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Institute of Applied Sciences and Technology
L1 Networks and telecommunications

Exam of Physics 1

Course questions:

I - Mention the properties of conductors in electrostatic equilibrium?

II - A conductive sphere (A) of radius R is connected to a constant voltage generator (Fig 1-A).

1- Represent, qualitatively, the charge on the conductive sphere (A).

2- We place next to (A) an insulated conductor (B) that is neutral (Fig 1-B). Represent qualitatively the new distribution of charges on the two conductors, justify.

3- If we connect the conductor (B) to the ground by a conductive wire (Fig 1- C), give the new distribution of charges.

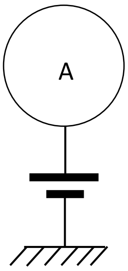


Figure (1-A)

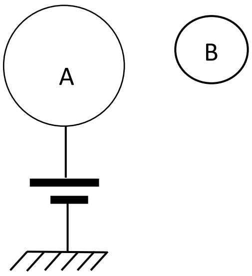


Figure (1-B)

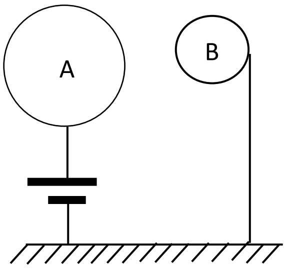


Figure (1-C)

Exercise 1 :

3 capacitors of capacity C_1, C_2, C_3, are connected as shown in the diagram. a voltage is applied between the two points A and B: $V_{AB} = 150$ V . We give: $C_1 = 1\eta F$, $C_2 = 1\eta F$.
$C_3 = 2\eta F$

1- Calculate the capacitance of the equivalent capacitor.

2- Calculate the charge of the equivalent capacitor.

3- Calculate the electric charge of each capacitor.

4- Calculate the potential difference between the two ends of each capacitor.

5- Find the energy stored in the capacitor C_2.

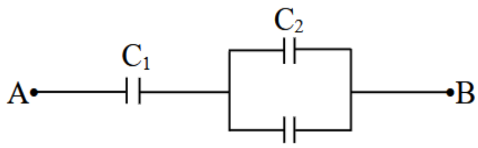


Figure 2

Exercise 2 :

Two point charges $\mathbf{q_B}$ and $\mathbf{q_C}$ are placed at the vertices B and C of an equilateral triangle of side 1m.

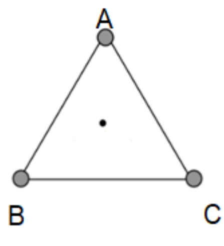
1- Find the electrostatic field at point A.

2- Find the electric potential at point A.

3- We place a charge $Q_A = 10^{-6}$ C at point A. Find the force exerted by the two charges on Q_A.

4- Calculate the internal energy of this system of 3 charges.

$\mathbf{q_B = -10^{-6}C}$, $\mathbf{q_C = 10^{-6}}$, $\mathbf{K = 9.10^9}$ N. m^2. C^{-2} **AB = AC = BC = a = 1m**

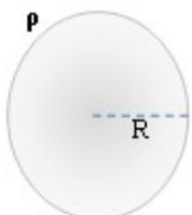


(Figure 3)

Exercise 3:

A sphere with center O and radius R carries a total charge Q distributed evenly over its volume. With a charge density ρ, $\vec{E}$ is the electrostatic field generated by this sphere at a point M in space. Using the Gauss theorem, find E(r) in terms of ρ and R. Consider the cases $r < R$ and $r > R$

(Figure 4)



A. CHEDDADI *BON COURAGE*

Physics Exam Correction :

cours questions : (3,5 Pts)

I. properties of conductors in electrostatic equilibrium :

1). The field $\vec{E}$ inside the conductor is zero $\vec{E}=0$

2) - The sum of Q_{int} charges inside the conductor is zero $Q_{it}=0$

3) The electric potential inside is constant $V = cte$

$\vec{F}=\vec{0}$, $\vec{E}=\vec{0}$ 0,5 $\begin{cases} Q_{int}=0 & 0{,}5 \\ V = cte & 0{,}5 \end{cases}$

II

0,5 0,5 0,5

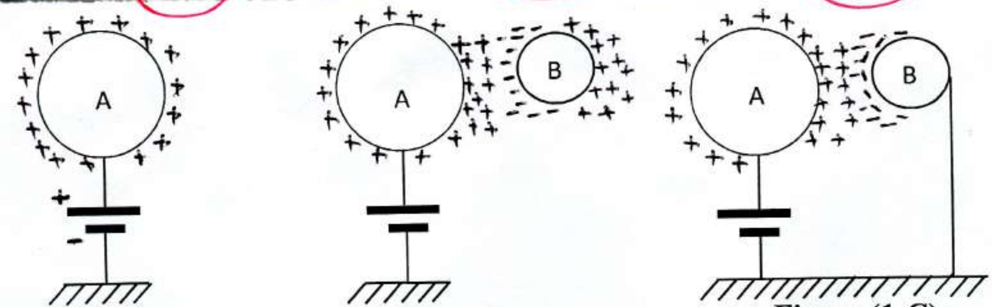


Figure (1-A) Figure (1-B) Figure (1-C)

0,5

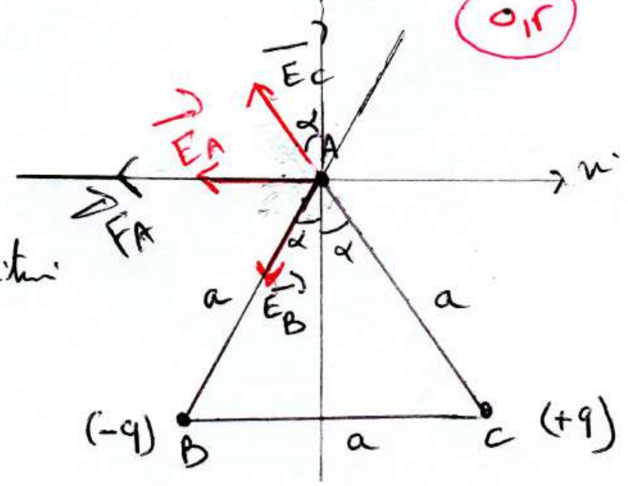
The positive charges of the conductive sphere (A) attract the negative charges of the conductor (B) and repel the positive charges. We have a new distribution of the charges of B. This is the phenomenon of partial influence.

Exercise 2 : (8 Pts)

1) Electrostatic field at point A :

we use the principle of superposition

$\vec{E_A} = \vec{E_B} + \vec{E_C}$ 0,5



$$\begin{cases} E_{B_y} = E_B \cos\alpha \\ E_{B_x} = E_B \sin\alpha \end{cases} \quad 0{,}1\sqrt{}$$

$$E_B = k \cdot \frac{|q_B|}{a^2} \quad 0{,}2\sqrt{}$$

$$q_B = -q$$

$$E_B = k \cdot \frac{|-q|}{a^2} = k \cdot \frac{q}{a^2} \quad 0{,}2\sqrt{}$$

$$|-q| = q$$

$$\cos\alpha = \frac{\sqrt{3}}{2} \quad \left(\alpha = \frac{\pi}{6}\right)$$

$$\sin\alpha = \frac{1}{2}$$

$$\vec{E_B} = -E_{Bx}\vec{i} - E_{By}\vec{j} \quad 0{,}2\sqrt{}$$

$$\vec{E_B} = -\left(\frac{kq}{a^2}\cdot\frac{1}{2}\vec{i} + \frac{kq}{a^2}\frac{\sqrt{3}}{2}\vec{j}\right)$$

$$\boxed{\vec{E_B} = -\frac{kq}{a^2}\left(\frac{1}{2}\vec{i} + \frac{\sqrt{3}}{2}\vec{j}\right)} \quad 0{,}5$$

$$\vec{E_C} = -E_{Cx}\vec{i} + E_{Cy}\vec{j} \quad 0{,}2\sqrt{}$$

$$\begin{cases} E_{Cy} = E_C \cos\alpha \\ E_{Cx} = E_C \sin\alpha \end{cases} \quad 0{,}2\sqrt{}$$

$$E_C = k \cdot \frac{|q_C|}{a^2} = k\frac{q}{a^2} \quad 0{,}2\sqrt{}$$

$$\vec{E_C} = -\frac{kq}{a^2}\cdot\frac{1}{2}\vec{i} + \frac{kq}{a^2}\cdot\frac{\sqrt{3}}{2}\vec{j}$$

$$\boxed{\vec{E_C} = \frac{kq}{a^2}\left(-\frac{1}{2}\vec{i} + \frac{\sqrt{3}}{2}\vec{j}\right)} \quad 0{,}1\sqrt{}$$

$$\vec{E_A} = \vec{E_B} + \vec{E_C}$$

$$\vec{E_A} = \frac{kq}{a^2}\left(-\frac{1}{2}\vec{i} - \frac{1}{2}\vec{i}\right) + \frac{kq}{a^2}\left(-\frac{\sqrt{3}}{2}\vec{j} + \frac{\sqrt{3}}{2}\vec{j}\right)$$

$$\vec{E_A} = -\frac{kq}{a^2}\vec{i} \quad 0{,}5 \quad , \frac{kq}{a^2} = \frac{9.10^{9}.10^{-6}}{1^2} = 9.10^{3}\ V/m$$

$$E_A = \sqrt{(9.10^{3})^2 + 0^2}$$

$$E_A = 9.10^{3}\ V/m \quad 0{,}1\sqrt{}$$

2) Electrical potential at point A

$$V_A = V_B + V_C = k\cdot\frac{(-q)}{a} + k\frac{(q)}{a} \quad 0{,}1\sqrt{} \quad 0{,}2\sqrt{}$$

$$V_A = 0\ V \quad 0{,}2\sqrt{}$$

3) $\vec{F_A}$

$$\vec{F_A} = q_A\vec{E} \quad 0{,}1\sqrt{}$$

$q_A > 0 \Rightarrow \vec{F_A}$ and $\vec{E_A}$ have the same sense $0{,}2\sqrt{}$

$$F_A = |q_A|\cdot E_A$$

$$F_A = 10^{-6}\cdot 9.10^{3} = 9.10^{-3}\ N \quad 0{,}2\sqrt{}$$

4) $$E_i = \sum_{i<j}^{N} U_{ij} \quad 0{,}2\sqrt{}$$

$$U_{ij} = k\cdot\frac{q_i q_j}{r_{ij}}$$

$$E_i = k\cdot\frac{q_1 q_2}{a} + k\frac{q_1 q_3}{a} + k\frac{q_2 q_3}{a} \quad 0{,}2\sqrt{}$$

$$(q_1 = q_B), (q_2 = q_C), (q_3 = q_A)$$

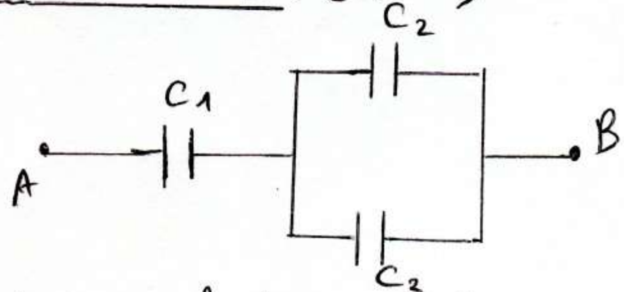
$E_i = k\cdot\frac{-q^2}{a} + k\cdot\frac{-q^2}{a} + k\cdot\frac{q^2}{a}$ 0,25

$E_i = \frac{kq^2}{a}(-1-1+1)$

$E_i = -\frac{kq^2}{a} = -\frac{9\cdot10^{9}\cdot(10^{-6})^2}{1}$

$\boxed{E_i = -9\cdot10^{-3}\,J}$ 0,25

Exercise 1: (4 pts)



1) Equivalente capacitor:

$C_2 // C_3 \Rightarrow C_{eq_1} = C_2 + C_3 = 1+2 =$ 0,25

$C_{eq_1} = 3\,\eta F$ 0,25

C_1 on series with C_{eq_1}

$C_{eq} = \frac{C_1\cdot C_{eq_1}}{C_1 + C_{eq_1}} =$ 0,25

$C_{eq} = \frac{1\times3}{1+3} = \frac{3}{4} = 0,75\,\eta F$ 0,25

2) Change of the equivalente capacitor:

$Q_T = C_{eq}\cdot V_{AB}$ 0,25

$Q_T = 0,75\cdot150 = 112,5\,\eta C$ 0,25

3) electric charge of each capacitor:

$Q_1 = Q_T = 112,5\,\eta C$ 0,25

$Q_2 = ?\quad Q_3 = ?$

$C_2 // C_3 \Rightarrow U_2 = U_3$

$Q_2 = C_2U_2 \Rightarrow U_2 = \frac{Q_2}{C_2}$

$Q_3 = C_3U_3 \Rightarrow U_3 = \frac{Q_3}{C_3}$

$U_2 = U_3 \Rightarrow$ 0,25

$\frac{Q_2}{C_2} = \frac{Q_3}{C_3}$

$C_3 = 2C_2$ 0,25

$\frac{Q_2}{\cancel{C_2}} = \frac{Q_3}{2\cancel{C_2}}$

$Q_3 = 2Q_2$

$Q_1 = Q_2 + Q_3 = Q_2 + 2Q_2 = 3Q_2$

$Q_2 = \frac{Q_1}{3} = \frac{112,5\cdot10^{-9}}{3} = 37,5\,\eta C$ 0,25

$Q_3 = 2Q_2 = 2\times37,5 = 75\,\eta C$ 0,25

4) potentiel difference between the two ends of each capacitor:

$U_1 = \frac{Q_1}{C_1} = \frac{112,5\cdot10^{-9}}{10^{-9}} = 112,5\,V$ 0,25

$U_2 = \frac{Q_2}{C_2} = \frac{37,5\cdot10^{-9}}{10^{-9}} = 37,5\,V$ 0,25

$U_3 = \frac{Q_3}{C_3} = \frac{75\cdot10^{-9}}{2\cdot10^{-9}} = 37,5\,V$ 0,25

5) Energy stored in the capacitor C_2

$$E_{C_2} = \frac{1}{2} C_2 V_2^2 \quad (0{,}25)$$

$$= \frac{1}{2} \cdot 10^{-9} (37{,}5)^2 = 703 \cdot 10^{-9}\ \text{J}$$

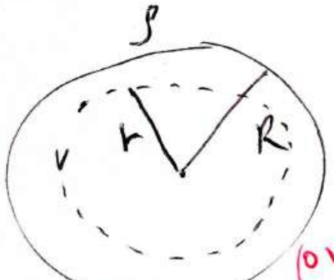
$$= 0{,}7\mu\ \text{J} \quad (0{,}25)$$

Exercise 3: (4,5 Pts)

We use the Gauss theorem to find $E(r)$

$$\Phi = \iint_{S_G} \vec{E} \cdot \vec{dS} = \frac{\Sigma Q_i}{\varepsilon_0} \quad (0{,}5)$$

Case 1: $r < R$



(0,5)

$$E_{int} \cdot S_G = \frac{\Sigma Q_i}{\varepsilon_0} \quad (0{,}5)$$

The distribution of charges is on volume:

$$Q = \rho \cdot V = \rho \cdot \frac{4}{3} \pi r^3 \quad (0{,}5)$$

$$S_G = 4 \pi r^2 \quad (0{,}5)$$

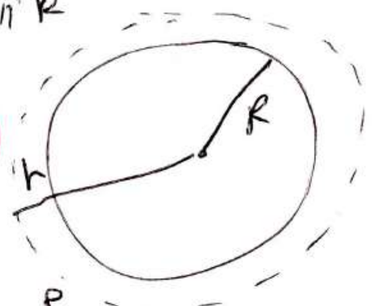
$$E_{int} \cdot 4 \pi r^2 = \frac{\rho}{\varepsilon_0} \cdot \frac{4}{3} \pi r^3$$

$$E_{int} = \frac{\rho}{3\varepsilon_0} r \quad (0{,}5)$$

case 2: $r > R$

$$Q_{int} = \rho \cdot V = \rho \frac{4}{3} \pi R^3$$

(0,5)



$$E_{ext} \cdot 4 \pi r^2 = \frac{\rho}{\varepsilon_0} \cdot \frac{4}{3} \pi R^3 \quad (0{,}5)$$

$$E_{ext} = \frac{\rho}{3\varepsilon_0} \cdot \frac{R^3}{r^2} \quad (0{,}5)$$