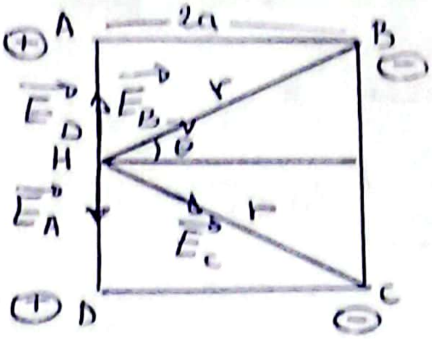
1 Inf — الحل النموذجي لامتحان كهرباء عامة

ت : 1

- 2026 / 2025 -



1 -

$$\vec{E}_H = \vec{E}_A + \vec{E}_B + \vec{E}_C + \vec{E}_D$$

$$\vec{E}_A = -|E_A|\vec{j}$$

$$\vec{E}_B = |E_B|\cos\theta\,\vec{i} + |E_B|\sin\theta\,\vec{j}$$

$$\vec{E}_C = |E_C|\cos\theta\,\vec{i} - |E_C|\sin\theta\,\vec{j}$$

$$\vec{E}_D = |E_D|\vec{j}$$

$$E_A = \frac{k|q_A|}{a^2} = \frac{k.q}{a^2} \Rightarrow \boxed{E_A = \frac{kq}{a^2}}$$

$$E_B = \frac{k|q_B|}{r^2}, \quad r = \sqrt{4a^2 + a^2} = \sqrt{5}\,a \Rightarrow r = \sqrt{5}\,a$$

$$E_B = \frac{k.5q}{5a^2} = \frac{kq}{a^2} \Rightarrow \boxed{E_B = \frac{kq}{a^2}}$$

$$E_C = \frac{k|q_C|}{r^2} = \frac{k.5q}{5a^2} \Rightarrow \boxed{E_C = \frac{kq}{a^2}}$$

$$E_D = \frac{k|q_D|}{a^2} = \frac{kq}{a^2} \Rightarrow \boxed{E_D = \frac{kq}{a^2}}$$

بالجمع نجد :

$$\vec{E}_H = 2|E_B|\cos\theta\,\vec{i}$$

$$\cos\theta = \frac{2a}{\sqrt{5}a} = \frac{2}{\sqrt{5}}$$

$$\vec{E}_H = 2.\frac{kq}{a^2}.\frac{2}{\sqrt{5}}\vec{i} \Rightarrow \boxed{\vec{E}_H = \frac{4}{\sqrt{5}}\frac{kq}{a^2}\vec{i}}$$

② الكمون الإجمالي $V(H)$:

$$V(H) = V_A + V_B + V_C + V_D$$

$$= \frac{Kq_A}{a} + \frac{Kq_B}{r} + \frac{Kq_C}{r} + \frac{Kq_D}{a}$$

$$= \frac{Kq}{a} + \frac{K(-5q)}{\sqrt{5}a} + \frac{K(-5q)}{\sqrt{5}a} + \frac{Kq}{a}$$

$$= \frac{2Kq}{a} - \frac{10Kq}{\sqrt{5}a} = \frac{Kq}{a}\left(2 - \frac{10}{\sqrt{5}}\right)$$

$$\boxed{V(H) = \frac{2Kq}{a}\left(1 - \frac{5}{\sqrt{5}}\right)}$$

③ - شعاع القوة الإجمالية $\vec{F}(H)$:

$$\vec{F}_H = q_H \cdot \vec{E}_H = -5q \cdot \frac{4}{\sqrt{5}} \frac{Kq}{a^2} \vec{i}$$

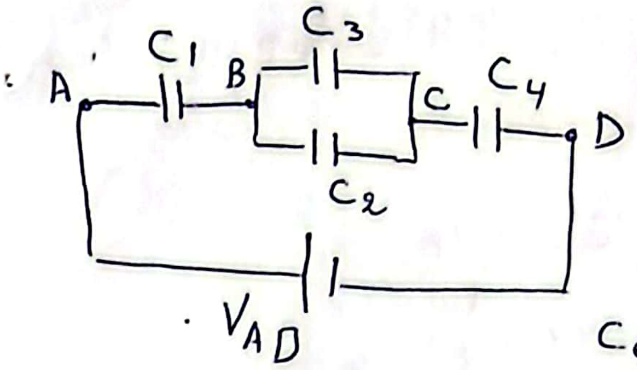
$$= -\frac{\cancel{5} \cdot 4}{\cancel{5}} \cdot \sqrt{5} \frac{Kq^2}{a^2} \vec{i} \Rightarrow \boxed{\vec{F}_H = -4\sqrt{5} \frac{Kq^2}{a^2} \vec{i}}$$

④ - الطاقة الكامنة للشحنة q_H :

$$E_{P_{q_H}} = q_H \cdot V_H = -5q \cdot \frac{2Kq}{a}\left(1 - \frac{5}{\sqrt{5}}\right)$$

$$\boxed{E_{P_{q_H}} = \frac{10Kq^2}{a}\left(\frac{5}{\sqrt{5}} - 1\right)}$$

حل التمرين (02) :



1- السعة المكافئة C_{eq} :

- C_2 و C_3 على التفرع :

$$C_{eq_1} = 5 + 15 = 20\,\mu F.$$

$$\boxed{C_{eq_1} = 20\,\mu F}$$

C_1 و C_{eq_1} على التسلسل :

$$C_{eq_2} = \frac{C_1\, C_{eq_1}}{C_1 + C_{eq_2}} = \frac{12 \cdot 20}{12 + 20} = \frac{240}{32} = \frac{30}{4}.$$

$$\boxed{C_{eq_2} = 7{,}5\,\mu F}$$

C_{eq_2} و C_4 على التسلسل

$$C_{eq} = \frac{C_{eq_2} \cdot C_4}{C_{eq_2} + C_4} = \frac{7{,}5 \cdot 30}{30 + 7{,}5} = \frac{225}{37{,}5} = 6.$$

$$\boxed{C_{eq} = 6\,\mu F}$$

(2) - فرق الكمون V_{AB} ، V_{BC} و V_{CD} وشحنة كل مكثفة :

$$Q_1 = C_{eq} \cdot V_{AD} = 6 \cdot 100 = 600\,\mu C \Rightarrow \boxed{Q_1 = 600\,\mu C}$$

$$V_{AB} = \frac{Q_1}{C_1} = \frac{600}{12} = 50\,V \Rightarrow \boxed{V_{AB} = 50\,V}$$

لدينا : $Q_4 = Q_1$ (الربط على التسلسل).

$$\boxed{Q_4 = 600\,\mu C} \quad , V_{CD} = \frac{Q_4}{C_4} = \frac{600}{30} = 20\,V$$

$$\boxed{V_{CD} = 20\,V}$$

$$V_{BC} = V_{AD} - (V_{AB} + V_{CD}) = 100 - (50 + 20) = 30\,V$$

$$\boxed{V_{BC} = 30V}$$

$V_{BC} = V_2 = V_3 = 30V$

(الربط على التفرع).

$Q_2 = C_2 V_2 = 5 \cdot 30 = 150 \mu C$.

$$\boxed{Q_2 = 150 \mu C}$$

$Q_3 = C_3 V_3 = 15 \cdot 30 = 450 \mu C \Rightarrow \boxed{Q_3 = 450 \mu C}$

3 - الطاقة المخزنة في الدارة:

$E_p = \frac{1}{2} C_{eq} V^2 = \frac{1}{2} \cdot 6 \times 10^{-6} \cdot (100)^2$

$$\boxed{E_p = 3 \times 10^{-4} J}$$

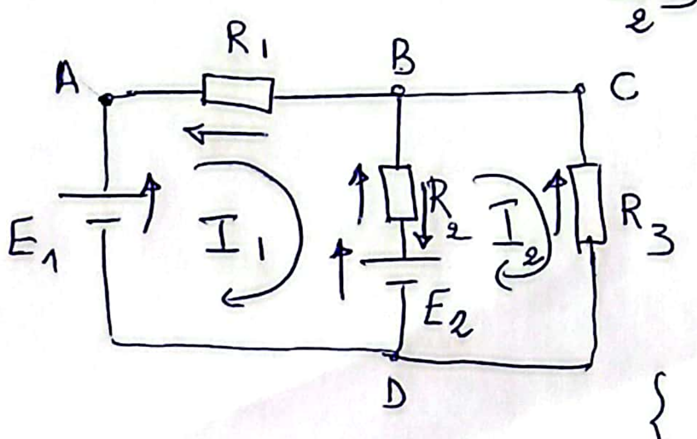
- حل التمرين 03:

1 - قانوني كيرشوف:

1 - القانون الأول: $\sum I_i = 0$.

2 - القانون الثاني $\sum E_i = 0$.

2 - حساب التيارات I_1 و I_2.



1 - نرسم الجهود على مستوى كل عنصر.

2 - نطبق $\sum V_i = 0$.

$$\begin{cases} E_1 - R_1 I_1 - R_2 (I_1 - I_2) - E_2 = 0 \\ E_2 - R_2 (I_2 - I_1) - R_3 I_2 = 0 \end{cases}$$

$$\begin{cases} E_1 - E_2 - (R_1 + R_2) I_1 + R_2 I_2 = 0 \\ E_2 + R_2 I_1 - (R_2 + R_3) I_2 = 0 \end{cases}$$

$$\begin{cases} 4 I_1 - 2 I_2 = 4 \; \ldots \; (1) \\ -2 I_1 + 3 I_2 = 4 \; \ldots \; (2) \end{cases}$$

بضرب (2) × (2) ثم نجمع نجد .

$$4 I_2 = 12 \Rightarrow \boxed{I_2 = 3\,A}$$

بالتعويض في (1) نجد .

$$4 I_1 - 6 = 4 \Rightarrow I_1 = \frac{4+6}{4} = \frac{10}{4} = 2{,}5$$

$$\boxed{I_1 = 2{,}5\,A}$$

(3) - في الفرع : AB - $I_1 = 2{,}5\,A$

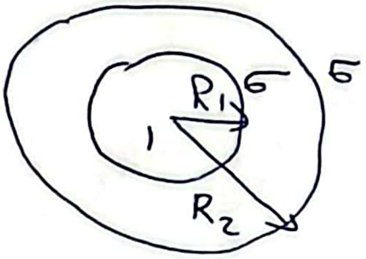
الفرع CD . $I_2 = 3\,A$

الفرع BD : $I_3 = I_2 - I_1$

$$\boxed{I_3 = 0{,}5\,A}$$

حل تمرين 04

1- بإستعمال نظرية غوص إيجاد الحقل الكهربائي



$$\oint \vec{E} \cdot \vec{ds} = \frac{\sum q}{\varepsilon_0}$$

$$\boxed{E \cdot S_g = \frac{q}{\varepsilon_0}}$$

- لما: $r < R_1$:

$$E_1 \cdot S_g = 0 \Rightarrow E_1 = 0$$

- لما: $R_1 < r < R_2$:

$$E_2 \cdot S_g = \frac{q}{\varepsilon_0}$$

$$E_2 \cdot \cancel{4\pi} r^2 = \frac{\sigma \cdot \cancel{4\pi} R_1^2}{\varepsilon_0} \Rightarrow \boxed{E_2 = \frac{\sigma R_1^2}{\varepsilon_0 r^2}}$$

- لما: $r > R_2$:

$$E_3 \cdot S_g = \frac{\sum q_{int}}{\varepsilon_0} = \frac{q_1 + q_2}{\varepsilon_0}$$

$$E_3 \cdot \cancel{4\pi} r^2 = \frac{\sigma \cdot \cancel{4\pi} R_1^2 + \sigma \cancel{4\pi} R_2^2}{\varepsilon_0}$$

$$\boxed{E_3 = \frac{\sigma (R_1^2 + R_2^2)}{\varepsilon_0 r^2}}$$

2- عبارة الكمون الكهربائي:

لدينا

$$dV = -E \cdot dr$$

$$V = -\int E \cdot dr$$

- لما $r > R_2$:

$$V_3(r) = -\int E_3 \cdot dr = -\int \frac{\sigma (R_1^2 + R_2^2)}{\varepsilon_0 r^2} dr$$

$$V_3(r) = \frac{\sigma (R_1^2 + R_2^2)}{\varepsilon_0 r} + C_3 .$$

لدينا

$$\left.\begin{array}{l} V(\infty) = 0 \\ V_3(\infty) = C_3 \end{array}\right\} C_3 = 0$$

$$\boxed{V_3(r) = \frac{\sigma (R_1^2 + R_2^2)}{\varepsilon_0 r}}$$

- لما $R_1 < r R_2$:

$$V_2(r) = -\int E_2 dr = -\int \frac{\sigma R_1^2}{\varepsilon_0 r^2} dr$$

$$V_2(r) = \frac{\sigma R_1^2}{\varepsilon_0 r} + C_2 \quad , \quad V_3(r = R_2) = V_2(r = R_2)$$

أي :

$$\frac{\sigma (R_1^2 + R_2^2)}{\sigma_0 R_2} = \frac{\sigma R_1^2}{\varepsilon_0 R_2} + C_2 .$$

$$\cancel{\frac{\sigma R_1^2}{\varepsilon_0 R_2}} + \frac{\sigma R_2^2}{\varepsilon_0 R_2} - \cancel{\frac{\sigma R_1^2}{\varepsilon_0 R_2}} = C_2 \Rightarrow C_2 = \frac{\sigma R_2}{\varepsilon_0} .$$

$$\boxed{V_2(r) = \frac{\sigma R_1^2}{\varepsilon_0 r} + \frac{\sigma R_2}{\varepsilon_0}}$$

- لما $r < R_1$:

$$V_1(r) = -\int E_1 \cdot dr = C_1$$

$$V_1(r) = C_1 \quad , \quad V_1(r = R_1) = V_2(r = R_1)$$

$$C_1 = \frac{\sigma R_1^2}{\varepsilon_0 R_1} + \frac{\sigma R_2}{\varepsilon_0} = \frac{\sigma R_1}{\varepsilon_0} + \frac{\sigma R_2}{\varepsilon_0} = \frac{\sigma}{\varepsilon_0} (R_1 + R_2)$$

$$\boxed{V_1(r) = \frac{\sigma}{\varepsilon_0} (R_1 + R_2)}$$