri de mesma magnitude.

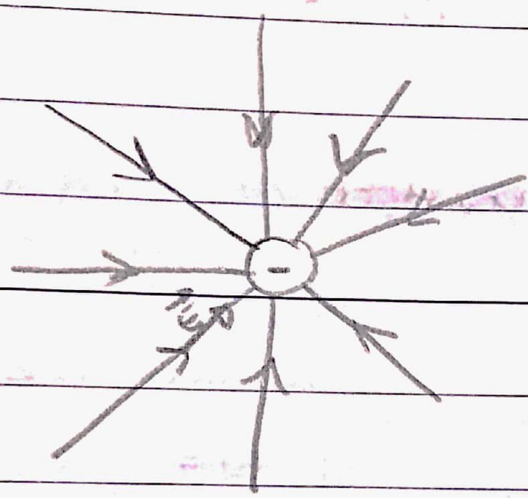
Obs: O sentido do campo aponta para Q se q e Q forem opostas, caso contrário aponta para fora.

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^2} \cdot \hat{r}$$

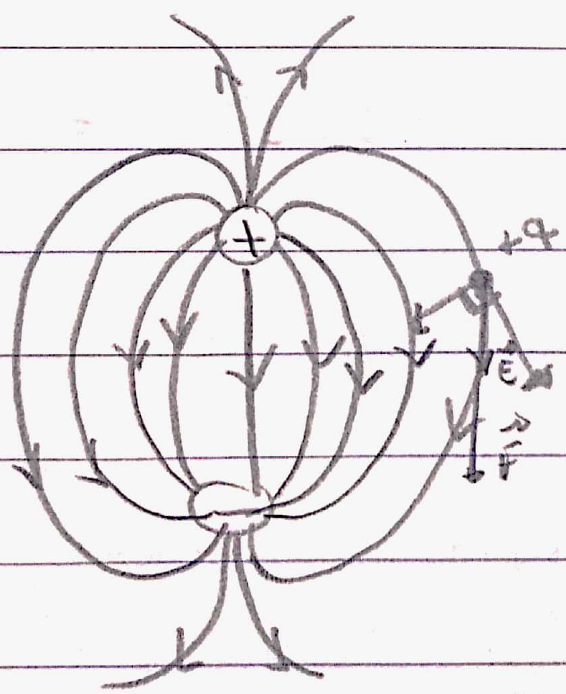
*Linhas de campo → apenas facilitam a Visualização

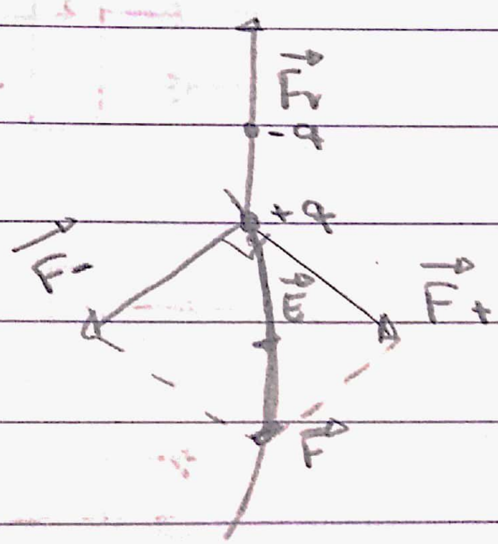


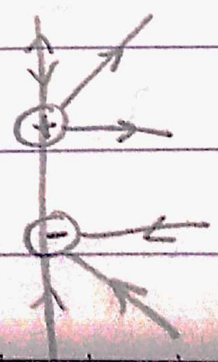
Quanto mais densas as linhas de campo, mais intenso o campo elétrico.



Dipolo- elétrico







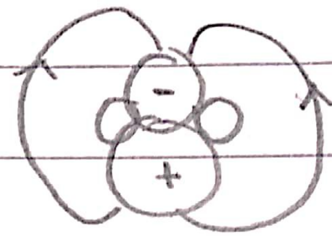
$F_+ = q\,\vec{E}_+$

$F_- = q\,\vec{E}_-$

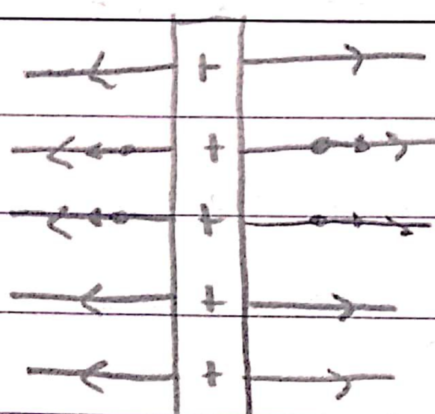
$\vec{F_r} = F_+ + F_- = q\overbrace{(\vec{E}_+ + \vec{E}_-)}^{\vec{E}_r}$

$\vec{F_r} = q\,\vec{E}_r$

$H_2O \Rightarrow$ dipolo elétrico



- Linhas de campo de uma placa carregada



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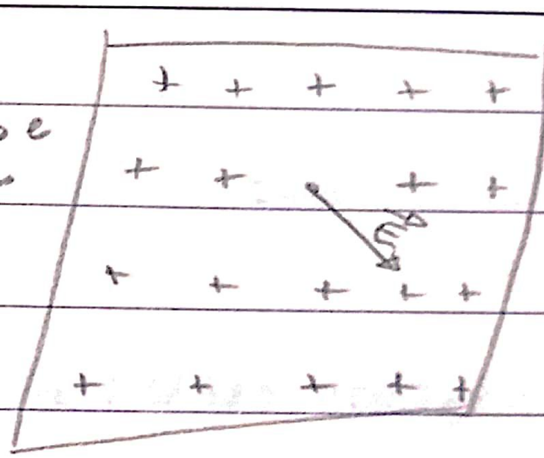
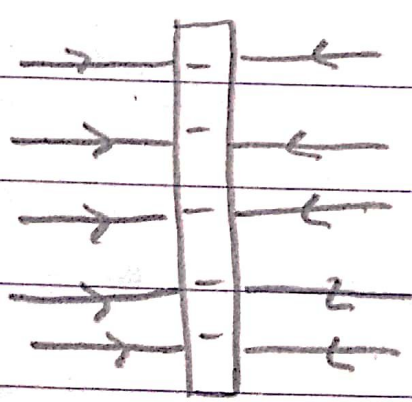
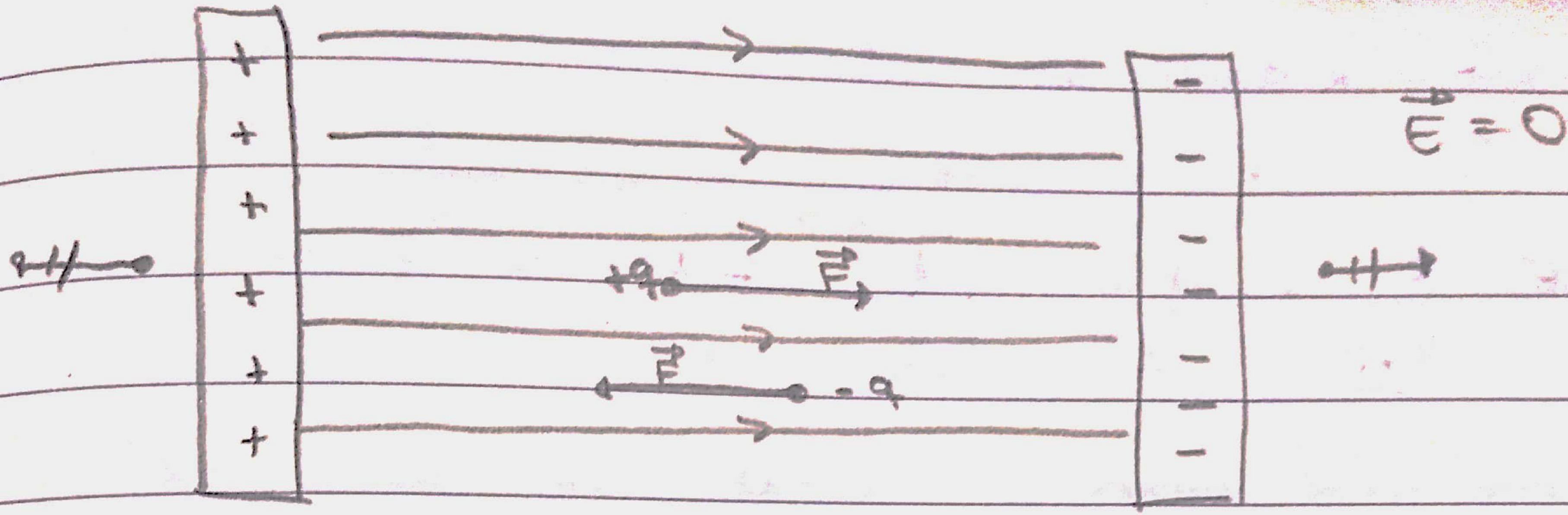
Paralelas e constante



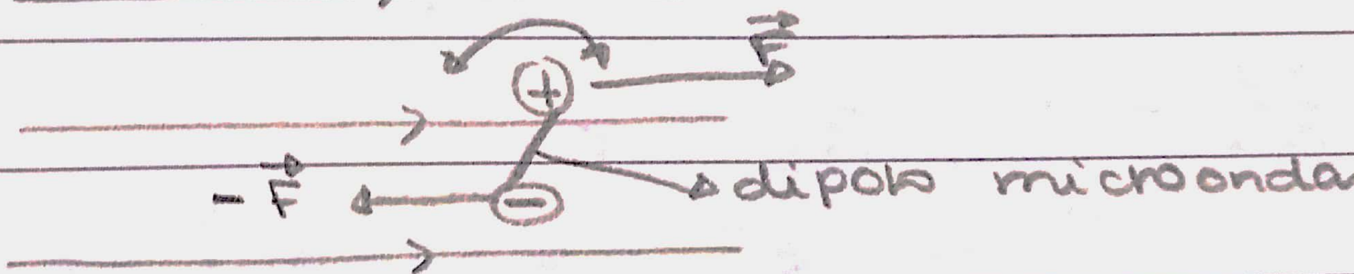
$\vec{E} = E_0\,\hat{i}$



$\vec{E} = E_0\,\hat{i} \therefore \vec{E} = -E_0\,\hat{i}$



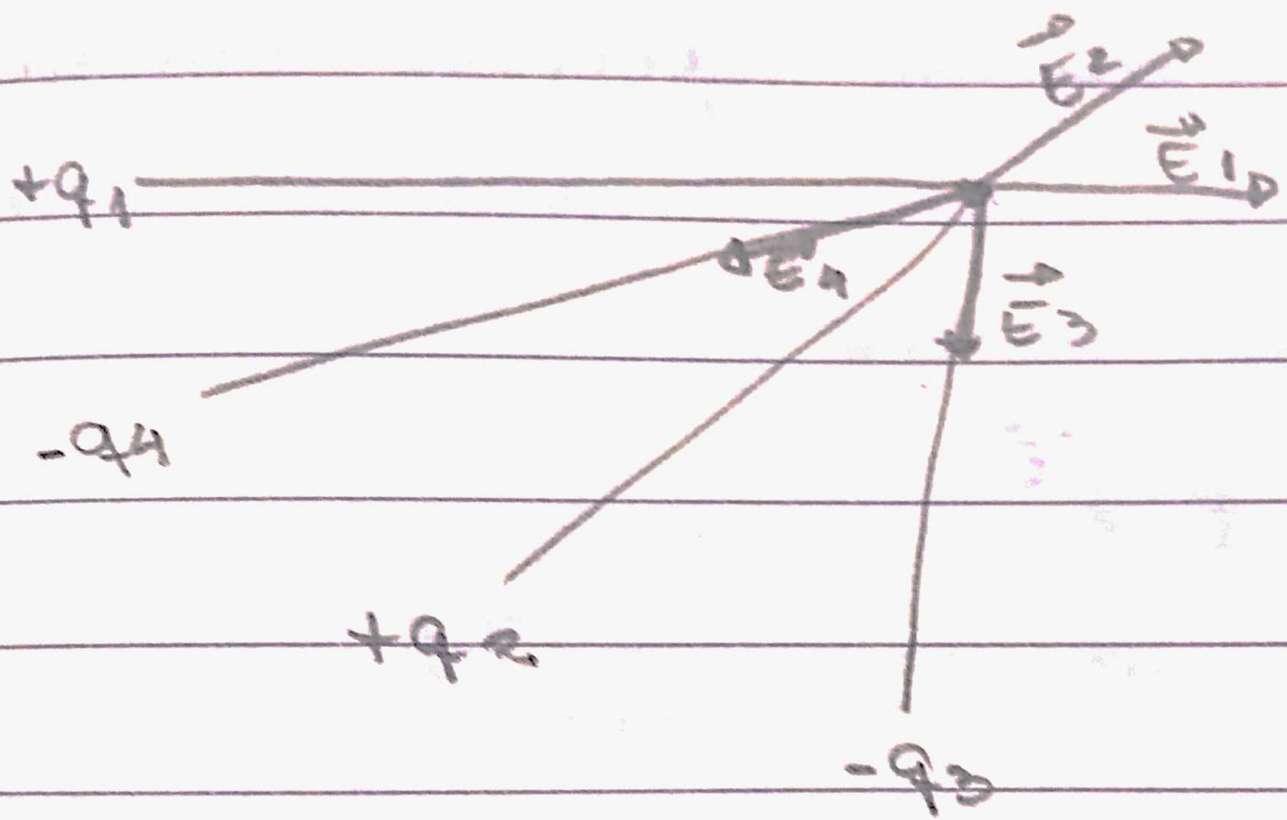
$$F = q \cdot \vec{E}$$

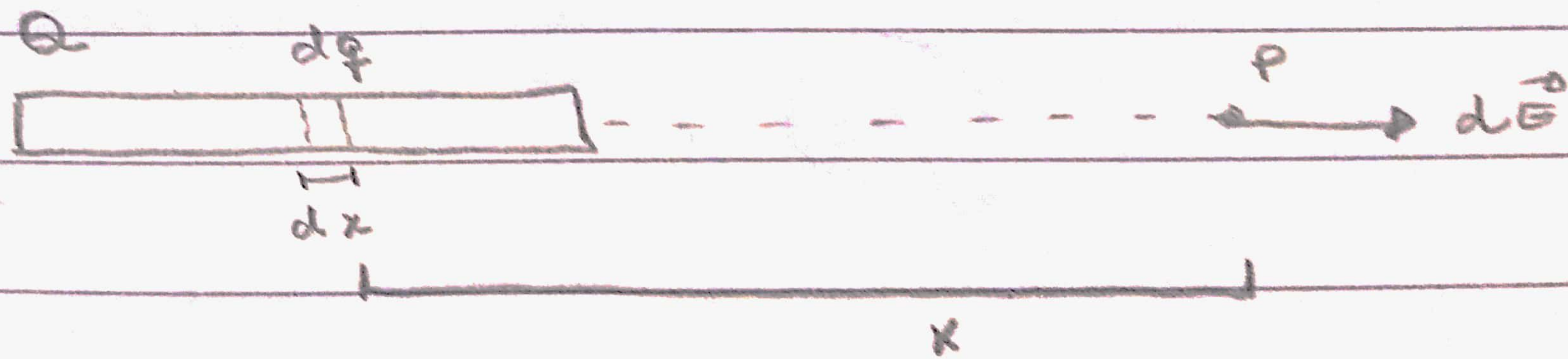


Fluxo campo elétrico → constante

linhas de campo + juntas → campo + intenso

- Cálculo de campo elétrico





$$\lambda = \frac{Q}{L}$$

$$dF = q \cdot dE$$

$$dE = \frac{1}{4\pi\varepsilon_0} \cdot \frac{dQ}{x^2} = \frac{1}{4\pi\varepsilon_0} \frac{q\,dQ}{x^2} = q \cdot dE$$

$$E = \int dE = \int \frac{1}{4\pi\varepsilon_0} \frac{dQ}{x^2}$$

$$\vec{E}_i = \frac{1}{4\pi\varepsilon_0} \frac{q_i}{r_i^2} \hat{r}_i$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4$$

$$\vec{E} = \sum_{i=0}^{4} \vec{E}_i$$