L.EIC

#2.1

Física II

Exercícios das aulas práticas

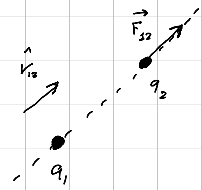
Quinta | 16h30 – 18h | B331

Diana Urbano | urbano@fe.up.pt

Tópicos: Capítulo:

Campo Elétrico #1

- $e \simeq 1{,}6 \times 10^{-19}\ C$
- $\vec{F}_{12} = k \dfrac{q_1 \cdot q_2}{r_{12}^2} \hat{r}_{12}$, $k = 9 \times 10^{9}\ N\, m^2\, C^{-2}$

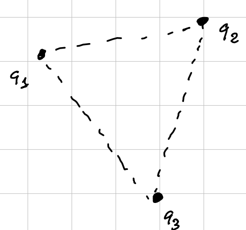


Paralelo à força gravítica:

$F_G = G \dfrac{m_1 \cdot m_2}{r^2}$, $G \simeq 10^{-11}\ N\, m^2\, kg^{-2}$

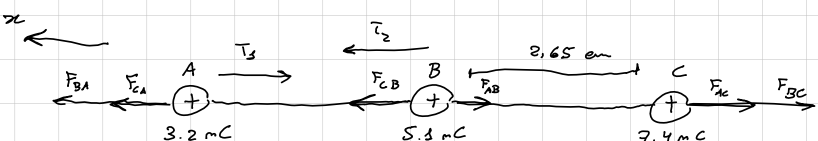
→ $q_1 \cdot q_2 > 0$ | Repulsão

→ $q_1 \cdot q_2 < 0$ | Atração



- Princípio da sobreposição
  $\vec{F}_2 = \vec{F}_{12} + \vec{F}_{32}$
  ...
- Campo elétrico
  $\vec{F} = q \vec{E}$
- $\vec{E}_p = k \dfrac{q}{r^2} \hat{r}$

5.



(a)

$F_A = F_{BA} + F_{CA} = k \left(\dfrac{5.1 \times 10^{-9} \times 3.2 \times 10^{-9}}{(2{,}65 \times 10^{-2})^2} + \dfrac{7{,}4 \times 10^{-9} \times 3.2 \times 10^{-9}}{(2 \times 2{,}65 \times 10^{-2})^2} \right) \simeq 2{,}85 \times 10^{-4}\ N$

$F_B = F_{CB} - F_{AB} = k \left(\dfrac{7{,}4 \times 10^{-9} \times 5{,}1 \times 10^{-9}}{(2{,}65 \times 10^{-2})^2} - \dfrac{3.2 \times 10^{-9} \times 5{,}1 \times 10^{-9}}{(2{,}65 \times 10^{-2})^2} \right) \simeq 2{,}75 \times 10^{-4}\ N$

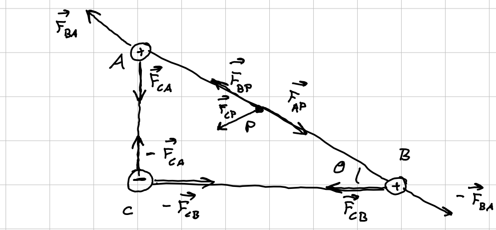
$F_C = -F_{AC} - F_{BC} = -k \left(\dfrac{3{,}2 \times 10^{-9} \times 7{,}4 \times 10^{-9}}{(2 \times 2{,}65 \times 10^{-2})^2} + \dfrac{5{,}1 \times 10^{-9} \times 7{,}4 \times 10^{-9}}{(2{,}65 \times 10^{-2})^2} \right) \simeq -5{,}60 \times 10^{-4}\ N$

(b) $a = 0$

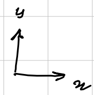
$\Sigma F = m a \Leftrightarrow F_A = -T_1 = -2{,}85 \times 10^{-4}\ N$

$\Leftrightarrow F_C = -T_2 = 5{,}60 \times 10^{-4}\ N$

8.



Não à escala

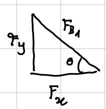


$$\sin\theta = \frac{\overline{AC}}{\overline{AB}} = \frac{1}{2} \Rightarrow \theta = 30^\circ$$

$$\|\vec{F}_{CA}\| = \left| k \frac{7\times10^{-9} \times (-5\times10^{-9})}{(1\times10^{-2})^2} \right| \simeq 335\times10^{-5}\ N \quad \begin{cases} \vec{F}_{CA} = (0, -315\times10^{-5})\ N \\ -\vec{F}_{CA} = (0, 315\times10^{-5})\ N \end{cases}$$

$$\|\vec{F}_{CB}\| = \left| k \frac{9\times10^{-9} \times (-5\times10^{-9})}{(\sqrt{3}\times10^{-2})^2} \right| \simeq 135\times10^{-5}\ N \quad \begin{cases} \vec{F}_{CB} = (-135\times10^{-5}, 0)\ N \\ -\vec{F}_{CB} = (135\times10^{-5}, 0)\ N \end{cases}$$

$$\|\vec{F}_{BA}\| = \left| k \frac{7\times10^{-9} \times 9\times10^{-9}}{(2\times10^{-2})^2} \right| \simeq 141\times10^{-5}\ N$$



$$\sin\theta = \frac{F_{BA,y}}{F_{BA}} \Leftrightarrow F_{BA,y} = \frac{141\times10^{-5}}{2} = 71\times10^{-5}\ N$$

$$\cos\theta = \frac{F_{BA,x}}{F_{BA}} \Leftrightarrow F_{BA,x} = \frac{141\times10^{-5}\times\sqrt{3}}{2} \simeq 122\times10^{-5}\ N$$

$$\vec{F}_{BA} = \begin{Bmatrix} -122\times10^{-5} \\ 71\times10^{-5} \end{Bmatrix} N \qquad -\vec{F}_{BA} = \begin{Bmatrix} 122\times10^{-5} \\ -71\times10^{-5} \end{Bmatrix} N$$

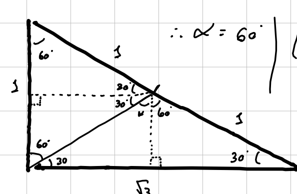
$$\vec{F}_A = \begin{Bmatrix} -122 \\ -244 \end{Bmatrix} \times10^{-5}\ N \qquad \vec{F}_B = \begin{Bmatrix} -13 \\ -71 \end{Bmatrix} \times10^{-5}\ N \qquad \vec{F}_C = \begin{Bmatrix} 135 \\ 315 \end{Bmatrix} \times10^{-5}\ N$$

//

$$\|\vec{F}_{AP}\| = \left| k \frac{7\times10^{-9}}{(1\times10^{-2})^2} \right| \simeq 63\times10^{4}\ N$$

$$\|\vec{F}_{BP}\| = \left| k \frac{9\times10^{-9}}{(1\times10^{-2})^2} \right| \simeq 81\times10^{4}\ N$$

$$\|\vec{F}_{CP}\| = \left| k \frac{-5\times10^{-9}}{(1\times10^{-2})^2} \right| \simeq -45\times10^{4}\ N$$



$\therefore \alpha = 60^\circ$

$\left(\frac{\sqrt{3}}{2}\right)^2 + \left(\frac{1}{2}\right)^2 = \overline{CP}^2$

$\overline{CP} = 1$

$$\vec{F}_P = \vec{E}$$

$$\vec{F}_{AP} = \begin{Bmatrix} 63\times\frac{1}{2} \\ -63\times\frac{\sqrt{3}}{2} \end{Bmatrix} \times10^{4}\ N \qquad \vec{F}_{BP} = \begin{Bmatrix} -81\times\frac{1}{2} \\ 81\times\frac{\sqrt{3}}{2} \end{Bmatrix} \times10^{4}\ N \qquad \vec{F}_{CP} = \begin{Bmatrix} -45\times\frac{\sqrt{3}}{2} \\ -45\times\frac{1}{2} \end{Bmatrix} \times10^{4}\ N$$

$$= \begin{Bmatrix} -48 \\ -102 \end{Bmatrix} \times10^{4}\ N/C$$

2.

$q_1 + q_2 = 10\ \mu C$

$r = 3\ mm$

$\hookrightarrow |F| = 24\ mN$

a) $$|q_1||q_2| = \frac{\overbrace{F k}^{1} r^2}{k} = 2{,}4 \times 10^{-11}$$

$$\begin{cases} q_1 + q_2 = 10 \times 10^{-6} \\ q_1 \cdot q_2 = 2{,}4 \times 10^{-11} \end{cases} \Leftrightarrow \begin{cases} q_1 = 10^{-5} - q_2 \\ 10^{-5} q_2 - q_2^2 = 2{,}4 \times 10^{-11} \end{cases}$$

$$\overset{\dots}{\Leftrightarrow} \begin{cases} |q_1| = 6 \times 10^{-6} \ \vee\ 4 \times 10^{-6} \\ |q_2| = 4 \times 10^{-6} \ \vee\ 6 \times 10^{-6} \end{cases} //$$

b) $$\begin{cases} q_1 + q_2 = 10 \times 10^{-6} \\ q_1 \cdot q_2 = -2{,}4 \times 10^{-11} \end{cases} \Leftrightarrow \begin{cases} q_1 = 10^{-5} - q_2 \\ 10^{-5} q_2 - q_2^2 = -2{,}4 \times 10^{-11} \end{cases}$$

$$\overset{\dots}{\Leftrightarrow} \begin{cases} q_1 = 12 \times 10^{-6} \ \vee\ -2 \times 10^{-6} \\ q_2 = -2 \times 10^{-6} \ \vee\ 12 \times 10^{-6} \end{cases} //$$

3.

$r = 5{,}3 \times 10^{-11}\ m$

$q = 1{,}602 \times 10^{-19}\ C$

$$E = \frac{k\,|q|}{r^2} \simeq 5{,}1 \times 10^{11}\ \frac{N}{C} //$$

4.

$E = 150\ \frac{N}{C}$

$m = 9{,}109 \times 10^{-31}\ kg$

$g = 9{,}8\ m/s^2$

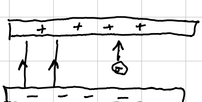
$q = 1{,}602 \times 10^{-19}\ C$

$$F_g = m \cdot g \simeq 8{,}93 \times 10^{-30}\ N$$

$$F_e = E q \simeq 2{,}403 \times 10^{-17}\ N$$

$$\frac{F_e}{F_g} \simeq 2{,}7 \times 10^{12} //$$

6.



$d = 2{,}0\ cm$

$\Delta t = 15\ \mu s$

$m = 9{,}109 \times 10^{-31}\ kg$

$q = 1{,}602 \times 10^{-19}\ C$

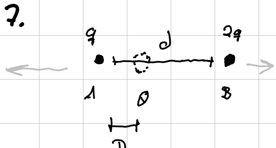
a) $$x = \frac{1}{2} a t^2 \Leftrightarrow a = \frac{2x}{t^2} \simeq 1{,}77 \times 10^{8}\ m/s^2$$

$$F = m a \simeq 1{,}62 \times 10^{-22}\ N$$

$$E = \frac{F}{q} \simeq 1{,}01 \times 10^{-3}\ \frac{N}{C} //$$

b) $$v = a t \simeq 2{,}67 \times 10^{3}\ m/s$$

7.



$$\frac{\cancel{q} Q}{D}\cancel{k} + \frac{2\cancel{q}\,Q}{d-D}\cancel{k} = \frac{2\cancel{q^2}}{d^2}\cancel{k} \Leftrightarrow \frac{Q}{D} + \frac{2Q}{d-D} = \frac{2q}{d^2}$$

$$\Leftrightarrow Q d^3 - Q D d^2 + 2Q d^2 = 2qDd - 2qD^2$$

??

9.

$q_1 = 300\ nC$

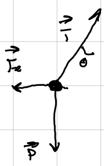
$q_2 = 500\ nC$

$m_1 = m_2 = m$

$L = 8\ cm$

$d = 15\ cm$

$\theta = 10^\circ$

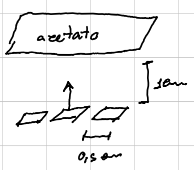


$$\begin{cases} T\cos\theta = m g \\ T\sin\theta = \dfrac{k\, q_1\, q_2}{d^2} \end{cases} \iff \begin{cases} m = \dfrac{T\cos\theta}{g} \\ T = \dfrac{k\, q_1\, q_2}{d^2 \sin\theta} \end{cases}$$

$$\cdots \iff \begin{cases} m \simeq 34{,}7\ g \\ T \simeq 0{,}346\ N \end{cases}$$

$\otimes$

1.



$80 g / m^2$

$$A = 0{,}005^2 = 2{,}5 \times 10^{-5}\ m^2$$

$$m = 80 \times 2{,}5 \times 10^{-5} = 0{,}002\ g \equiv 2 \times 10^{-6}\ kg$$

$$F_g = m g \simeq 1{,}96 \times 10^{-5}\ N \rightarrow F_e > 10^{-5}$$

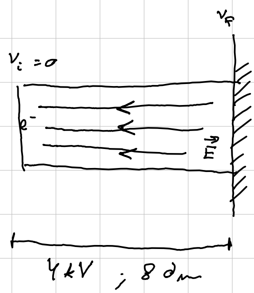
$$F_e = \frac{k\, Q\, Q}{r^2} \iff Q = \sqrt{\frac{F_e\, r^2}{k}} \simeq \underline{\underline{4{,}67 \times 10^{-10}\ C}}$$

Corrente

#2

2, 7 | 1, 3, 5, 8, 6 | 4, 9

2.



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

  $q < 0$, logo $\vec{F}$ é simétrica ao $\vec{E}$

- $W_{\vec{F}_{rest}} = \Delta E_c = \int_A^B \vec{F}_{res} \cdot d\vec{l}$
- $W_{\vec{F}_{rest}} = -\Delta U$, se conservativo

- $\Delta U = q\,\Delta V$

$\boxed{V}$ Energia de cada eletrão

a) $\Delta U = q\,\Delta V = -1{,}602 \times 10^{-19} \times 4 \times 10^{3} = -6{,}4 \times 10^{-16}$ J

$\Delta E_m = 0 \rightarrow \Delta E_c = -\Delta U = 6{,}4 \times 10^{-16}$ J

$\Delta E_c = \frac{1}{2} m v_f^2 - \cancel{\frac{1}{2} m v_i^2}$

$\Leftrightarrow v_f = \sqrt{2 \times 6{,}4 \times 10^{-16} \times \frac{1}{9{,}109 \times 10^{-31}}} \simeq 3{,}7 \times 10^{7}$ m/s

b) $\Delta V = \int_0^{0{,}8} E\, ds \Leftrightarrow \Delta V = 0{,}8\,E \Leftrightarrow E = \frac{4000}{0{,}8} \Leftrightarrow E = 5000$ V/m

1.

$\Delta V = 220$ V

$m = 9{,}109 \times 10^{-31}$ kg

$v_i = 0$

$\Delta U = q\,\Delta V = -1{,}6 \times 10^{-19} \times 220 = -3{,}52 \times 10^{-17}$ J

$\Delta E_m = 0 \rightarrow \Delta E_c = -\Delta U = 3{,}52 \times 10^{-17}$ J

$v_f = \sqrt{\frac{2\,\Delta E_c}{m}} = \sqrt{\frac{3{,}52 \times 10^{-17} \times 2}{9{,}109 \times 10^{-31}}} = 8{,}8 \times 10^{9}$ m/s

7.

a) $\Delta Q = \int_0^{10} I\,dt = 20t + t^3 \Big|_0^{10}$

$= 200 + 1000 = 1200$ mC $\equiv 1{,}2$ C

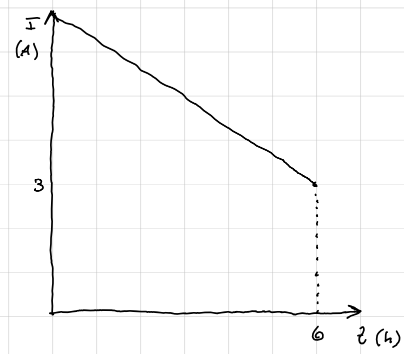
b) $\overline{I} \times 10 = 1{,}2$

$\Leftrightarrow \overline{I} = 0{,}12$ A $= 120$ mA

Fís. II

3. a) $60\ \%$ de $250\ Ah = 150\ Ah \equiv 5{,}4 \times 10^5\ C$

b)



$\Delta V = 12\ V$

$\Delta Q = 3 \times 6 \times 3600 + 4 \times 6 \times 3600 \times \frac{1}{2}$

$= 108000\ C$

$60\ \%$ —— $5{,}4 \times 10^5$

x —— $5{,}4 \times 10^5 + 1{,}08 \times 10^5$

$x = 72\ \%$

5. $40\ mA \mid 3\ V$ ou $2 \times \{1{,}5\ V \mid 8\ Ah\} = 28800\ C$

$P = I\,\Delta V = 0{,}040 \times 3 = 0{,}12\ W$

$I_{bat} = \dfrac{P}{\Delta V} = \dfrac{0{,}12}{3} = 0{,}04\ A$

$0{,}04\ C$ —— $1\ s$

$28800\ C$ —— x

$x = 720000\ s \equiv 200$ horas

6. $30\ A$, $230\ V$ $\}$ $P = 30 \times 230 = 6900\ W$

8. $\varepsilon = 1{,}5\ V \mid 9{,}6 \times 10^{21}$ eletrões durante 2 horas

a) $\Delta q = 1{,}602 \times 10^{-19} \times 9{,}6 \times 10^{21} = 1537\ C$

$\bar{I} = \dfrac{\Delta q}{\Delta t} = \dfrac{1537}{2 \times 3600} = 0{,}2136\ A \equiv 214\ mA$

b) $\Delta U = \Delta V \cdot \Delta q = 1{,}5 \times 1537 = 2306\ J \equiv 2{,}3\ kJ$

c) $\bar{P} = \Delta V \cdot \bar{I} = 1{,}5 \times 0{,}2136 \equiv 320\ mW$

d) $0{,}214 \times 2 = 0{,}428\ Ah$ gastas

Carga Final $= 3 - 0{,}428 = 2{,}57\ Ah$

4.

$\mathcal{E} = 1,2\ V$

$Q_{máx} = 2300\ mAh$

$\Delta U_{máx}$?

$Q_{máx} = 2,3\ Ah = 8280\ C$

$\Delta U_{máx} = Q_{máx} \cdot \mathcal{E} = 8280 \times 1,2 = 9936\ J$ //

9.

$T_{ideal} = 20\ °C$

$P = 132\ kJ / 1\ minuto$

$\Delta V = 220\ V$

12 cent. / kWh

$\Delta t = 10$ minutos

a) $P = 2200\ W$

$P = I\,\Delta V \Leftrightarrow I = \frac{2200}{220} = 10\ A$ //

b) $\Delta U = 2200 \times 10 \times 60 = 1320\ kJ = 0,37\ kWh$

custo $= 12 \times 0,37 = 4,4$ cêntimos //

Resistência

1.

$T_{inicial} = 12\,°C$

$\dfrac{R_{Final}}{R_{inicial}} = 1,1$

A 20 °C:

↳ $\rho_{cobre} = 17\ n\Omega\,m$

↳ $\alpha_{cobre} = 0,0039\ °C^{-1}$

$R_{20} = \rho \dfrac{L}{A} = 17 \times 10^{-9} \dfrac{L}{A}\ \Omega\,m$

$R_{12} = R_{20}\left(1 + \alpha_{20}\left(T - 20\right)\right)$

$= 17 \times 10^{-9} \dfrac{L}{A}\left(1 + 3,9 \times 10^{-3} \times (-8)\right)$

$= 16,5 \times 10^{-9} \dfrac{L}{A}\ \Omega\,m$

$R_{Final} = 1,1\ R_{12} = 18,1 \times 10^{-9} \dfrac{L}{A}\ \Omega\,m$

$R_{Final} = R_{20}\left(1 + \alpha_{20}\left(T_{Final} - 20\right)\right)$

$\Leftrightarrow \dfrac{18,1 \times \cancel{10^{-9}} \cancel{\frac{L}{A}}}{17 \times \cancel{10^{-9}} \cancel{\frac{L}{A}}} = 1 + 0,0039\left(T_{Final} - 20\right)$

$\Leftrightarrow T_{Final} \simeq 36,6\ °C$

$\therefore \Delta T = 36,6 - 12 = 24,8\ °C$

2.

$L_{inicial} = 1\ m$

$R_{inicial} = 0,3\ \Omega$

$L_{Final} = 2\ m$

$V_{inicial} = V_{Final}$

$\rho_{inicial} = \rho_{Final}$

$V_{inicial} = V_{Final} \Leftrightarrow A_i \times L_i = A_F \times L_F \Leftrightarrow A_i = 2 A_F$

$R_{inicial} = L_i \dfrac{\rho}{A_i} \Leftrightarrow \rho = \dfrac{R_i \times A_i}{L} = 0,3\ A_i = 0,6\ A_F$

$R_{Final} = L_F \dfrac{\rho}{A_F} = 2 \times \dfrac{0,6\ \cancel{A_F}}{\cancel{A_F}} = 1,2\ \Omega$

5.

$P = 60\ W$

$\Delta V = 230\ V$

$R_{20°C} = 65\ \Omega$

$\rho_{20°} = 55\ n\Omega\,m$

$\alpha_{20} = 0,0045\ °C^{-1}$

$P = \Delta V\, I \Leftrightarrow I = \dfrac{60}{230} \simeq 0,261\ A$

$R_{ligado} = \dfrac{\Delta V}{I} = \dfrac{230}{0,261} \simeq 881\ \Omega$

$R_{ligado} = R_{20}\left(1 + \alpha_{20}\left(T_{ligado} - 20\right)\right)$

$\Leftrightarrow 881 = 65\left(1 + 0,0045\left(T_{ligado} - 20\right)\right)$

$\Leftrightarrow T_{ligado} \simeq 2810\ °C$

6.

	A	B	C
R	6 kΩ	3 kΩ	8 kΩ
I			2 mA

$\Delta V_C = R_C\, I_C = 8 \times 10^{3} \times 2 \times 10^{-3} = 16\ V$

$R_{AB} = \dfrac{R_A\ R_B}{R_A + R_B} = \dfrac{6 \times 10^{3} \times 3 \times 10^{3}}{(6 + 3) \times 10^{3}} = 2\ k\Omega$

$I_{AB} = I_C = 2\ mA$

$\Delta V_{AB} = \Delta V_A = \Delta V_B = R_{AB}\ I_{AB} = 4\ V$

$\mathcal{E} = \Delta V_{AB} + \Delta V_C = 16 + 4 = 20\ V$

3.

$- \to +$

$\Delta V = 3V$

$I = 4A$

$+ \to -$

$\Delta V = 12V$

$I = -2A$

$$\Delta V = \varepsilon - rI$$

$$\begin{cases} 3 = \varepsilon - 4r \\ 12 = \varepsilon + 2r \end{cases} \Leftrightarrow \begin{cases} 3 = 12 - 2r - 4r \\ \varepsilon = 12 - 2r \end{cases} \Leftrightarrow \begin{cases} r = \frac{9}{6}\ \Omega \\ \varepsilon = 9\ V \end{cases}$$

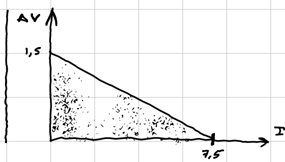
a) $r = 1,5\ \Omega$

b) $\varepsilon = 9\ V$

4.

$\varepsilon = 1,5\ V$

$r = 0,2\ \Omega$



$I_{máx} \to \Delta V = 0 \Rightarrow 0 = \varepsilon - rI_{máx}$

$\Leftrightarrow I_{máx} = 7,5\ A$

$P_{dissipada} = rI^2 = 0,2 \times 7,5^2 = 11,25\ W$

7. **a)**

$$P_{resist} = RI^2$$
$$\Delta V = I(R + r)$$
$$\Rightarrow P_{resist} = R\frac{\Delta V^2}{(R+r)^2}$$

Teorema da máxima transferência de potência

$$\frac{\partial P_{resist}}{\partial R} = \frac{\Delta V^2 (R - r)}{(R + r)^3}$$

$$\frac{\partial P_{resist}}{\partial R} = 0 \Leftrightarrow \Delta V^2 (R - r) = 0 \wedge (R + r)^3 \neq 0$$

$$\Leftrightarrow (\Delta V^2 = 0 \vee \boxed{R = r}) \wedge R \neq -r$$

b)

$$R = \frac{\Delta V}{I} \Leftrightarrow I = \frac{\Delta V}{R} = \frac{\Delta V_{resist} + \Delta V_{dissipado}}{R + r} = \frac{\varepsilon}{2R}$$

$$P = I^2 R = \frac{\varepsilon^2}{4R^2} R = \frac{\varepsilon^2}{4R}\ \square$$

ou

$$P_{resist} = RI^2 = \varepsilon I - rI^2$$

$$RI^2 = \varepsilon I - rI^2 \Leftrightarrow 2RI^2 = \varepsilon I \Leftrightarrow 2RI = \varepsilon \Leftrightarrow 2\Delta V = \varepsilon$$

$$P_{resist} = \frac{\Delta V^2}{R} = \frac{\left(\frac{\varepsilon}{2}\right)^2}{R} = \frac{\varepsilon^2}{4R}\ \square$$

8.

$$R_{AC} = \frac{50 \times (560 + 65)}{50 + 560 + 65} \simeq 46,3\ \Omega$$

$$R_{AB} = \frac{560\,(50 + 65)}{50 + 560 + 65} \simeq 95,4\ \Omega$$

$$R_{BC} = \frac{65\,(560 + 50)}{50 + 560 + 65} \simeq 58,7\ \Omega$$

$$\begin{cases} R_{AC} = R_1 + R_3 \\ R_{AB} = R_1 + R_2 \\ R_{BC} = R_2 + R_3 \end{cases} \Leftrightarrow \begin{cases} R_1 = 46,3 - R_3 \\ R_2 = 95,4 - R_1 \\ R_3 = 58,7 - R_2 \end{cases}$$

$$\overset{\cdots}{\Leftrightarrow} \begin{cases} - \\ R_2 = 49,1 + R_3 \\ R_3 = 9,6 - R_3 \end{cases} \Leftrightarrow \begin{cases} R_1 = 41,5\ \Omega \\ R_2 = 53,9\ \Omega \\ R_3 = 4,8\ \Omega \end{cases}$$

9.

$d = 1,29$ mm

$I_{máx} = 6\,A$

$\rho_{20} = 17\ \text{m}\Omega\,\text{m}$

$\alpha_{20} = 0,0039\ {}^\circ C^{-1}$

$L = 40$ m

a)

$$A = \pi \left(\frac{d}{2}\right)^2 \simeq 1,307 \times 10^{-6}\ m^2$$

$$R = \rho \frac{L}{A} = 17 \times 10^{-9} \frac{40}{1,307 \times 10^{-6}} \simeq 0,5203\ \Omega$$

$$\Delta V = RI \simeq 3,12\ V$$

$I = 6A$

b)

$$P = \Delta V\, I \simeq 18,7\ W$$

10.

$d = 1,8$ mm

$8g/s$

$\Delta V = 220$ V

$\rho_{20} = 1000\ \text{m}\Omega\,\text{m}$

$\alpha_{20} = 0,0004\ {}^\circ C^{-1}$

$T = 100\ {}^\circ C$

$2257,2\ J/g$

$$A = \pi \left(\frac{d}{2}\right)^2 \simeq 2,54 \times 10^{-6}\ m^2$$

— // —

$$P = 2257,2 \times 8 \simeq 18,1\ kW$$

$$P = I \Delta V = \frac{\Delta V^2}{R} \Leftrightarrow R_{100^\circ} = \frac{220^2}{18100} \simeq 2,68\ \Omega$$

$$R_{100^\circ} = R_{20^\circ}(1 + \alpha_{20} \cdot 80) \Leftrightarrow R_{20^\circ} = \frac{2,68}{1 + 80 \times 0,0004} \simeq 2,60\ \Omega$$

— // —

$$R_{20^\circ} = \rho_{20^\circ} \frac{L}{A} \Leftrightarrow L = \frac{2,60 \times 2,54 \times 10^{-6}}{1000 \times 10^{-9}} \simeq 6,6\ m$$

11.

$d = 0,1$ mm

Cobre:

$L = 32$ cm

$\rho_{20^\circ} = 17\ \text{m}\Omega\,\text{m}$

$\alpha_{20^\circ} = 0,0039\ {}^\circ C^{-1}$

Tungsténio:

$L = 10$ cm

$\rho_{20^\circ} = 55\ \text{m}\Omega\,\text{m}$

$\alpha_{20^\circ} = 0,0045\ {}^\circ C^{-1}$

$$A = \pi \left(\frac{d}{2}\right)^2 \simeq 7,85 \times 10^{-9}\ m^2$$

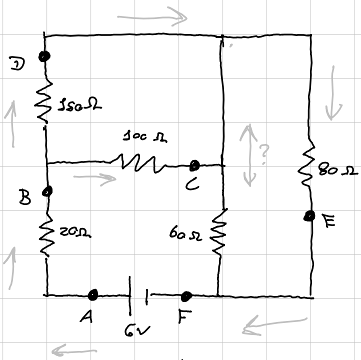
$$R_{C,20^\circ} = \rho_{20} \frac{L}{A} \simeq 0,693\ \Omega \qquad R_{T,20^\circ} \simeq 0,700\ \Omega$$

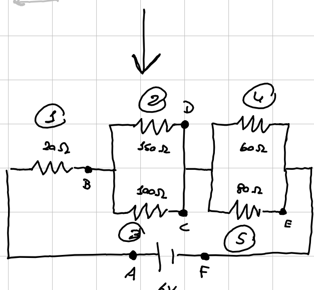
$$R_{C,20^\circ}(1 + \alpha_{C,20^\circ}(T - 20)) = R_{T,20^\circ}(1 + \alpha_{T,20^\circ}(T - 20))$$

$$\Leftrightarrow 0,693 + 0,00270\,(T - 20) = 0,700 + 0,00315\,(T - 20)$$

$$\Leftrightarrow T - 20 = \frac{0,693 - 0,700}{0,00315 - 0,00270} \Leftrightarrow T \simeq 3,02\ {}^\circ C$$

12.





$$R_{CD} = \frac{100 \times 150}{100 + 150} = 60\ \Omega$$

$$R_{EF} = \frac{80 \times 60}{80 + 60} \simeq 34,3\ \Omega$$

$$R_{eq} = 20 + R_{CD} + R_{EF} \simeq 114\ \Omega$$

$$P_{eq} = \frac{\Delta V^2}{R} = \frac{6^2}{114} = 0,315\ W$$

$$I_{eq} = \frac{P}{\Delta V} = \frac{0,315}{6} = 0,0525\ A$$

---

1 $I = 52,5\ mA \rightarrow P_1 = RI^2 \simeq 55,1\ mW$

$\longrightarrow \Delta V_1 = RI = 1,05\ V$

2, 3 $I = 52,5\ mA \rightarrow \Delta V_{2,3} = R_{CD} I = 3,15\ V$

$$P_2 = \frac{\Delta V^2}{R} = \frac{3,15^2}{150} \simeq 66,2\ mW$$

$$P_3 = \frac{\Delta V^2}{R} = \frac{3,15^2}{100} \simeq 99,2\ mW$$

4, 5 $I = 52,5\ mA \rightarrow \Delta V_{4,5} = R_{EF} I = 1,8\ V$

$$P_4 = \frac{\Delta V^2}{R} = \frac{1,8^2}{60} = 54\ mW$$

$$P_5 = \frac{\Delta V^2}{R} = \frac{1,8^2}{80} = 40,5\ mW$$

Condensadores

3, 7 | 4, 6, 5, 8, 1, 2

3. a)

$$C_{eq} = \frac{(C_1 + C_2)\,C_3}{(C_1+C_2)+C_3} = \frac{(1{,}2+4{,}3)\times 2{,}5}{1{,}2+4{,}3+2{,}5} \simeq 1{,}72\ \mu F$$

$$Q_{eq} = C_{eq}\cdot \Delta V_{AB} = 1{,}72\times 10^{-6}\times 9 \simeq 15{,}5\ \mu C \quad = Q_3 = Q_{1+2}$$

$$C_{1+2} = C_1 + C_2 = 1{,}2 + 4{,}3 = 5{,}5\ \mu F$$

$$\Delta V_{1+2} = \Delta V_1 = \Delta V_2 = \frac{Q_{1+2}}{C_{1+2}} = \frac{15{,}5}{5{,}5} \simeq 2{,}81\ V$$

$$Q_1 = \Delta V_1 \cdot C_1 = 2{,}81 \times 1{,}2 = 3{,}4\ \mu C$$

$$Q_2 = \Delta V_2 \cdot C_2 = 2{,}81 \times 4{,}3 = 12\ \mu C$$

b)

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{(15{,}5\times 10^{-6})^2}{1{,}72\times 10^{-6}} = 69{,}8\times 10^{-6}\ J$$

7. a)

$$\frac{1}{C_{BAD}} = \frac{1}{18}+\frac{1}{18}+\frac{1}{18} \Leftrightarrow C_{BAD} \simeq 6\ pF$$

$$\frac{1}{C_{BCD}} = \frac{1}{6}+\frac{1}{6}+\frac{1}{6} \Leftrightarrow C_{BCD} \simeq 2\ pF$$

$$C_{eq} = C_{BAD} + C_{BD} + C_{BCD} = 6+4+2 = 12\ pF$$

b)

$$C_{DB} = 4\ pF$$

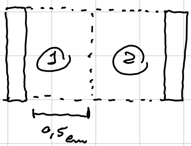
$$\frac{1}{C_{DCB}} = \frac{1}{6}+\frac{1}{6}+\frac{1}{6} \Leftrightarrow C_{DCB} \simeq 2\ pF$$

$$C_{D-B} = C_{DB} + C_{DCB} = 6\ pF$$

$$\frac{1}{C_{AD-B}} = \frac{1}{18}+\frac{1}{18}+\frac{1}{6} \Leftrightarrow C_{AD-B} = 3{,}6\ pF$$

$$C_{eq} = C_{AB} + C_{AD-B} = 18 + 3{,}6 = 21{,}6\ pF$$

4.



$A = 12\ cm^2$

$K_1 = 4{,}9$

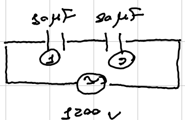
$K_2 = 5{,}6$

$$C_1 = \frac{K A}{4\pi k d} \simeq 1{,}04 \times 10^{-11}\ F$$

$$C_2 \simeq 1{,}19 \times 10^{-11}\ F$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow C_{eq} \simeq 5{,}5 \times 10^{-12}\ F$$

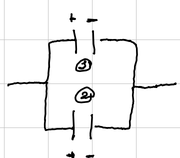
6.



a)

$$C_{eq} = \frac{C_1 \cdot C_2}{C_1 + C_2} \simeq 6{,}67\ \mu F$$

$$Q_1 = Q_2 = C \cdot \Delta V = 0{,}008\ C$$



b)

$Q_{eq} = 0{,}008 + 0{,}008 = 0{,}016\ C$

$C_{eq} = C_1 + C_2 = 30\ \mu F$

$\Delta V_{eq} = \frac{Q}{C} \simeq 533\ V = \Delta V_1 = \Delta V_2$

$Q_1 = C\,\Delta V \simeq 0{,}00533\ C$

$Q_2 \simeq 0{,}0107\ C$

5.

$A = 0{,}3\ m^2$

$d = 0{,}5\ cm$

$\Delta V_{Final} = 12\ V$

Acrílico:

$A = 0{,}3\ m^2$

espessura $= 0{,}5\ cm$

$K = 3{,}4$

$E_{máx} = 40\ kV/mm$

Ar seco:

$K \simeq 1$

$E_{máx} = 3\ kV/mm$

a)

Com dielétrico: ($K = 3{,}4$)	Sem ($K = 1$)
$C = \frac{K A}{4\pi k d} \simeq 7{,}8 \times 10^{-9}\ F$	$\simeq 2{,}3 \times 10^{-9}\ F$
$U = \frac{1}{2} C \Delta V^2 \simeq 5{,}6 \times 10^{-7}\ J$	$\simeq 1{,}6 \times 10^{-7}\ J$

$W = U_f - U_i \simeq 4{,}0 \times 10^{-7}\ J$

x ??

b)

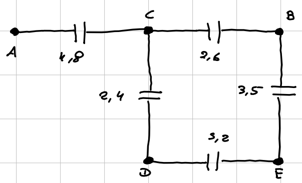
Com dielétrico:

$V_{máx} = E_{máx} \cdot d \simeq 200\ kV$

Sem:

$= 15\ kV$

8.



$\Delta V_{AB} = 5\,V$

$$\frac{1}{C_{CDEB}} = \frac{1}{2,4} + \frac{1}{5,2} + \frac{1}{3,5} \Leftrightarrow C_{CDEB} \simeq 1,12\ pF$$

$$C_{CB} \simeq 2,6 + 1,12 \simeq 3,72\ pF$$

$$\frac{1}{C_{eq}} \simeq \frac{1}{4,8} + \frac{1}{3,72} \Leftrightarrow C_{eq} \simeq 2,10\ pF$$

$$Q_{eq} = C \cdot \Delta V \simeq 10,5\ pC = Q_{AC} = Q_{CB}$$

$$\Delta V_{CB} = \frac{Q}{C} \simeq 2,82\ V = \Delta V_{CDEB}$$

$$Q_{CD} = Q_{CDEB} = C \cdot \Delta V \simeq 3,15\ pC \;//$$

1.

$P = 2000\ W$

$\Delta t = 0,002\ s$

$C = 50\ \mu F$

a)

$$\Delta U = P \cdot \Delta t = 4\,J$$

$$\Delta V = \sqrt{\frac{2\Delta U}{C}} = 400\ V \;//$$

$C = 250\ \mu F$

b)

$$\Delta V = \sqrt{\frac{2\Delta U}{C}} \simeq 179\ V \;//$$

c) Menor voltagem / Maior corrente e maior tamanho.

2.

a) $R = 4,0\ cm$

$k \simeq 1$

$$C_{esfera} = \frac{k\,R}{k} \simeq 4,44 \times 10^{-12}\ F \;//$$

b) $k = 5,6$

$R_v = 0,1\ cm$

~~$R_M = 4,1\ cm$~~

$$R_2 = R_1 + R_v = 4,1\ cm$$

$$C_{cond} = \frac{k\,R_1\,R_2}{k\,(R_2 - R_1)} \simeq 1,02 \times 10^{-9}\ F \;//$$

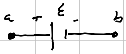
c)

$$\frac{C_{cond}}{C_{esfera}} \simeq \frac{1,02 \times 10^{-9}}{4,44 \times 10^{-12}} \simeq 230 \;//$$

Circuitos de corrente contínua

#5

Bateria



$V_a - V_b = \mathcal{E}$

$V_b - V_a = -\mathcal{E}$

Resistência

$V_a - V_b = RI$

$V_b - V_a = -RI$

Leis de conservação:

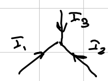
Lei das malhas

abcda $\rightarrow V_a - V_b + V_b - V_c + V_c - V_D + V_D - V_a = 0$

Lei das nós

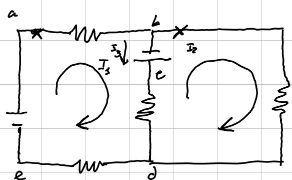
Soma das correntes que entram num nó

= Soma das correntes que saem num nó



$I_1 + I_2 + I_3 = 0$

3.



$$\begin{cases} V_a - V_b + V_b - V_c + V_c - V_d + V_d - V_e + V_e + V_a = 0 \\ V_b - V_c + V_c - V_D + V_D - V_b = 0 \end{cases}$$

$$\Leftrightarrow \begin{cases} 4{,}2\, I_1 - 5 + 7(I_1 - I_2) + 2{,}1\, I_1 - 6 = 0 \\ -5 + 7(I_1 - I_2) - 5{,}6\, I_2 = 0 \end{cases}$$

$$\Leftrightarrow \begin{cases} 13{,}3\, I_1 - 7\, I_2 = 11 \\ 7\, I_1 - 12{,}6\, I_2 = 5 \end{cases}$$

$$\Leftrightarrow \begin{cases} I_1 = \frac{11 + 7I_2}{13{,}3} \\ \frac{7(11 + 7I_2)}{13{,}3} - 12{,}6\, I_2 = 5 \end{cases} \qquad -8{,}916\, I_2$$

$$\Leftrightarrow \begin{cases} I_1 = 0{,}874 \text{ mA} \\ I_2 = 0{,}0885 \text{ mA} \end{cases} \Rightarrow I_1 - I_2 \simeq 0{,}785 \text{ mA}$$

$P_6 = \mathcal{E} \cdot I_1$

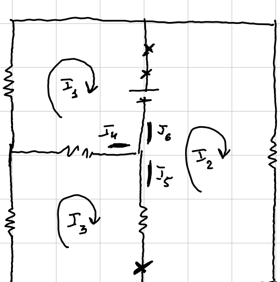
$\simeq 5{,}24$ mW

(Ambas fornecem)

$P_5 = \mathcal{E} \cdot (I_1 - I_2)$

$\simeq 3{,}93$ mW

4.



$$\begin{cases} -6 - 100(J_1 - J_3) - 150\, J_1 = 0 \\ -80\, J_2 - 60(I_2 - I_3) + 6 = 0 \\ -20\, J_3 - 100(I_3 - I_1) - 60(I_3 - I_2) = 0 \end{cases}$$

$$\Leftrightarrow \begin{cases} 250\, I_1 - 100\, I_3 = -6 \\ 140\, I_2 - 60\, I_3 = 6 \\ 100\, I_1 + 60\, I_2 - 180\, I_3 = 0 \end{cases} \quad \dots \Leftrightarrow \begin{cases} -I_1 = 23{,}4 \text{ mA} \\ I_2 = 43{,}5 \text{ mA} \\ I_3 = 1{,}5 \text{ mA} \end{cases}$$

$$P = I^2 R \quad \begin{cases} P_{20} \simeq 4{,}5 \times 10^{-5} \text{ W} \\ P_{60} \simeq 105{,}84 \text{ mW} \\ P_{80} \simeq 151{,}38 \text{ mW} \\ P_{100} \simeq 47{,}96 \text{ mW} \\ P_{150} \simeq 82{,}13 \text{ mW} \end{cases}$$

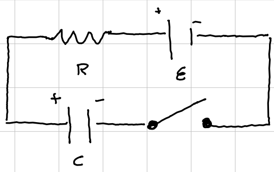
$$P = I\,\mathcal{E} \quad \Big\{ P_{6V} \simeq 120{,}6 \text{ mW}$$

$\boxed{I_1 + I_2}$

??

Método de sobreposição

RC - DC Circuit



$$RI + \frac{Q}{C} - \mathcal{E} = 0 \iff R\frac{dQ}{dt} + \frac{Q}{C} = \mathcal{E}$$

$$Q(t) = Q_h(t) + Q_p$$

→ Equação particular

$Q(t=0) = 0$

$Q_p = \mathcal{E} C$

→ Equação homogénea

$$R\frac{dQ}{dt} + \frac{Q}{C} = 0 \iff \frac{dQ}{dt} = -\frac{Q}{RC}$$

$$\Rightarrow Q_h(t) = e \cdot e^{-\frac{t}{RC}}$$

$$\therefore Q(t) = e\, e^{-\frac{t}{RC}} + \mathcal{E}C$$

↳ $Q(t=0) = 0$

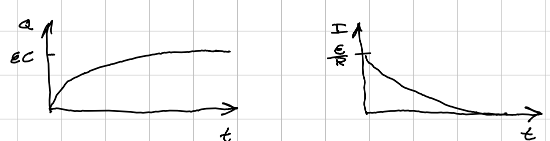
$e = -\mathcal{E}C$

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

Ao carregar

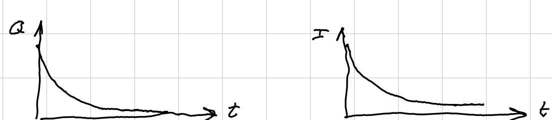
$$V(t) = \mathcal{E}\left(1 - e^{-\frac{t}{RC}}\right)$$

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

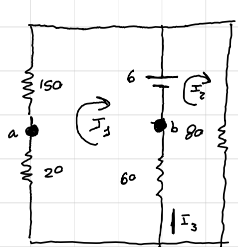


Ao descarregar:

$$R\frac{dQ}{dt} + \frac{Q}{C} = 0 \quad ; \quad I = -\frac{dQ}{dt}$$



1. $t \to \infty$



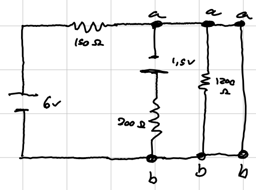
$$\begin{cases} -6 - 60(I_1 - I_2) - 20 I_1 - 150 I_1 = 0 \\ +6 - 80 I_2 - 60(I_2 - I_1) = 0 \end{cases}$$

$$\iff \begin{cases} 230 I_1 - 60 I_2 = -6 \\ 140 I_2 - 60 I_1 = 6 \end{cases} \iff \left[\begin{array}{cc|c} 115 & -30 & -3 \\ -30 & 70 & 3 \end{array}\right] \therefore \iff \begin{array}{l} I_1 \simeq -16{,}8 \text{ mA} \\ I_2 \simeq 35{,}7 \text{ mA} \end{array}$$

$$\Delta V_{a-b} = -R_{20} I_1 + R_{60}(I_2 - I_1) \simeq 3{,}483 \text{ V}$$

$$E = \frac{1}{2} C \, \Delta V_{a-b}^2 \simeq 236{,}5 \text{ mJ}$$

5. a)

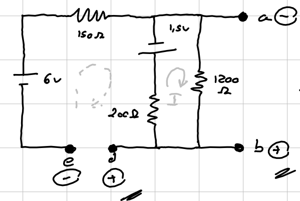


$I_{1200} = 0$

$1,5 - 200\, I_{200} = 0 \iff I_{200} = \frac{1,5}{200}$ A

$-150\, I_{150} + 6 = 0 \iff I_{150} = \frac{6}{150}$ A

b)



$1,5 - 200\, I - 1200\, I = 0 \iff I = -\frac{1,5}{1400}$ A

$\Delta V_{a-b} = R\, I \simeq -1,286$ V

$Q_{68} = \Delta V \cdot C \simeq 87$ mC

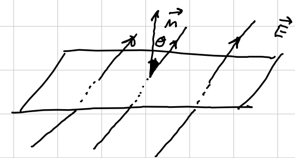
$\Delta V_{c-d} = 6 - 0 + 1,5 + 200 I \simeq -7,29$ V

$Q_{82} = \Delta V \cdot C \simeq 597$ mC

Fluxo elétrico #6

→ Quantidade de linhas de campo que passam numa superfície

$$\phi = \iint_A \vec{E} \cdot \vec{n} \, dS$$



Em campos uniformes e simetrias bem definidas:

$$\phi = E \cdot A \quad (\mathrm{V\,m})$$

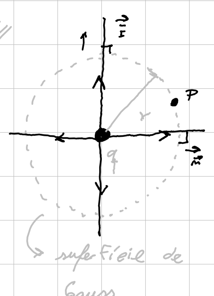
<u>Lei de Gauss:</u>

Numa superfície fechada

$$\oiint_A \vec{E} \cdot \hat{n} \, dS = \frac{Q_{interior}}{\varepsilon_0} = 4\pi k \, Q_{interior}$$

da superfície de Gauss

Ex//

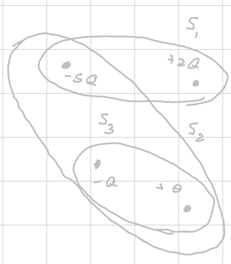


$$\vec{E}_P = k \frac{q}{r^2} \hat{r} \qquad Q_{int} = q$$

$$\oiint_A \vec{E} \cdot \hat{n} \, dS = \iint E \, dS = E \, 4\pi r^2$$

$$E \, 4\pi r^2 = \frac{q}{\varepsilon_0} \Leftrightarrow E = \frac{q}{4\pi \varepsilon_0 r^2} = k \frac{q}{r^2} \quad \square$$

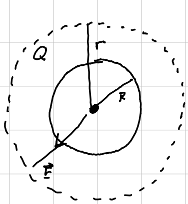
Ex//



$$\phi_{S_1} = \frac{-3Q}{\varepsilon_0}$$

$$\phi_{S_3} = 0 \quad (Q_{int} = 0)$$

5.



$$\oiint \vec{E} \cdot \hat{n} \, dS = E \cdot A = 4\pi r^2 E(r) \qquad Q_{int} = Q$$

Se $r \geq R$:

$$E \, 4\pi r^2 = \frac{Q}{\varepsilon_0} \Leftrightarrow E = k \frac{Q}{r^2} \quad //$$

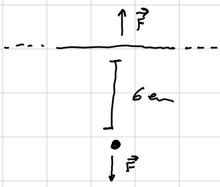
$$\rho_{unif} = \frac{Q}{V}$$

Se $r < R$:

$$Q_{int} = \rho V_1 = \frac{r^3}{R^3} Q$$

$$4\pi r^2 E = \frac{1}{\varepsilon_0} Q \frac{r^3}{R^3} \Leftrightarrow E = k \frac{Q}{R^3} r \quad //$$

2.



$q = 5\ nC$

$d = 6\ cm$

$\lambda = 7\ nC/cm$

→ Campo devido ao fio de carga uniforme

$$E = \frac{2k\lambda}{d} \simeq 21,0 \times 10^{9}\ \frac{m}{F}\ \frac{nC}{cm}\ \frac{1}{cm}$$

$$F = qE \simeq 105 \times 10^{9}$$

$$\simeq 1,05\ mN$$

Potemcial Eletrostático #7

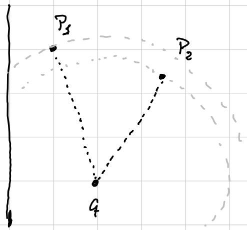
Tópicos: Capítulo:

$\Delta V = -\int \vec{E}\, d\vec{r}$

$\updownarrow$

$\vec{E} = \vec{\nabla} V = \begin{Bmatrix} \frac{\partial V}{\partial x} \\ \frac{\partial V}{\partial y} \\ \frac{\partial V}{\partial z} \end{Bmatrix} \cdot V$

$= k \frac{q}{r^2} \hat{r}$



$V(P_2) - V(P_1) = -\int_{r_1}^{r_2} \vec{E}\, d\vec{r}$

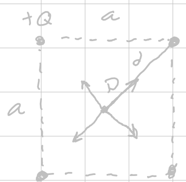
$\downarrow$

$V(P_2) - V(P_1) = -\int_{r_2}^{r_2} k \frac{q}{r^2}\, dr$

$= k q \left(\frac{1}{r_2} - \frac{1}{r_1} \right)$

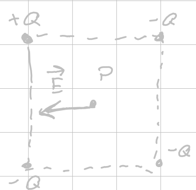
$< 0, \quad r_1 < r_2$

Ex///



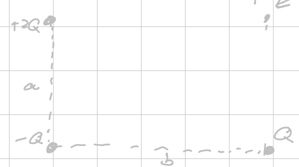
$\vec{E}_P = 0 \qquad \left(d = \frac{\sqrt{2}}{2} a \right)$

$V_P = 4 \times k \frac{Q}{d} = 8\sqrt{2}\, k \frac{Q}{a}$



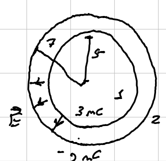
$\vec{E}_P \neq 0$

$V_P = 0$



W para arrastar q do infinito para P ?

4.



$|V(P_2) - V(P_1)| = -\int_{r_1}^{r_2} \vec{E}\, d\vec{r}$

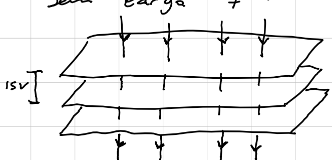
Sup. de Gauss:

$\hookrightarrow \phi = E\, 4\pi r^2 \qquad \hookrightarrow Q = Q_1 \qquad \phi = \frac{Q_{in}}{\varepsilon_0}$

$= -\frac{1}{\varepsilon_0} \int \frac{Q_1}{4\pi r^2}\, dr = k Q_1 \left(\frac{1}{r_2} - \frac{1}{r_1} \right) \simeq 154,3\ V$

8. a) Sem carga q:

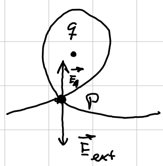
$\vec{E}(\vec{r}) = -\vec{\nabla} V(r) \rightarrow E_{ext} \cdot d = \Delta V$



$\Leftrightarrow E_{ext} \simeq 187,5\ \frac{V}{m}$

Fís. II

b)

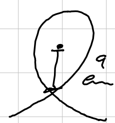


$\vec{E} = 0 \Leftrightarrow \vec{E}_q = -\vec{E}_{ext} = -387,5$ V/m

$\Rightarrow q < 0$

c) $\uparrow \vec{E}_q$ Para cima

d)



$E = k \frac{q}{r^2} \Leftrightarrow q \simeq$

Força magnética

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

$\vec{F}_m = 0$ se:

$\rightarrow q = 0 \quad \rightarrow v = 0 \quad \rightarrow B = 0 \quad \rightarrow v \,/\!/\, B$

2.

$q = 1{,}602 \times 10^{-19}$

$\Delta V = 200\ V$

$\vec{E} = \vec{0}$

$\vec{B} = 0{,}025\ T$

$d = 16{,}35\ cm$

$r = 8{,}175\ cm$

$U = q\,\Delta V \simeq 3{,}204 \times 10^{-17}\ J = \Delta E_c$

$\Delta E_c = \frac{1}{2} m v^2 \iff v^2 = \frac{2\Delta E_c}{m}$

$\underbrace{F_m}_{} = m\frac{v^2}{r} \iff q\cancel{v}B = m\frac{v^{\cancel{2}}}{r} \iff v^2 = \left(\frac{qBr}{m}\right)^2$

$\frac{2\Delta E_c}{\cancel{m}} = \frac{q^2 B^2 r^2}{m^{\cancel{2}}} \iff m = \frac{q^2 B^2 r^2}{2\Delta E_c} \simeq 1{,}67 \times 10^{-27}\ kg$

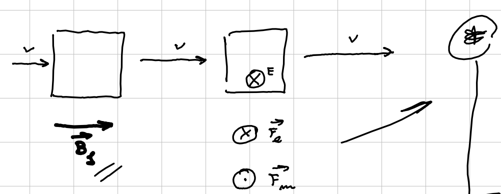
4.

I: $\vec{B}_1$

II: $\vec{B}_2$

$\vec{E} = E\hat{j}$

$\vec{F}_m = 0$



$\uparrow \vec{B}_2 = \frac{E}{v}$ //

$F_R = 0$

$\iff F_m = -F_e$

$\iff \cancel{q}vB_2 = -\cancel{q}E$

$\iff B_2 = \frac{E}{v}$

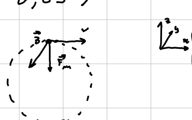
3.

$m = 1{,}67 \times 10^{-27}\ kg$

$v = 1{,}84 \times 10^5\ m/s$

$B = -0{,}062\ T$

$t = 0{,}85\ \mu s$



$r = \frac{mv}{qB} \simeq \frac{1{,}67 \times 1{,}84}{1{,}602 \times 0{,}062} \times \frac{10^{-27} \times 10^5}{10^{-19}} \simeq 0{,}0309\ m$

$\omega = \frac{qB}{m} \cong 0{,}059 \times 10^8 \simeq 5{,}9 \times 10^6\ rad/s$

$\theta = 5{,}9 \times 10^6 \times 8{,}5 \times 10^{-5} \simeq 50{,}15\ rad$

$\vec{r}(t) = (r\cos\theta(t) - r)\hat{k} - r\sin\theta(t)\,\hat{i}$

$\simeq (2{,}37,\ 0,\ -1{,}11)\ cm$ //

$\otimes$

Campo Magnético

TP10

$$\oint_c \vec{B} \cdot d\vec{l} = \mu_0 I_{int} \quad \simeq \quad \oiint \vec{E} \cdot d\vec{S} = \frac{Q_{in}}{\varepsilon_0}$$

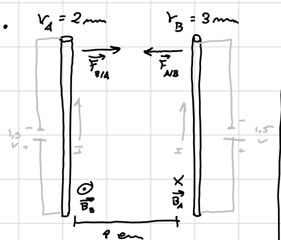
$$\mu_0 = 4\pi \times k_m = 4\pi \times 10^{-7} \ \frac{T \cdot m}{A}$$

Ex//

$$\oint_c \vec{B} \cdot d\vec{l} = B \oint_c d\vec{l} = B \cdot 2\pi r$$

$$B \cdot 2\cancel{\pi} r = 4\cancel{\pi} k_m I \iff B = \frac{2 k_m I}{r}$$

2.



(*) Assumindo sentido da corrente

$\Delta V = 1,5 \ V$

$\rho = 17 \ n\Omega \cdot m$

$l = 60 \ cm$

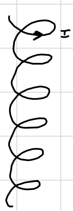
$$A = \pi r^2 \quad \Big\} \quad A_1 \simeq 1,26 \times 10^{-5} m^2 \quad A_2 \simeq 2,83 \times 10^{-5} m^2$$

$$R = \rho \frac{l}{A} \quad \Big\} \quad R_1 \simeq 8,12 \times 10^{-4} \Omega \quad R_2 \simeq 3,61 \times 10^{-4} \Omega$$

$$I = \frac{\Delta V}{R} \quad \Big\} \quad I_1 \simeq 1848 \ A \quad I_2 \simeq 4158 \ A$$

$$F = \frac{2 k_m L I_1 I_2}{d} \simeq 10,2 \ N$$

5.



$d = 0,315 \ mm$

$l = 60 \ m$

$N = 200$ espiras

$\mathcal{E} = 3 V$

$\rho_{20°C} = 17 \ n\Omega \cdot m$

$$A = \pi \left(\frac{d}{2}\right)^2 \simeq 7,793 \times 10^{-8} \ m^2$$

$$R = \rho \frac{L}{A} \simeq 13,09 \ \Omega$$

$$I = \frac{\Delta V}{R} \simeq 0,2292 \ A$$

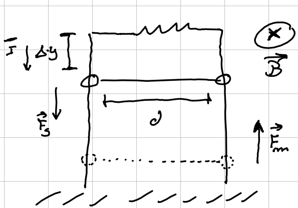
$$m = NAI \simeq 3,57 \times 10^{-6} \ A \ m^2$$

Fig. II

Indução Eletromagnética #9

Tópicos: Capítulo:

5.



$g = 9{,}8\ m/s^2$

v constante

$\frac{\partial B}{\partial t} = 0$

Lei de Faraday:

1. Escolher $\hat{n}$
2. Calcular ϕ
3. $\frac{\partial \phi}{\partial t}$
4. $= -\mathcal{E}$
5. Sinal de $\mathcal{E}$
6. Lei de Owm
7. Lei de Lenz

v constante $\rightarrow a = 0 \rightarrow F_R = 0$

$\Leftrightarrow F_g = F_m \Leftrightarrow 9{,}8\, m = I \cdot d \cdot B$

. $\vec{n} \parallel \vec{B}$

$\phi = BA = B\, d\, \Delta y > 0$

$\frac{d\phi}{dt} = B\, d\, \frac{dy}{dt} = B\, d\, v$

$\frac{d\phi}{dt} = -\mathcal{E} \Leftrightarrow B\, d\, v = -\mathcal{E} < 0$

$I = \frac{|\mathcal{E}|}{R} = \frac{|B\, d\, v|}{R}$

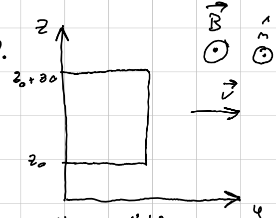
8. Campo magnético induzido $\odot$ B_{ind} — Quando v terminal B B ind

$\therefore$ Corrente: I ↓

$9{,}8\, m = I\, d\, B \Leftrightarrow 9{,}8\, m = \frac{|B\, d\, v|}{R}\, d\, B$

$\Leftrightarrow v = \frac{9{,}8\, mR}{B^2 d^2}$ //

7.



$v = 3\ m/s$

$B = (6 - y)$

$e = 20\ cm$

$l = 30\ cm$

$A = 0{,}06\ m^2$

$\phi(t) = \iint B \times dS = \int_{z_0}^{z_0 + 0{,}3} \int_{vt}^{0{,}2 + vt} (6 - y)\, dy\, dz$

$= \int_{z_0}^{z_0 + 0{,}3} \left(\left| 6y - \frac{y^2}{2} \right|_{vt}^{0{,}2 + vt} \right) dz$

...

$= 0{,}3\, (1{,}2 - 0{,}6t - 0{,}02) = -0{,}18t$

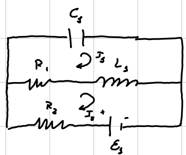
$\frac{d\phi}{dt} = -0{,}18 \Rightarrow \mathcal{E} = 0{,}18$ ✓ //

$\therefore$ Sentido da corrente: $\vec{I}$ ↓

Fis. II

(*)	Resistência	Condensador	Indutor
$V =$	RI	$\frac{Q}{C} = \frac{\int I \, dt}{C}$	$L \frac{dI}{dt}$
	(Ω)	(F)	(H)

8.



$\mathcal{E} = 5 \, V$

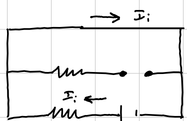
$R_1 = 2500 \, \Omega$

$R_2 = 50 \, \Omega$

$C = 3,6 \, \mu F$

$L = 7,2 \, H$

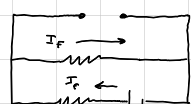
- Instante inicial | $I_{L,i} = 0$



$$I_i = I_{R_2,i} = \frac{V}{R_2} = \frac{5}{50} = 0,1 \, A$$

$$I_{C,i} = I_i = 0,1 \, A$$

- Instante final



$$R_{eq} = R_1 + R_2 = 2550 \, \Omega$$

$$I_F = \frac{V}{R_{eq}} = \frac{5}{2550} = 1,96 \, mA$$

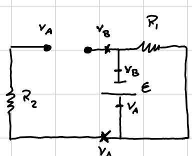
$$I_{L,F} = I_F = 1,96 \, mA$$

$$V_{C,F} = V_{R_1,F} = RI = 2500 \times 0,00196 \simeq 4,9 \, V$$

$$Q_{C,F} = V \cdot C = 4,9 \times 3,6 \times 10^{-6} \simeq 17,6 \, \mu C$$

11. Instante inicial:

a)



$$V_A - V_B = 5 \, V$$

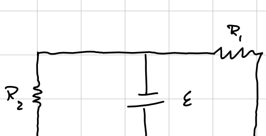
$$\hookrightarrow V_{R_2} = 0 \, V$$

b)

$$V_L = L \frac{dI}{dt} \Leftrightarrow \frac{dI}{dt} = \frac{V_L}{L} = \frac{5}{0,412} \simeq 12,1 \, A \, s^{-1}$$

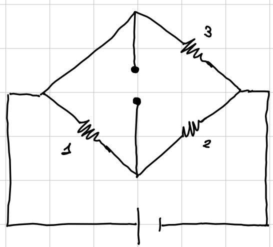
$$V_{R_2} = R I \Rightarrow \frac{dV}{dt} = R \frac{dI}{dt} \simeq 3400 \times 12,1 \simeq 41,3 \, kV \, s^{-1}$$

c) Estado estacionário:



$$V_{R_2} = \mathcal{E} = 5 \, V$$

10. Instante inicial:



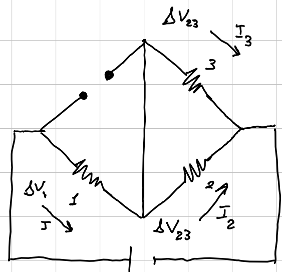
$$R_{eq} = \frac{1}{\frac{1}{1800+2700} + \frac{1}{4700}} \simeq 2299\ \Omega$$

$$I_{eq} = \frac{9}{2299} \simeq 3,91\ mA$$

$$I_3 = \frac{9}{4700} \simeq 1,91\ mA$$

$$I_1 = I_2 = \frac{9}{1800+2700} \simeq 2.0\ mA$$

Estado estacionário:



$$R_{2,3} = \frac{1}{\frac{1}{2700} + \frac{1}{4700}} \simeq 1715\ \Omega$$

$$R_{eq} = 1800 + R_{2,3} \simeq 3515\ \Omega$$

$$I_{eq} = I_1 = \frac{9}{3515} \simeq 2,56\ mA$$

$$\Delta V_1 = R_1 I_1 \simeq 4,61\ V$$

$$\Delta V_2 = \Delta V_3 = \mathcal{E} - \Delta V_1 \simeq 4,39\ V$$

$$I_2 = \frac{\Delta V_2}{R_2} \simeq 1,63\ mA$$

$$I_3 = \frac{\Delta V_3}{R_3} \simeq 0,93\ mA$$