# Lista 1

1) $E = 7{,}2\cdot10^6\,N/C \quad d = 0{,}5m \quad K_0 = 9{,}0\cdot10^9\ Nm^2C^{-2}$

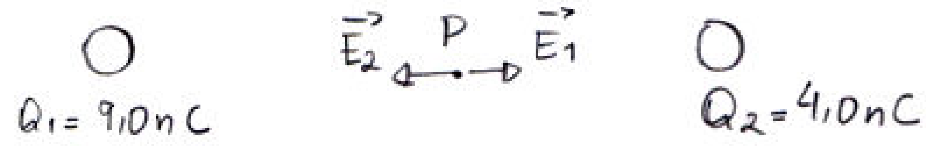
$$E = \frac{K_0\cdot Q}{d^2} \qquad E\cdot d^2 = K_0 Q \qquad Q = \frac{E\cdot d^2}{K_0}$$

$$Q = \frac{7{,}2\cdot10^6\cdot(5\cdot10^{-1})^2}{9{,}0\cdot10^9} = \frac{7{,}2\cdot10^6\cdot25\cdot10^{-2}}{9{,}0\cdot10^9} = \frac{180\cdot10^4}{9\cdot10^9} = 20\cdot10^{-5}$$

$$\boxed{Q = 2{,}0\cdot10^{-4}C}$$

2) I) C     II) C     III) E     $\boxed{\Rightarrow \text{"d"}}$

3)



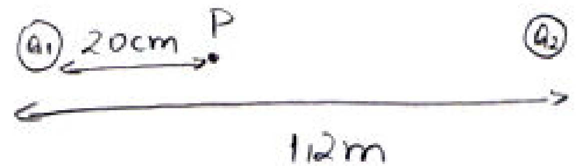

$$E_1 = \frac{K_0 Q}{d^2} = \frac{9{,}0\cdot\cancel{10^9}\cdot9\cdot\cancel{10^{-9}}}{(3\cdot10^{-2})^2} = \frac{81\cdot10^0}{9\cdot10^{-4}} = 9\cdot10^{+4}\ N/C$$

$$E_2 = \frac{K_0 Q}{d^2} = \frac{9{,}0\cdot\cancel{10^9}\cdot4\cdot\cancel{10^{-9}}}{(2\cdot10^{-2})^2} = \frac{36\cdot10^0}{4\cdot10^{-4}} = 9\cdot10^{+4}\ N/C$$

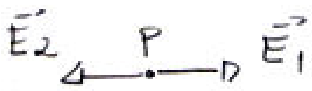
$$\vec{E}_{RES} = \vec{E}_1 + \vec{E}_2 \Rightarrow E_{RES} = E_1 - E_2 = 9\cdot10^{+4} - 9\cdot10^{+4}$$

$\boxed{E_{RES} = 0}$ (o campo no ponto P é nulo)

4)




$Q_1 = 4{,}0nC$
$Q_2 = 1{,}0\cdot10^{-4}C$



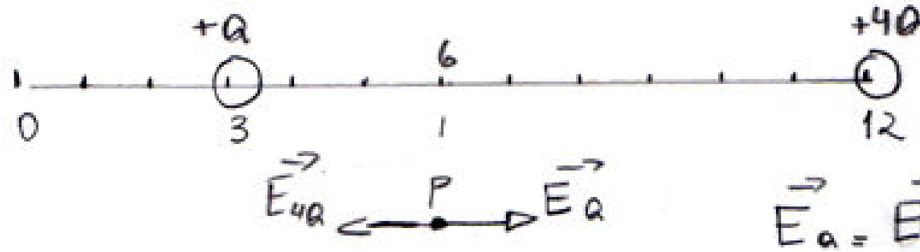
$$E_1 = \frac{K_0 Q_1}{d^2} = \frac{9{,}0\cdot10^{9}\cdot 4\cdot10^{-6}}{(2\cdot10^{-1})^2} = \frac{36\cdot10^{3}}{4\cdot10^{-2}} = 9{,}0\cdot10^{5}\ N/C$$

$$E_2 = \frac{K_0 Q_2}{d^2} = \frac{9{,}0\cdot10^{9}\cdot 1{,}0\cdot10^{-4}}{1} = 9{,}0\cdot10^{5}\ N/C$$

$$E_{RES} = E_1 - E_2 = 9{,}0\cdot10^{5} - 9{,}0\cdot10^{5} = 0$$

O campo elétrico resultante no ponto P é nulo.

5)




$\boxed{12-3=9}$

$$\vec{E}_Q = \vec{E}_{4Q}$$

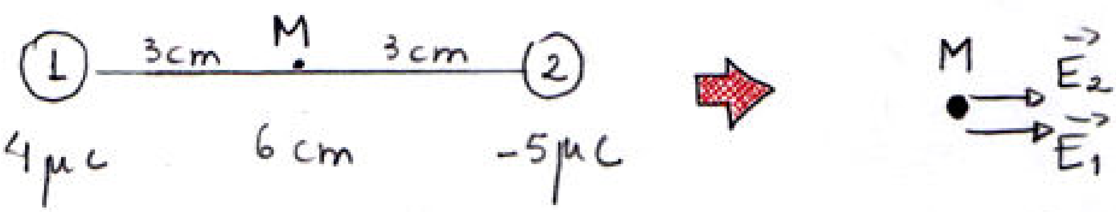
$$\frac{\cancel{K_0}\,Q}{d^2} = \frac{\cancel{K_0}\,Q}{d^2} \Rightarrow \frac{\cancel{Q}}{x^2} = \frac{4\cancel{Q}}{(9-x)^2} \Rightarrow \frac{1}{x^2} = \frac{4}{(9-x)^2}$$

$$\sqrt{\frac{1}{x^2}} = \sqrt{\frac{4}{(9-x)^2}} \Rightarrow \frac{1}{x} = \frac{2}{(9-x)} \qquad 9-x = 2x$$

$$9 = 2x + x \Rightarrow 9 = 3x \qquad x = \frac{9}{3} \qquad x = 3$$

O campo elétrico será nulo a 3 unidades a direita de Q, ou seja na posição 6.

⑥

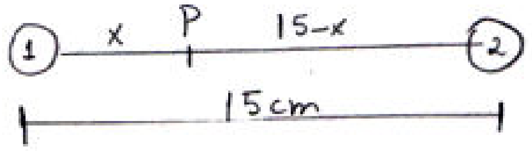



$$E_1 = \frac{K_0 Q_1}{d^2} = \frac{9{,}0\cdot10^{9}\cdot 4{,}0\cdot10^{-6}}{(3{,}0\cdot10^{-2})^2} = \frac{36\cdot10^{3}}{9{,}0\cdot10^{-4}} = 4\cdot10^{7}\ N/C$$

$$E_2 = \frac{K_0 Q_2}{d^2} = \frac{9{,}0\cdot10^9 \cdot 5{,}0\cdot10^{-6}}{(3{,}0\cdot10^{-2})^2} = \frac{45\cdot10^3}{9\cdot10^{-4}} = 5{,}0\cdot10^7\ N/C$$

$$E_{RES} = E_1 + E_2 = 4{,}0\cdot10^7 + 5{,}0\cdot10^7 = \boxed{9{,}0\cdot10^7\ N/C}$$

7




$Q_1 = 4\mu C \quad Q_2 = 9\mu C$

O campo eletrico será nulo quando $E_1 = E_2$

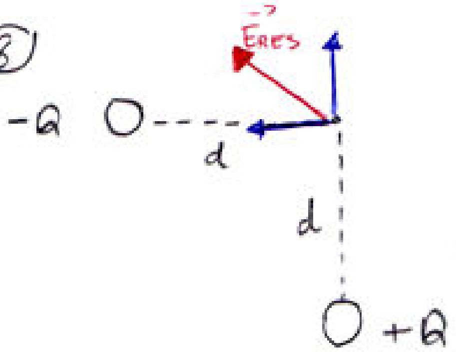
$$\frac{\cancel{K_0} Q}{d^2} = \frac{\cancel{K_0} Q}{d^2} \qquad \frac{4\cdot\cancel{10^{-6}}}{x^2} = \frac{9\cdot\cancel{10^{-6}}}{(15-x)^2} \Rightarrow \frac{4}{x^2} = \frac{9}{(15-x)^2}$$

$$\sqrt{\frac{4}{x^2}} = \sqrt{\frac{9}{(15-x)^2}} \Rightarrow \frac{2}{x} = \frac{3}{15-x} \Rightarrow 2\cdot(15-x) = 3x$$

$$30 - 2x = 3x \Rightarrow 30 = 3x + 2x \Rightarrow 30 = 5x \Rightarrow x = \frac{30}{5}$$

$$\boxed{x = 6cm}$$

8




$Q = 3\mu C \qquad d = 2cm$

O campo gerado pelas duas cargas possuem o mesmo módulo na situação da figura.

$$E_1 = E_2 = \frac{K_0 Q}{d^2} = \frac{9{,}0\cdot10^9 \cdot 3{,}0\cdot10^{-6}}{(2{,}0\cdot10^{-2})^2} = \frac{27\cdot10^3}{4{,}0\cdot10^{-4}} = 6{,}75\cdot10^7\ N/C$$

Como os dois vetores são perpendiculares entre si, o vetor resultante será dado pelo Teorema de Pitágoras.

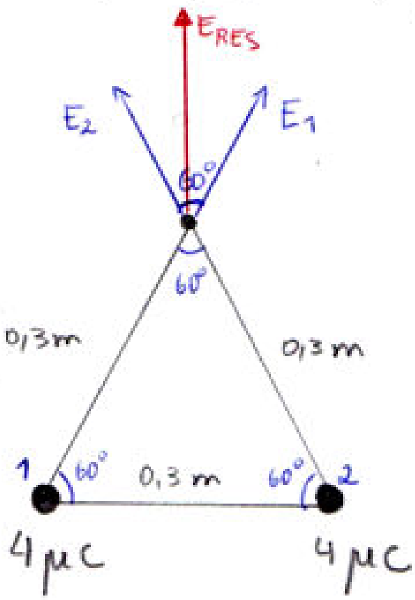
Como os valores a serem calculados são grandes, omitimos $10^7$ do cálculo, mas o acrescentamos no resultado final:

$$E_{RES}^2 = E_1^2 + E_2^2 \Rightarrow E_{RES} = \sqrt{E_1^2 + E_2^2}$$

$$E_{RES} = \sqrt{6{,}75^2 + 6{,}75^2} \Rightarrow \sqrt{45{,}5625 + 45{,}5625}$$

$$E_{RES} = \sqrt{91{,}125} \Rightarrow \boxed{E_{RES} \simeq 9{,}54 \cdot 10^7 \, N/C}$$

09




→ Um triângulo equilátero possui todos seus lados iguais e ângulos internos valendo 60°. Calcula-se $E_1$ e $E_2$ (que são, em módulo, iguais) e efetua-se a soma vetorial.

$$E_1 = E_2 = \frac{K_0 \cdot Q}{d^2} = \frac{9{,}0 \cdot 10^9 \cdot 4{,}0 \cdot 10^{-6}}{(3{,}0 \cdot 10^{-1})^2} = \frac{36 \cdot 10^3}{9{,}0 \cdot 10^{-2}} = 4{,}0 \cdot 10^5 \, N/C$$

Para se fazer a soma vetorial nesse caso, recorremos à Regra do Paralelogramo:

$$E_{RES} = \sqrt{E_1^2 + E_2^2 + 2 \cdot E_1 \cdot E_2 \cdot \cos\alpha}$$

Sabendo que cosseno de $60° = 0{,}5$, e usando a mesma estratégia da questão 08, temos:

$$E_{RES} = \sqrt{4^2 + 4^2 + 2 \cdot 4 \cdot 4 \cdot \cos 60^\circ} =$$

$$E_{RES} = \sqrt{16 + 16 + 2 \cdot 4 \cdot 4 \cdot 0{,}5} = \sqrt{16 + 16 + 16} = \sqrt{48}$$

$$\boxed{E_{RES} \approx 6{,}9 \cdot 10^5 \ N/C}$$

Lista 2

① a) $2{,}45 \cdot 10^4$ b) $2{,}0 \cdot 10^8$ c) $1{,}6 \cdot 10^{-3}$

d) $9{,}2 \cdot 10^{-7}$ e) $1{,}4 \cdot 10^4$ f) $6{,}9 \cdot 10^{-4}$

g) $2{,}34 \cdot 10^0$ h) $2{,}0 \cdot 10^{-5}$

② a) $63 \cdot 10^{13} = 6{,}3 \cdot 10^{14}$ b) $8 \cdot 10^{-8}$

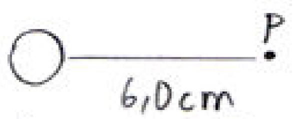
c) $4{,}0 \cdot 10^{-7}$ d) $4{,}0 \cdot 10^{25}$

e) $223 \cdot 10^5 + 7 \cdot 10^5 = (223 + 7) \cdot 10^5 = 230 \cdot 10^5 = 2{,}3 \cdot 10^7$

f) $6{,}11 \cdot 10^{10} - 1{,}9 \cdot 10^9 = 6{,}11 \cdot 10^{10} - 0{,}19 \cdot 10^{10} = 5{,}92 \cdot 10^{10}$

g = $(2 \cdot 10^{-5})^2 = 4 \cdot 10^{-10}$

h) $\sqrt{3{,}6 \cdot 10^5} = \sqrt{36 \cdot 10^4} = 6 \cdot 10^2$

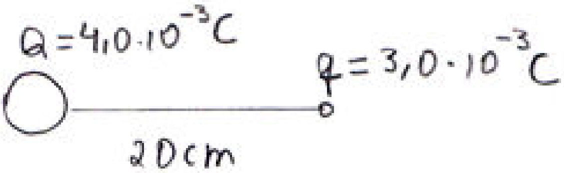
③ 


$Q = 2{,}0 \cdot 10^{-7}$ C

$$V = \frac{K_0 \cdot Q}{d} = \frac{9{,}0 \cdot 10^9 \cdot 2{,}0 \cdot 10^{-7}}{6{,}0 \cdot 10^{-2}} = \frac{18 \cdot 10^2}{6{,}0 \cdot 10^{-2}}$$

$$\boxed{V = 3{,}0 \cdot 10^4 \ V}$$

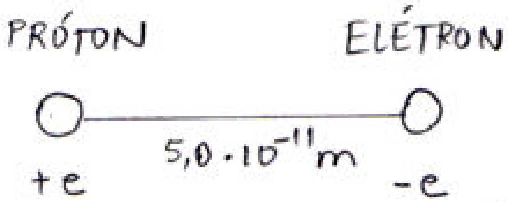
4)




$E_{POT} = \dfrac{K_0\, q \cdot Q}{d}$

$E_{POT} = \dfrac{9{,}0 \cdot 10^{9} \cdot 4{,}0 \cdot 10^{-3} \cdot 3{,}0 \cdot 10^{-3}}{2 \cdot 10^{-1}} = \dfrac{108 \cdot 10^{3}}{2 \cdot 10^{-1}} = 54 \cdot 10^{4} = \boxed{5{,}4 \cdot 10^{5}\ J}$

5)




$e = 1{,}6 \cdot 10^{-19}\ C$ $\quad E_{POT} = \dfrac{K_0\, q \cdot Q}{d}$

$E_{POT} = \dfrac{9{,}0 \cdot 10^{9} \cdot 1{,}6 \cdot 10^{-19} \cdot 1{,}6 \cdot 10^{-19}}{5{,}0 \cdot 10^{-11}} = \dfrac{23{,}04 \cdot 10^{-29}}{5{,}0 \cdot 10^{-11}} = \boxed{4{,}6 \cdot 10^{-18}\ J}$

6) (a) aumenta.

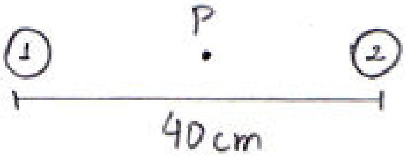
7)


$Q = 4{,}0 \cdot 10^{-6}\ C$

$V = \dfrac{K_0\, Q}{d} = \dfrac{9{,}0 \cdot 10^{9} \cdot 4{,}0 \cdot 10^{-6}}{2 \cdot 10^{-1}} =$

$V = \dfrac{36 \cdot 10^{3}}{2 \cdot 10^{-1}} = 18 \cdot 10^{4} = \boxed{1{,}8 \cdot 10^{5}\ V}$

8) $Q_1 = -2\ \mu C$ $\qquad Q_2 = 2\ \mu C$



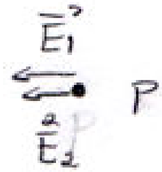

a) O potencial resultante no ponto P será a soma do potencial gerado pelas duas cargas no ponto P.

$V_1 = \dfrac{K_0\, Q_1}{d} = \dfrac{9{,}0 \cdot 10^{9} \cdot (-2{,}0 \cdot 10^{-6})}{2 \cdot 10^{-1}} = -\dfrac{18 \cdot 10^{3}}{2 \cdot 10^{-1}} = -9{,}0 \cdot 10^{4}\ V$

$V_2 = \dfrac{K_0\, Q}{d} = \dfrac{9{,}0 \cdot 10^{9} \cdot 2 \cdot 10^{-6}}{2 \cdot 10^{-1}} = \dfrac{18 \cdot 10^{3}}{2 \cdot 10^{-1}} = 9{,}0 \cdot 10^{4}\ V$

a) $V_P = V_1 + V_2 = -9{,}0 \cdot 10^4 + 9{,}0 \cdot 10^4 = 0$

b) $\vec{E}_P = \vec{E}_1 + \vec{E}_2$




O campo elétrico gerado pelas duas cargas possui a mesma direção e sentido.

Em módulo, $E_1 = E_2$:

$$E = \frac{K_0 Q}{d^2} = \frac{9{,}0 \cdot 10^9 \cdot 2{,}0 \cdot 10^{-6}}{(2 \cdot 10^{-1})^2} = \frac{18 \cdot 10^{+3}}{4 \cdot 10^{-2}} = 4{,}5 \cdot 10^5 \text{ N/C}$$

$$\vec{E}_{RES,P} = \vec{E}_1 + \vec{E}_2 = 4{,}5 \cdot 10^5 + 4{,}5 \cdot 10^5 = \boxed{9{,}0 \cdot 10^5 \text{ N/C}}$$

c) Embora o potencial em P seja nulo, o campo elétrico resultante não é. Isto é decorrente do fato do potencial elétrico ser uma grandeza escalar enquanto o campo elétrico é vetorial.

9

a)

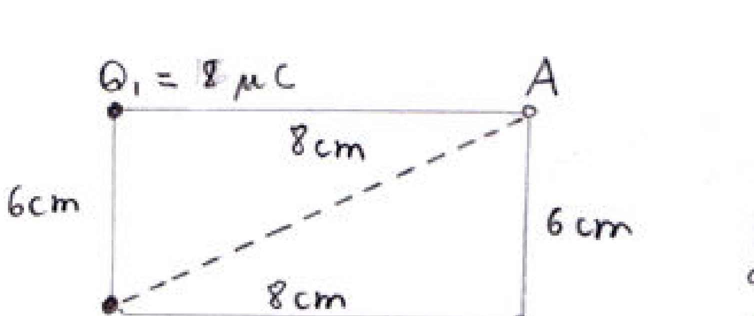

$V_A = +3000\text{ V}$

$V = \frac{K_0 Q}{d}$ $\quad V \cdot d = K_0 Q$

$$Q = \frac{V \cdot d}{K_0} = \frac{3{,}0 \cdot 10^3 \cdot 3 \cdot 10^{-1}}{9{,}0 \cdot 10^9} = \frac{9{,}0 \cdot 10^2}{9{,}0 \cdot 10^9} = \boxed{1{,}0 \cdot 10^{-7} \text{ C}}$$

b) $$E = \frac{K_0 \cdot Q}{d^2} = \frac{9{,}0 \cdot 10^9 \cdot 1{,}0 \cdot 10^{-7}}{(3{,}0 \cdot 10^{-1})^2} = \frac{9{,}0 \cdot 10^2}{9{,}0 \cdot 10^{-2}} = \boxed{1{,}0 \cdot 10^4 \text{ N/C}}$$

10




OBS: a resposta desta questão depende do desenho que é feito, logo, pode haver outras possibilidades.

O potencial resultante em P é a soma dos potenciais $V_1$, $V_2$ e $V_3$.

$$V_1 = \frac{K_0 Q}{d} = \frac{9{,}0 \cdot 10^9 \cdot \cancel{8{,}0} \cdot 10^{-6}}{\cancel{8{,}0} \cdot 10^{-2}} = \frac{9{,}0 \cdot 10^3}{10^{-2}} = 9{,}0 \cdot 10^5\ V$$

$$V_2 = \frac{K_0 Q}{d} = \frac{9{,}0 \cdot 10^9 \cdot 16 \cdot 10^{-6}}{10 \cdot 10^{-2}} = \frac{144 \cdot 10^{+3}}{10 \cdot 10^{-2}} = 14{,}4 \cdot 10^5\ V$$

(a distância entre $Q_2$ e A é encontrada pelo Teorema de Pitágoras)

$d^2 = \sqrt{6^2 + 8^2}$ $\quad d^2 = \sqrt{36+64}$ $\quad d = \sqrt{100}$ $\quad d = 10\ cm$

$$V_3 = \frac{K_0 Q}{d} = \frac{9{,}0 \cdot 10^9 \cdot (-12 \cdot 10^{-6})}{6 \cdot 10^{-2}} = \frac{-108 \cdot 10^3}{6 \cdot 10^{-2}} = -18 \cdot 10^5\ V$$

$$V_{RES} = 9{,}0 \cdot 10^5 + 14{,}4 \cdot 10^5 - 18 \cdot 10^5 = (9 + 14{,}4 - 18) \cdot 10^5$$

$$\boxed{V_{RES} = 5{,}4 \cdot 10^5\ V}$$

11) a) $V_1 = \frac{K_0 Q}{d} = \frac{9{,}0 \cdot 10^9 \cdot 4{,}0 \cdot 10^{-6}}{1} = 36 \cdot 10^3 = 3{,}6 \cdot 10^4\ V$

$$V_2 = \frac{K_0 Q}{d} = \frac{9{,}0 \cdot 10^9 \cdot 4{,}0 \cdot 10^{-6}}{2} = \frac{36 \cdot 10^3}{2} = 18 \cdot 10^3 = 1{,}8 \cdot 10^4\ V$$

$$V_3 = \frac{K_0 Q}{d} = \frac{9{,}0 \cdot 10^9 \cdot 4{,}0 \cdot 10^{-6}}{3} = \frac{36 \cdot 10^3}{3} = 12 \cdot 10^3 = 1{,}2 \cdot 10^4\ V$$

b) C e B estão no mesmo potencial: $18 \cdot 10^4\ V$

A, F e E estão no mesmo potencial: $12 \cdot 10^4\ V$