Eletromagnetismo

Ficha 1

4\. (1) $Q_1 = +6e$, $Q_2 = -4e$ $\longrightarrow$ $Q_1 = 1e$, $Q_2 = 1e$

$6e - ae = -4e + ae \Leftrightarrow a = 5$

Q_1 recebe 5 eletrões do Q1.

(2) $Q_1 = 0$, $Q_2 = +2e$ $\longrightarrow$ $Q_1 = 1e$, $Q_2 = 1e$

Q_1 dá um eletrão ao Q_2.

(3) $Q_1 = -12e$, $Q_2 = +14e$ $\longrightarrow$ $Q_1 = 1e$, $Q_2 = 1e$

$-12e + ae = 14e + ae \Leftrightarrow a = \frac{26}{2} = 13$

Q1 da 13 eletrões ao Q2.

Ordem da → transferência: (2) < (1) < (3)
→ Módulo das cargas presentes (2) = (1) = (3)

7\. $\vec{E} = \frac{\vec{F}}{q_0} = k\frac{Q}{r^2}\hat{r}$

Visto haver simetria, muitos pontos anulam-se

$$\vec{E} = \frac{k \times (+2)}{r^2} (+\hat{j})$$

14| $\vec{F}_3 = \vec{F}_{13} + \vec{F}_{23} = 0$ $\qquad L_{12} = L_{23} = L$

$\Leftrightarrow \vec{F}_{13} = -\vec{F}_{23}$

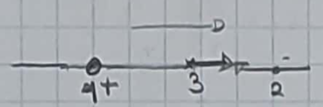
$\Leftrightarrow \cancel{k}\dfrac{|q_1||\cancel{q_3}|}{(2L)^2} = -\cancel{k}\dfrac{|\cancel{q_3}||q_2|}{L^2}$

$\Leftrightarrow \dfrac{|q_1|}{|q_2|} = \dfrac{4L^2}{L^2}$

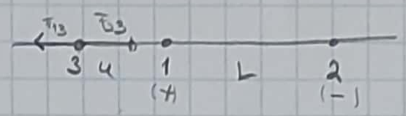
$\Leftrightarrow \dfrac{|q_1|}{|q_2|} = 4$

15| $q_1 = +1{,}0\ \mu C$ $\qquad q_2 = -3{,}0\ \mu C$ $\qquad L = 10{,}0\ cm = 0{,}10\ m$

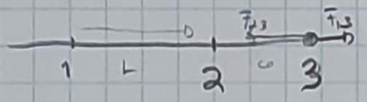
1º caso no meio ? ×



2º caso à esquerda



3º caso à direita ✓



Pois $F_{13} > F_{23}$

$|\vec{F}_{13}| = |\vec{F}_{23}|$

$\Leftrightarrow \left|\cancel{k}\dfrac{|q_1||\cancel{q_3}|}{a^2}\right| = \left|\cancel{k}\dfrac{|q_2||\cancel{q_3}|}{(L+a)^2}\right|$

$\Leftrightarrow^{*} \dfrac{1\times10^{-6}}{a^2} = \dfrac{3\times10^{-6}}{(0{,}10+a)^2}$

$\Leftrightarrow a^2 + 0{,}2a + 0{,}01 = 3a^2$

$\Leftrightarrow -2a^2 + 0{,}2a + 0{,}01 = 0$

$\Leftrightarrow a = 0{,}1366 \ \vee\ a \simeq -0{,}0366$

como $\underline{\underline{a > 0}}$

$a \simeq 14\ cm$

R: $a = +14\ cm$, $y = 0$

* ou:

$\dfrac{(0{,}10+a)^2}{a^2} = 3$

$\Leftrightarrow \left(\dfrac{0{,}10+a}{a}\right)^2 = 3$

$\Leftrightarrow \left(\dfrac{0{,}10+a}{a}\right) = \pm\sqrt{3}$

$\Leftrightarrow \dfrac{\cancel{a}\left(\dfrac{0{,}10}{a}+1\right)}{\cancel{a}} = \pm\sqrt{3}$

$\dfrac{0{,}10}{a} + 1 = \pm\sqrt{3}$

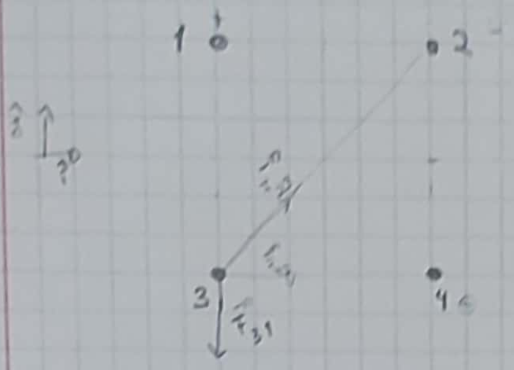
$\Leftrightarrow \dfrac{0{,}10}{a} = \pm\sqrt{3} - 1$

$\Leftrightarrow a = 0{,}1366$ ✓

$a = -0{,}0366$

9) $q_1 = -q_2 = 100\ mC$

$q_3 = -q_4 = 200\ mC \qquad a = 5{,}0\ cm = 5 \times 10^{-2}\ m$



$d = \sqrt{2a^2}$
$= \sqrt{2}\, a$
$= 0{,}07$

$\theta = 45^\circ$

$$\vec{F}_3 = \vec{F}_{q_1 q_3} + \vec{F}_{q_2 q_3} + \vec{F}_{q_4 q_3}$$

$$= \frac{k\,|q_1| \times |q_3|}{a^2}(-\hat{j}) + F_{q_2 q_3} \cos\theta\,(\hat{i}) + F_{q_2 q_3} \sin\theta\,(\hat{j}) + \frac{k\,|q_4 q_3|}{a^2}(\hat{i})$$

$$= 0{,}072(-\hat{j}) + \vec{F}_{q_2 q_3}\cos\theta + \vec{F}_{q_2 q_3} \times \sin\theta + 0{,}114\,(\hat{i})$$

$$= 0{,}072(-\hat{j}) + 0{,}114(\hat{j}) + 0{,}026(\hat{i} + \hat{j})$$

$$= 0{,}17\,(\hat{i}) + 0{,}046\,(-\hat{j})$$

$$|\vec{F}_{q_3}| = \sqrt{0{,}17^2 + 0{,}046^2} \simeq 0{,}176$$

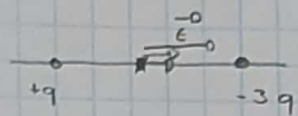
$$\tan\alpha = \frac{0{,}046}{-0{,}17} = -0{,}27$$

$$\alpha = -15^\circ \qquad (\alpha \in [-90, 90])$$

Ficha 2 → Eletromagntismo

3] a)

No Meio:



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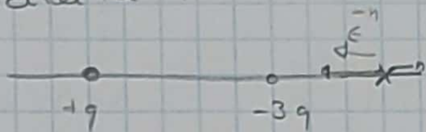
À direita:



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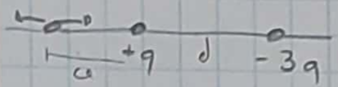
Mas a força sentida da partícula "-3q" será sempre maior do que a partícula "+q".

À Esquerda:



✓

b)

$$|\vec{E}| = \frac{k\,|q|}{r^2} \qquad |\vec{E}| = 0\ ?$$

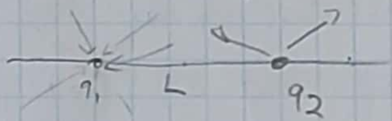
$$|\vec{E}| = |\vec{E}_{pq_1}| + |\vec{E}_{pq_2}|$$

$$= \frac{k\,|-1|}{a^2}(-\hat{i}) + \frac{k\,|3|}{(a+d)^2}$$

$$= k\left(-\frac{1}{a^2} + \frac{3}{a^2+2ad+d}\right)$$

Não será possível.

8] $q_1 = -5{,}00\ q \qquad q_2 = +2{,}00\ q$



O campo poderá ser Nulo à direita de q_2

$$|\vec{E}| = |\vec{E}_{pq_1}| + |\vec{E}_{pq_2}|$$

$$\Leftrightarrow -|\vec{E}_{pq_1}| = +|\vec{E}_{pq_2}|$$

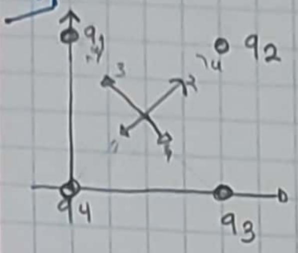
$$\Leftrightarrow \frac{\cancel{k}\,|q_1|}{a^2} = \frac{\cancel{k}\,|q_2|}{(a-L)^2}$$

$$\Leftrightarrow \frac{5}{a^2} = \frac{2}{a^2-2La+L^2}$$

$$\Leftrightarrow 5(a^2-2La+L^2) = 2a^2$$

$$\Leftrightarrow a = 2.7\,L$$

9)



$q_1 = +10\ mC$
$q_2 = -20\ mC$
$q_3 = 20\ mC$
$q_4 = -10\ mC$

$a = 5\ cm = 0{,}05\ m$

$d^2 = \left(\frac{a}{2}\right)^2 + \left(\frac{a}{2}\right)^2$

$\Leftrightarrow d^2 = \frac{2a^2}{4}$

$= 1{,}25 \times 10^{-3}$

Eixo do "x":

$$|E_p| = \frac{k\,|-20|}{d^2}(\hat{i}) + \frac{k\,|-10|}{d^2}(-\hat{i})$$

$$= k\left(\frac{20-10}{d^2}\right) \times 10^{-9} = 72\ 000\ N/C$$

Eixo do "y":

$$E_p = \frac{k\,|20 \times 10^{-9}|}{d^2}(+\hat{y}) + \frac{k\,|10 \times 10^{-9}|}{d^2}(-\hat{y})$$

$$= \frac{k}{d^2} \times 10^{-9}\ (+20-10)$$

$$= \frac{k}{d^2} \times 10^{-9}\ (+10) = +72\ 000\ N/C$$

converter os ângulos

$$E_p = 72\ 000 \times (\cos 45 + \operatorname{sen} 45) + 72000\ (\cos 135 + \operatorname{sen} 135)$$

$$= \underbrace{72000\ (\cos 45 + \cos 135)}_{0} + 72000\ (\operatorname{sen} 45 + \operatorname{sen} 135)$$

$$= 0 + 72000\ (2 \times \operatorname{sen} 45)(\hat{y})$$

$$= 101823 \approx 1{,}02 \times 10^5 (\hat{y})\ N$$

Exercício das 8 cargas: ②

Visto haver simetria:

$$|\vec{E}_0| = |\vec{E}_{0\,q_7}| + |\vec{E}_{0\,q_3}|$$

$$= \frac{k}{r}|1\times10^{-6}|(\hat{i}) + \frac{k}{r}|-1\times10^{-6}|(\hat{i})$$

$$= \frac{k}{r}\times 2\times 1\times10^{-6}$$

$$= \frac{9\times10^{9}\times10^{-6}\times2}{1} = 18\times10^{3} = 18\,000\ \frac{N}{C}$$

c)

$$\vec{F}_{protão} = q_{protão}\,\vec{E}_0$$

$$= 1,6\times10^{-19}\times18\,000\ (\hat{i})$$

$$= 2,9\times10^{-15}\ (\hat{i})\ N$$

Extra 2:

$$\vec{F} = q\vec{E} = |\vec{a}|\,m$$

a)

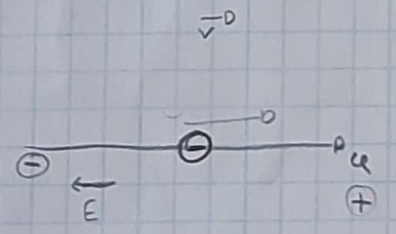
$$F = |q||\vec{E}| = |\vec{a}|\,m$$

$$\Leftrightarrow |a| = \frac{1,6\times10^{-19}\times1000}{9,1\times10^{-3}}(-\hat{i}) = 1,76\times10^{13}\ m/s^2\ (-\hat{i})$$

b)

A velocidade não se anulará.

$$\left(\begin{array}{l}\vec{E} = -100\,\hat{i}\ N/C \\ \vec{a} = -1,76\times10^{13}\ m/s^2\,(\hat{i})\end{array}\right)$$



46) $v = 5,00 \times 10^8\ cm/s = 5,00 \times 10^6\ m/s$

$\vec{E} = 1,00 \times 10^3\ N/C$

$\vec{F} = |q| \times |\vec{E}| = m\vec{a} \Leftrightarrow |\vec{a}| = \frac{1,6 \times 10^{-19} \times 1 \times 10^{3}}{9,1 \times 10^{-3}}$

$= 1,76 \times 10^{14}\ m/s^2$

$\begin{cases} v = v_0 - at \\ x = x_0 + v_0 t - \frac{1}{2}at^2 \end{cases} \Leftrightarrow \begin{cases} 0 = v_0 - at \\ x = 0 + v_0 t - \frac{1}{2}at^2 \end{cases}$

$\Leftrightarrow \begin{cases} t = 2,8 \times 10^{-8}\ s \\ x = 7,12 \times 10^{-2}\ m \end{cases}$

c → $8,00\ mm = 8 \times 10^{-3}\ m$

$\begin{cases} v = 5,00 \times 10^6 - at \\ 8 \times 10^{-3} = 5,00 \times 10^6 t - \frac{1}{2} \times 1,76 \times 10^{14} t^2 \end{cases} \Leftrightarrow \begin{cases} v = 4,7 \times 10^6 \\ t = 1,65 \times 10^{-9} \end{cases} \vee \begin{cases} v = -4,7 \times 10^6 \\ t = 5,52 \times 10^{-8} \end{cases}$

Teríamos $t = 1,65 \times 10^{-9}$, $v = 4,71 \times 10^6$ e $v = -4,72 \times 10^6$, $t = 5,52 \times 10^{-8}$

Mas como ele nunca chega a inverter o movimento, só teremos $v = 4,7 \times 10^6$ e $t = 1,65 \times 10^{-9}$

$E_{ci} \times \%\text{perdida} = |\Delta E_c|$

$\Leftrightarrow \cancel{\frac{1}{2}m} v_i^2 \times \%\text{perdida} = \left|\cancel{\frac{1}{2}m}(v_f^2 - v_i^2)\right|$

$\Leftrightarrow \%\text{perdida} = \left|\frac{v_f^2 - v_i^2}{v_i^2}\right|$

$\Leftrightarrow \%\text{perdida} = \left|\frac{4,71^2 - 5^2}{5^2}\right| \frac{\cancel{\times 10^6}}{\cancel{10^6}} \simeq 0,1126$

$\simeq 11,26\ \%$

~ // ou = //

* Em $x = 7,12 \times 10^{-2}\ m$ ele perde 100 % de E_c

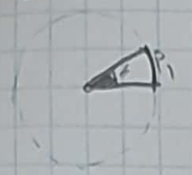
logo $7,12 \times 10^{-2}$ — 100 %

8×10^{-3} — x

$\Leftrightarrow x = 11,2\ \%$

Digitalizada com CamScanner

22) $Q = -300e$ $r = 4,00$ cm $\alpha = 40°$



$$L = P_1 = \frac{2\pi r}{\left(\frac{360}{40}\right)} \simeq 2,8 \times 10^{-2} \text{ m}$$

$$Q = \lambda L \Leftrightarrow \lambda = \frac{-300e}{2,8\times10^{-2}} = 1,71 \times 10^{-15} \text{ C/m}$$

b)

$Q = -300\,e$ $r = 2,00$ cm

$Q = \sigma A$ $A = \pi r^2$

$$\sigma = \frac{-300e}{\pi(2\times10^{-2})^2} \simeq -3,82 \times 10^{-14} \text{ C/m}^2$$

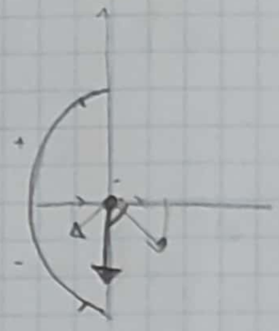
c) $Q = \sigma A$ $A = 4\pi r^2$

$$\sigma = \frac{-300e}{\pi 4 r^2} = -9,56\times10^{-15} \text{ C/m}^2$$

d) $Q = \rho V$ $V = \frac{4}{3}\pi r^3$

$$\rho = \frac{-300\,e}{\frac{4}{3}\pi r^3} \simeq -1,43\times10^{-12} \text{ C/m}^3$$

24 $r = 5,00$ cm $+q = 4,50\ pC$
$-q = -4,50\ pC$



$|\vec{E}| = \frac{k |q|}{r^2}$

$dq = \lambda . ds$

$|E| = \int dE = \int_{\theta_i}^{\theta_f} \frac{k\ dq}{r^2} \sin\theta$

$ds \to r.d\theta$

$= \int_{\theta_i}^{\theta_f} \frac{k\ \lambda\ ds}{r^2} \sin\theta$

$= \int_{\theta_i}^{\theta_f} \frac{k\ \lambda\ r\, d\theta}{r^2} \sin\theta$

$= \frac{k\lambda}{r} \int_{\theta_i}^{\theta_f} \sin\theta\ d\theta$

$\lambda = \frac{-q}{\frac{1}{4} 2\pi r}$

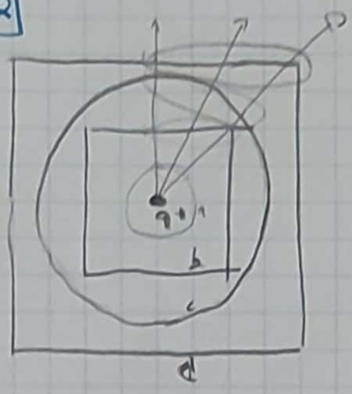
$= -\frac{k\ 2q}{\pi r^2} \cos\theta \Big|_{0°}^{90°}$

$= -\frac{k\ 2q}{\pi r^2} \left[\cos 90 - \cos 0 \right]$

$= \frac{k\ 2q}{\pi r^2} \approx 20.6\ (-\hat{j})\ \frac{N}{C}$

Ficha 3 → Eletromagnetismo

2)



a → $\phi_{E(a)} = \phi_{E(b)} = \phi_{E(c)} = \phi_{E(d)}$

d) $E = \frac{kq}{r^2}$, logo:

$E_a > E_b > E_c > E_d$; Módulo é constante em qualquer ponto da superfície de a e c, e varia de ponto nas superfícies b e d

1)

$E_r = \frac{kq}{r^2}$ $\quad \cdot\ E_{esfera} = \frac{kQ}{R^2}$

$\cdot\ E_{casca\ menor} = \frac{k(3Q+Q)}{(2R)^2} = \frac{k\cancel{4}Q}{\cancel{4}R^2}$

$\cdot\ E_{casca\ maior} = \frac{k(3Q+Q+5Q)}{(3R)^2} = \frac{k\cancel{9}Q}{\cancel{9}R^2}$

Pelo que, $E_{esfera} = E_{casca\ menor} = E_{casca\ maior} = \frac{kQ}{R^2}$

4) $a = 3\ m$ $\quad \vec{E}_{face\ superior} = -34\,\hat{k}\ \frac{N}{C}$

$\vec{E}_{face\ inferior} = +20\,\hat{k}\ \frac{N}{C}$

$\phi = \int |\vec{E}|_{face\ superior}\, dA + \int |\vec{E}|_{face\ inf.}\, dA$

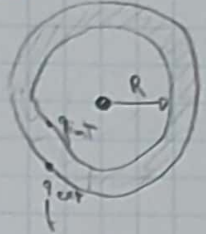
$= 34 \times 3^2 + 20 \times 3^2 = 486$

$\phi = \frac{q_{int}}{\varepsilon_0}$

$\Leftrightarrow q_{int} = \cdot\,\phi \times \varepsilon_0$

$\Leftrightarrow q_{int} = -486\,\varepsilon_0 = -4{,}3 \times 10^{-9}\ C = -4.3\ mC$

6]



$$\phi_E = \int \vec{E}\, d\vec{A} = \int |E|\,|dA| \underbrace{\cos(\widehat{E, dA})}_{0}$$

$$= \int |E|\,|dA| = E\, A_0 = E\, 4\pi r^2$$

$E \underbrace{4\pi r^2}_{\neq 0} = 0 \Leftrightarrow E = 0 \Leftrightarrow \frac{q_{int}}{\varepsilon_0} = 0 \Leftrightarrow q_{int} = 0$ △

$q_{int} = (q_A + q_{f\,int}) = 0$

① $+4 + q_{f\,int} = 0$

$\Leftrightarrow q_{ext} = -4$

② $q_{\_} - 6 + q_{f\,int} = 0$

$\Leftrightarrow q_{f\,int} = 6$

③ $+16 + q_{f\,int} = 0$

$\Leftrightarrow q_{f\,int} = -16$

a] 2, 13

b] $q_B = q_{f\,int} + q_{f\,ext}$

① $0 = +4 + q_{ext}$

$\Leftrightarrow q_{ext} = 4$

② $10 = +6 + q_{f\,ext}$

$\Leftrightarrow q_{f\,ext} = +4$

③ $-12 = -16 + q_{f\,ext}$

$\Leftrightarrow q_{f\,ext} = 4$

logo são todos iguais

18) superfícies fechadas, logo $\phi_E = \int \vec{E}\, d\vec{a} = \frac{q_{int}}{\varepsilon_0}$

$\phi_E\ (0 < r < r_1) = -1{,}8\ \phi$

$\phi_E\ (r_1 < r < r_2) = 0$

$\phi_E\ (r_2 < r < r_3) = +0{,}8\ \phi$

$\phi_E\ (r_3 < r < r_4) = 0$

$\phi_E\ (r > r_4) = -0{,}4\ \phi$

$q_{int} = \phi_E\ \varepsilon_0$

→ Q central: $q_{int} = (-1{,}8 \cdot \phi)\ \varepsilon_0 = -8\ uC$

Q A: $(q_{\text{ponto central}} + q_a) = 0{,}8\ \phi\ \varepsilon_0 \Leftrightarrow q_A = +12\ uC$

Q B: $(q_{\text{ponto central}} + q_A + q_B) = -0{,}4\ \phi\ \varepsilon_0 \Rightarrow q_B = -5{,}3\ uC$

$\begin{cases} Q \text{ sup. ext } A = 12 - 8 = 4\ u.C \\ Q \text{ sup ext } B = 12 - 8 - 5{,}3 = -1{,}3\ u.C \end{cases}$

50) $\phi_E = \int \vec{E} \cdot d\vec{a} = \frac{q_{int}}{\varepsilon_0} \Leftrightarrow E\, 4\pi r^2 = \frac{q_{int}}{\varepsilon_0} \Leftrightarrow E = \frac{q_{int}}{4\pi r^2\, \varepsilon_0}$

$E\ (r \leq a) = 0$

$V = \frac{4}{3}\pi r^3$

a) $E(r=0) = 0$

b) $E\left(r = \frac{a}{2{,}00}\right) = 0$

$V = \frac{\pi 4}{3} \times (r^3 - a^3)$

c) $E(r = a) = 0$

$q_{int} = \rho V$

$$\boxed{E\ (a < r \leq b) = \frac{\rho V}{4\pi r^2 \varepsilon_0} = \frac{\rho\ \cancel{\pi} \times \cancel{4}\ (r^3 - a^3)}{\cancel{4}\cancel{\pi}\ r^2\ \varepsilon_0 \times 3}}$$

d) $E_{(r = 1{,}50a)} = \frac{\rho\ (1{,}50a)^3 - a^3}{3\ \varepsilon_0 \times (1{,}50\ a)^2} = \frac{4{,}32 \times 10^{-12}}{5{,}97 \times 10^{-12}} \simeq 7{,}32\ N/C$

$a = 10cm = 0{,}1\ m$

$\rho = 1{,}84\ nC/m^3 = 1{,}84 \times 10^{-9}\ C$

e) $E_{(r=b)} = \frac{\rho\ (2a)^3 - a^3}{3\ \varepsilon_0 \times (2a)^2} = \frac{\rho\ 7\ a^{\cancel{3}}}{3 \times \varepsilon_0 \times 4\ \cancel{a^2}}$

$\simeq 12{,}1\ N/C$

b)

$$E(r \geq b) = \frac{q_{int}}{4\pi r^2 \varepsilon_0} = \frac{\rho \cancel{4\pi} (b^3 - a^3)}{\cancel{4\pi}\, 3 r^2 \varepsilon_0}$$

$q_{int} = \rho V$

$$V = \frac{4\pi}{3} \times (b^3 - a^3)$$

$$E(r=3b) = \frac{\rho (8a^3 - a^3)}{3 \times 9 b^2 \varepsilon_0} = \frac{\rho\, 7 a^{\cancel{3}}}{3 \times 9 \cancel{b^2} \varepsilon_0} \approx 1{,}35 \frac{N}{C}$$

Ficha 4

P4)

$W_{e\,(A \to B)} = 3{,}94 \times 10^{-19}\,J$ Eletrão $= q = -e$

- $V_B - V_A = \Delta V^{A-B} = \frac{-W_q^{A\to B}}{q} = \frac{-3{,}94 \times 10^{-19}}{-e} = 2{,}4625\,V$

- $V_C - V_A = \Delta V^{C-A} = \frac{-W_q^{C\to A}}{q}$

Assim só depende da posição final e inicial. Então podemos ir de A para C por qualquer percurso que o resultado será o mesmo.

$V_B - V_A = \Delta^{A-B} = 2{,}4625$

$V_C - V_B = \Delta^{B-C} = 0$

$V_{C-A} = (\Delta^{A-B} + \Delta^{B-C})$

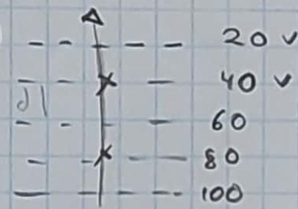
$= 2{,}4625 + 0$

$= 2{,}4625\,J$

- $V_C - V_B = = \Delta^{B-C} = 0$, porque B e C estão na mesma linha equipotencial.

Q4)

(1)

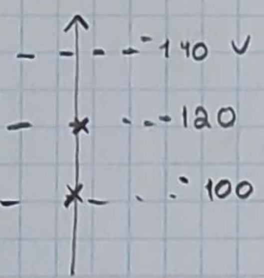


$40 - 80 = -\int_A^B \mathcal{E}\, d r$

$(\Leftrightarrow) -40 = -E\, d_{AB}$

$(\Leftrightarrow) E = \frac{40}{2d} = \frac{20}{d}$

(2)

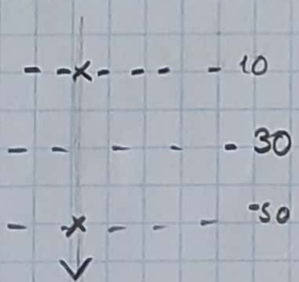


$-120 - (-100) = \int_A^B E_2\, d r$

$(\Leftrightarrow) -20 = -E_2\, d_{AB}$

$(\Leftrightarrow) E_2 = \frac{20}{2d} = \frac{10}{d}$

(3)



$-10 - (-50) = \int_A^B E_3\, d r$

$(\Leftrightarrow) 40 = E_3\, d_{AB}$

$(\Leftrightarrow) E_3 = \frac{40}{4d} = \frac{10}{d}$

a) 1, 2 = 3

b) 3

25

a) Será Maior.

b) O trabalho realizado pela força usada para deslocar a esfera A será positiva.

c) Será Negativo

d) O trabalho não depende da trajetória, logo será igual.

15

$$V_p = \sum_{1}^{4} \frac{kQ}{r}$$

$$= k \times \left(\frac{-q}{d} + \frac{q}{d} - \frac{q}{d} - \frac{-q}{2d} \right)$$

$$= k \times \left(\frac{2q}{2d} - \frac{q}{2d} \right) = \frac{kq}{2d} = 5{,}62 \times 10^{-4}\, V$$

34

a) $V = 1500\, x^2$ $\qquad x = 1{,}3\ cm$

$V(x) = 1500\, x^2$

$$\Delta V^{A\to B} = -E \int_A^B dr$$

$$\vec{E} = -\overrightarrow{grad}\, V$$

$$= -\left(\frac{\partial V}{\partial x} + \frac{\partial V}{\partial y} + \frac{\partial V}{\partial z} \right)$$

Como V é em função do x:

$$= -\frac{\partial V}{\partial x}$$

$$= \frac{-\partial(1500\, x^2)}{\partial x} = -3000\, x\ ;$$

Logo $|\vec{E}(x = 1{,}3 \times 10^{-2})| = +39\ \frac{N}{C}$

b) O campo elétrico aponta para a placa 1.

?

6 $\vec{E} = \left| -\frac{\partial V}{\partial x} \right|$ $\qquad$ a) $|E_2|, > |E_4| > |E_1| = |E_3| = |E_5|$

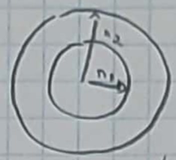
b) Negativo, $\frac{\uparrow}{i}$ $\qquad$ c) Positivo, $\frac{\uparrow}{i}$

Ficha 5

6)

$r_1 = 38,0\ mm$

$r_2 = 40,0\ mm$



??

$$C = \frac{Q}{V_c} = \frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0\, 4\pi r_1 r_2}{(40-38)\times10^{-2}} = 84,5\ pF$$

b)

$$C = \frac{A\varepsilon_0}{d} \qquad C_{total} = C_1 + C_2 = 2C_1$$

$C\ total = 84,5\ pF$

$C_1 = C_2 = 42,25\ pF$

$$A_{placa} = \frac{C \times d}{\varepsilon_0} = 191\ cm^2$$

14)

$V_{c_1} = V_{c_2} \qquad C_1 = C_2 = 6,0\ \mu F \qquad V_{Bateria} = 10\ V$

$Q_{total} = C_1V_1 + C_2V_2 = 120\ \mu C$

$Q_1 = Q_2 = 60\ \mu C$

$d_1 = d$ e $d_2 = \frac{d}{2}$

$$C_2 = \frac{\varepsilon A}{\frac{d}{2}} = 2\times\frac{\varepsilon A}{d} = 2\times C_{2\,antes}$$

$$\begin{aligned} Q\ total &= C_1V_1 + C_2V_2 \\ &= C_{1\,antes}V_{1\,antes} + 2\,C_{2\,antes}V_2 \\ &= 60 + 2\times10\times6 \\ &= 60 + 60\times2 \\ &= 3\times60 \end{aligned}$$

R: $3\times60 - 2\times60 = \underline{\underline{60}}\ \mu C$

b) $\Delta Q = 60 \mu C$

15) $C_1 = 100\ pF = 100 \times 10^{-12} F$

$V_{C_1} = 50 V$

Antes: $Q = V \times C = 50 \times 100 \times 10^{-12} = 5 \times 10^{-9}$

Início	Final
$V_{C_1} = 50 V$	$V_{C_1} = V_{C_2} = 35 V$
$V_{C_2} = 0$	

$Q_{total} = 5 \times 10^{-9}$

$= Q_1 + Q_2$

$\Leftrightarrow 5 \times 10^{-9} = 35 \times 100 \times 10^{-12} + Q_2$

$\Leftrightarrow Q_2 = 1,5 \times 10^{-9}$

$\Leftrightarrow V_2 C_2 = 1,5 \times 10^{-9}$

$\Leftrightarrow C_2 \simeq 4,29 \times 10^{-11}$

$= 43 \times 10^{-12}$

$= 43\ pF$

19) $C_1 = 1,0 \mu F$ $\quad C_2 = 3,0 \mu F$ $\quad V_1 = V_2 = 100 V$

Início:

$|Q_1| = 100 \mu F$

$|Q_2| = 300 \mu F$

$|Q_{Total\ início}| = 200 \mu F$

Final:

$Q_{total} = 200 \mu F$

$C_{eq} = C_1 + C_2 = 4 \mu F$

$V = \frac{200}{4} = 50 V$

$V = \frac{Q}{C}$

$\Leftrightarrow Q = V C$

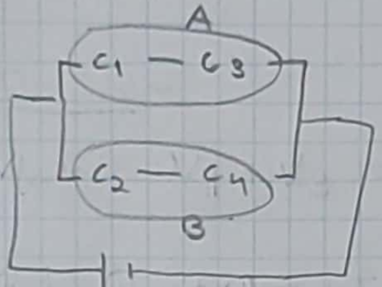
b) $V_1 = 50$

$Q_1 = 50 \times 1 = 50 \mu C$

c) $Q_2 = 50 \times 3 = 150 \mu C$

27| $V_{bateria} = 12{,}0\,V$

$C_1 = 1{,}0\,\mu F \quad C_2 = 2{,}00\,\mu F \quad C_3 = 3{,}00\,\mu F \quad C_4 = 4{,}00\,\mu F$



$V_A = V_B = V_{fonte}$

$Q_{total} = Q_A + Q_B$

$C_{eq} = C_A + C_B$

$= \frac{3}{4} + \frac{4}{3} = \frac{25}{12}$

- $Q_1 = Q_3$
- $V_A = V_{C_1} + V_{C_3}$
- $\frac{1}{C_A} = \frac{1}{C_1} + \frac{1}{C_3}$

$\Leftrightarrow \frac{1}{C_A} = \frac{1}{1} + \frac{1}{3}$

$\Leftrightarrow \frac{1}{C_A} = \frac{4}{3} \Leftrightarrow C_A = \frac{3}{4}$

- $Q_2 = Q_4$
- $V_B = V_{C_2} + V_{C_4}$
- $\frac{1}{C_B} = \frac{1}{C_2} + \frac{1}{C_4}$

$\Leftrightarrow \frac{1}{C_B} = \frac{1}{2} + \frac{1}{4}$

$\Leftrightarrow \frac{1}{C_B} = \frac{3}{4} \Leftrightarrow C_B = \frac{4}{3}$

$V_A = V_{C_1} + V_{C_3}$

$\Leftrightarrow 12 = \frac{Q_1}{C_1} + \frac{Q_3}{C_3}$

$\Leftrightarrow 12 = \frac{Q_1}{1} + \frac{Q_1}{3}$

$\Leftrightarrow 12 = \frac{3Q_1}{3} + \frac{Q_1}{3}$

$\Leftrightarrow \frac{12 \times 3}{4} = Q_1$

$\Leftrightarrow Q_1 = Q_3 = 9\,\mu C$

$V_B = V_{C_2} + V_{C_4}$

$\Leftrightarrow 12 = \frac{Q_2}{2} + \frac{Q_4}{4}$

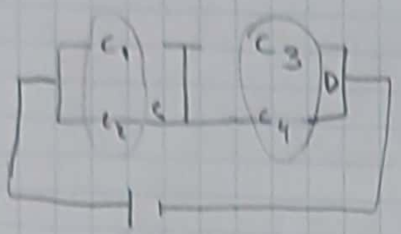
$\Leftrightarrow 12 = \frac{2Q_2}{4} + \frac{Q_2}{4}$

$\Leftrightarrow \frac{4 \times 12}{3} = Q_2$

$\Leftrightarrow Q_2 = Q_4 = 16\,\mu C$

a) b) c) d) $Q_1 = Q_3 = 9\,\mu C$ e $Q_2 = Q_4 = 16\,\mu C$

2) b) 3) h)



$V_{c_3} = V_{c_4}$

$V_{c_1} = V_{c_2}$

$Q_c = Q_1 + Q_2$

$Q_D = Q_3 + Q_4$

$Q_{total} = Q_C = Q_D$

25

$Q_C = 25 = Q_1 + Q_2$

$\Leftrightarrow 25 = V_1 C_1 + V_2 C_2$, $V_2 = V_1$

$\Leftrightarrow 25 = V_1 (C_1 + C_2)$

$\Leftrightarrow \frac{25}{3} = V_1 \Leftrightarrow V_1 = 8,33\ \mu C$

$Q_1 = 8,33\ \mu C$

$Q_2 = 8,33 \times 2 = 16,66\ \mu C$

$Q_D = 25 = Q_3 + Q_4$, $V_4 = V_3$

$\Leftrightarrow 25 = V_3 C_3 + V_4 C_4$

$\Leftrightarrow 25 = V_3 (C_3 + C_4)$

$\Leftrightarrow V_3 = V_4 = \frac{25}{7} \simeq 3,57$

$Q_3 = 10,71\ \mu C$

$Q_4 = 14,28\ \mu C$

R: $Q_1 = 8,33\ \mu C$ $Q_2 = 16,66\ \mu C$

$Q_3 = 10,71\ \mu C$ $Q_4 = 14,28\ \mu C$

21|
$A_1 = 1{,}5\ cm^2 = 1{,}5 \times 10^{-4}\ m^2$ $|\vec{E}_1| = 2000\ V/m$

$A_2 = 0{,}70\ cm^2 = 0{,}70 \times 10^{-4}\ m^2$ $|\vec{E}_2| = 1500\ V/m$

$$E = \frac{\sigma}{\varepsilon_0} \rightsquigarrow \frac{Q}{A}$$

$E_1 = 2000$

$\Leftrightarrow 2000 = \frac{Q_1}{A \times \varepsilon_0} \Leftrightarrow Q_1 = 2000 \times A \times \varepsilon_0 \simeq 2{,}655 \times 10^{-12}$

$E_2 = 1500$

$\Leftrightarrow 15000 = \frac{Q_2}{A \times \varepsilon_0} \Leftrightarrow Q_2 = 1500 \times A \times \varepsilon_0 \simeq 9{,}2925 \times 10^{-13}$

$Q\,total = Q_1 + Q_2 \approx 3{,}6 \times 10^{-12}\ C = \underline{\underline{3{,}6\ pC}}$

42| $C = 1{,}3\ pF$ $d' = 2d$ $C' = 2{,}6\ pF$ $\boxed{\text{Cera}}$

$$C_{Ar} = \frac{\varepsilon_0 A}{d} = 1{,}3$$

$$C_{cera} = \frac{\varepsilon_0 A\ k}{d'} = \frac{k}{2} \frac{\varepsilon_0 A}{d} = \frac{k}{2} C_{ar}$$

$\Leftrightarrow 2{,}6 = \frac{k}{2} \times 1{,}3$

$\Leftrightarrow k = \frac{2 \times 2{,}6}{1{,}3}$

$\Leftrightarrow \underline{\underline{k = 4}}$

Ficha TP 6

1)

$I = 125\ \mu A = 125 \times 10^{-6}$ $I = \frac{\Delta Q}{\Delta T}$

$\Delta t = 23\ s$

$\Rightarrow \Delta Q = I \times \Delta t = 125 \times 10^{-6} \times 23$

$= 2{,}875 \times 10^{-3}\ C$

$Q = n e \Rightarrow n = \frac{Q}{e} = \frac{2{,}875 \times 10^{-3}}{1{,}6 \times 10^{-19}} \simeq 1{,}8 \times 10^{16}$ protões

2)

$P = 10\ W$

$V = 220$

$\Delta t = 12\ h$

$= 12 \times 60 \times 60\ s$

$P = V I$

$\Leftrightarrow I = \frac{P}{V} = \frac{1\cancel{0}}{22\cancel{0}}$

$I = \frac{\Delta Q}{\Delta t} \Rightarrow \Delta Q = I \times \Delta t$

$\Delta Q = \frac{1}{22} \times 12 \times 60 \times 60$

$\approx 1963\ C$

3)

$J = 440\ A/cm^2 = 440 \times 10^{-4}\ A/m^2$

$J = \frac{I}{\Delta A} = \frac{\Delta Q}{\Delta t\, \Delta A}$

$I = 0{,}5\ A$

$A = \pi r^2$

$440 \times 10^{-4} = \frac{0{,}5}{\pi r^2}$

$\Leftrightarrow r^2 \approx 3{,}62 \times 10^{-8} \Rightarrow r = 1{,}9 \times 10^{-4}$

$d = 2r = 3{,}8 \times 10^{-4}\ m = 0{,}38\ mm$

4)

$R = 50\ \Omega$ so $20°C$ $\alpha = 3,92 \times 10^{-3}\ C^{-1}$

$R: 76,8\ \Omega$

$R(T) = 76,8$

$\Leftrightarrow 76,8 = 50\left(1 + 3,92 \times 10^{-3}(T-20)\right)$

$\Leftrightarrow 1 + 3,92 \times 10^{-3}(T-20) = \frac{76,8}{50}$

$\Leftrightarrow T - 20 = \frac{\left(\frac{76,8}{50} - 1\right)}{3,92 \times 10^{-3}}$

$\Leftrightarrow T = \frac{\left(\frac{76,8}{50} - 1\right)}{3,92 \times 10^{-3}} + 20 \approx 156,7\ °C$

5)

$V = 75,0\ mV = 75 \times 10^{-3}\ V$ $I = 0,200\ mA = 0,2 \times 10^{-3}\ A$

$P = VI = 75 \times 10^{-3} \times 0,2 \times 10^{-3}$

$= 15 \times 10^{-6}\ W$

$= 15\ \mu W$

6)

$d = 1,0\ mm$

$L = 2.0\ m$

$R = 50\ m\Omega$

$R = \rho \frac{L}{A}$ $A = \pi r^2$

$= \pi \left(\frac{d}{2}\right)^2$

$\rho = \frac{R \times A}{L} = \frac{50 \times 10^{-3}}{2} \times \pi \left(\frac{1 \times 10^{-3}}{2}\right)^2$

$\approx 1,96 \times 10^{-8}\ \Omega\, m$

$\sigma = \frac{1}{\rho} = 5,09 \times 10^{7}\ \Omega^{-1} m^{-1}$

7

$L = 15\,m \qquad d = 2\,mm = 2\times10^{-3}\,m$

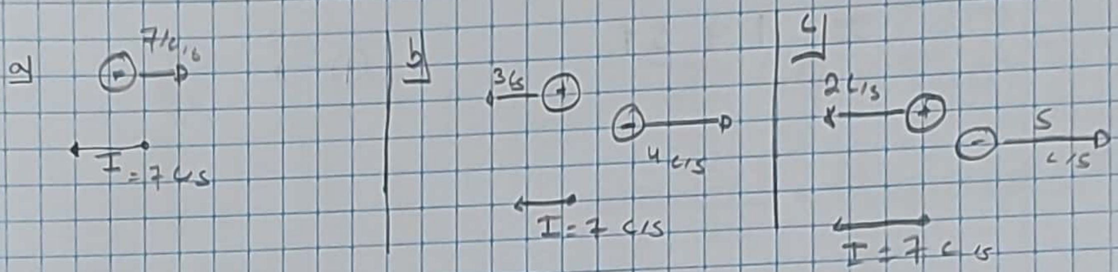
$I = 20\,A \qquad \sigma = 5,8\times10^{7}\,\Omega^{-1}\,m^{-1}$

$$\rho = \frac{R\times A}{L} \Rightarrow \sigma = \frac{L}{R\times A}$$

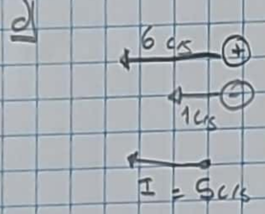
$$\Rightarrow R = \frac{15}{5,8\times10^{7}\times\pi\left(\frac{2\times10^{-3}}{2}\right)^2} \simeq 8,2\times10^{-2}\,\Omega$$

• $V = R\times I = 20\times 8,2\times10^{-2} = 1,65\,V$

Q1



d



$A = B = C < D$

Q10

a) $I = \frac{\Delta Q}{\Delta t}$ → Conservação da carga $I_A = I_B = I_C$

b) $J = \frac{I}{A}$, sabemos que o $I_A = I_B = I_C$
e $A_A > A_C > A_B$, pelo que
$J_A < J_C < J_B$.

c) $J = \sigma \vec{E} \Rightarrow \vec{E} = \frac{J}{\sigma}$ → constante e
como $J_A < J_C < J_B$, então
$E_A < E_C < E_B$.

25)

$V = 2{,}9\ V \qquad I = 0{,}30\ A$

$R = 1{,}1\ \Omega \quad (20°C) \qquad \alpha = 4{,}5\times10^{-3}\ C$

$R = 9{,}67$

$R(T) = 1{,}1\,(1 + 4{,}5\times10^{-3}\,(T - 20))$

$9{,}67 = 1{,}1\,(1 + 4{,}5\times10^{-3}\,(T - 20))$

$\Leftrightarrow 8{,}79 = (1 + 4{,}5\times10^{-3}(T - 20)$

$\Leftrightarrow 8{,}79 - 1 = 4{,}5\times10^{-3}\,(T - 20)$

$\Leftrightarrow T = \dfrac{8{,}79 - 1}{4{,}5\times10^{-3}} + 20$

$\Leftrightarrow T \simeq 1751$

49)

$L = 2{,}60\times10^{-6}\ m^2 \qquad V = 75{,}0 \qquad A = c\times l$

$\rho = 5{,}0\times10^{-7}\ \Omega m$

$R = \rho \dfrac{L}{A}$

- $P = 5000\ W$

$P = VI \Rightarrow P = \dfrac{V^2}{R} = \dfrac{V^2\times A}{\rho L}$

$\Rightarrow L = \dfrac{V^2 A}{\rho P} = 5{,}85\ m$

B

$V = 100\,V \qquad L = ?$

$L = \dfrac{V^2 A}{\rho P} = 10{,}4\ m$