Corrigé du Rattrapage de Physique2

Exercice 1 : (07 points)

1. La force exercée par q_O, q_B et q_C sur q_A :

$$CA = 2\sqrt{a^2+b^2}\ (\mathbf{0.25});\ \vec{u}_{OA} = \vec{\imath}\ (\mathbf{0.25});\ \vec{u}_{BA} = -\vec{\jmath}\ (\mathbf{0.25})$$

$$\vec{u}_{CA} = \frac{\overrightarrow{CA}}{CA} = \frac{\overrightarrow{CO}+\overrightarrow{OA}}{CA} = \frac{\overrightarrow{OA}-\overrightarrow{OC}}{CA} = \frac{a\vec{\imath}-b\vec{\jmath}}{\sqrt{a^2+b^2}}(\mathbf{0.25})$$

$$\vec{F}_{OA} = K\frac{q_O q_A}{OA^2}\vec{u}_{OA}(\mathbf{0.25}) = K\frac{q^2}{2a^2}\vec{\imath}\ (\mathbf{0.25});\ \vec{F}_{CA} = K\frac{q_A q_C}{CA^2}\vec{u}_{CA}(\mathbf{0.25}) = \frac{3Kq^2}{4(a^2+b^2)^{3/2}}(a\vec{\imath}-b\vec{\jmath})(\mathbf{0.25})$$

$$\vec{F}_{BA} = K\frac{q_A q_B}{BA^2}\vec{u}_{BA}(\mathbf{0.25}) = \frac{Kq^2}{4b^2}\vec{\jmath}\ (\mathbf{0.25})$$

2. Le champ créé en P :

$$OP = AP = BP = CP = \frac{CA}{2} = \sqrt{a^2+b^2}\ (\mathbf{0.25});\ \vec{u}_{CP} = \vec{u}_{CA} = \frac{a\vec{\imath}-b\vec{\jmath}}{\sqrt{a^2+b^2}}\ (\mathbf{0.25});\ \vec{u}_{AP} = -\vec{u}_{CP} = \frac{-a\vec{\imath}+b\vec{\jmath}}{\sqrt{a^2+b^2}}(\mathbf{0.25})$$

$$\vec{u}_{OP} = \vec{u}_{OB} = \frac{\overrightarrow{OB}}{OB} = \frac{\overrightarrow{OA}+\overrightarrow{AB}}{OB} = \frac{a\vec{\imath}+b\vec{\jmath}}{\sqrt{a^2+b^2}}\ (\mathbf{0.25});\ \vec{u}_{BP} = -\vec{u}_{OP} = -\frac{a\vec{\imath}+b\vec{\jmath}}{\sqrt{a^2+b^2}}(\mathbf{0.25})$$

$$\vec{E}_O = K\frac{q_O}{OP^2}\vec{u}_{OP}(\mathbf{0.25}) = 2Kq\frac{a\vec{\imath}+b\vec{\jmath}}{(a^2+b^2)^{3/2}}(\mathbf{0.25});\vec{E}_C = K\frac{q_C}{CP^2}\vec{u}_{CP}(\mathbf{0.25}) = 3Kq\frac{a\vec{\imath}-b\vec{\jmath}}{(a^2+b^2)^{3/2}}(\mathbf{0.25})$$

$$\vec{E}_B = K\frac{q_B}{BP^2}\vec{u}_{BP}(\mathbf{0.25}) = Kq\frac{a\vec{\imath}+b\vec{\jmath}}{(a^2+b^2)^{3/2}}\ (\mathbf{0.25});\ \vec{E}_A = K\frac{q_A}{AP^2}\vec{u}_{AP}(\mathbf{0.25}) = Kq\frac{-a\vec{\imath}+b\vec{\jmath}}{(a^2+b^2)^{3/2}}(\mathbf{0.25})$$

$$\vec{E} = \vec{E}_O + \vec{E}_A + \vec{E}_B + \vec{E}_C\ (\mathbf{0.25}) = \frac{Kq}{(a^2+b^2)^{3/2}}(5a\vec{\imath}+b\vec{\jmath})\ (\mathbf{0.25})$$

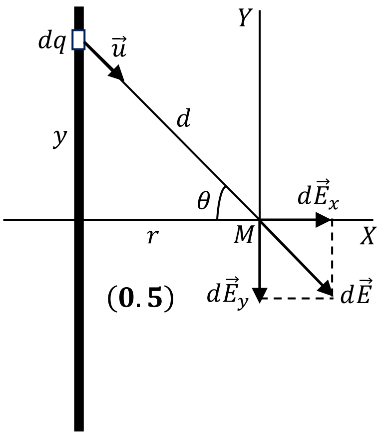
Le potentiel créé en P :

$$V = V_O + V_A + V_B + V_C\ (\mathbf{0.25}) = K\frac{q_O}{OP} + K\frac{q_A}{AP} + K\frac{q_B}{BP} + K\frac{q_C}{CP}(\mathbf{0.25}) = \frac{5Kq}{\sqrt{a^2+b^2}}\ (\mathbf{0.25})$$

Exercice 2 : (07 points)

1. Champ électrique créé par le fil infini :

1.1. Calcul direct :



La charge dq crée au point M le champ élémentaire :

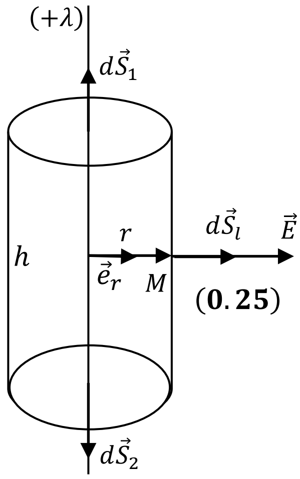
$$d\vec{E} = K\frac{dq}{d^2}\vec{u}\ (\mathbf{0.25});\ dq = \lambda dl\ (\mathbf{0.25})$$

A cause de la symétrie, la composante suivant y de $\vec{E}$ est nulle :

$$\vec{E} = E_x\vec{\imath}\,(\mathbf{0.25});\ E_x = \int dE_x = \int dE\cos\theta = \int k\frac{\lambda dl}{d^2}cos\theta(\mathbf{0.25})$$

$$dl = dy\ (\mathbf{0.25}); \tan\theta = \frac{y}{r}(\mathbf{0.25}) \Rightarrow y = r\tan\theta\ (\mathbf{0.25}) \Rightarrow dy = \frac{r}{\cos^2\theta}d\theta\ (\mathbf{0.25}); d = \frac{r}{\cos\theta}(\mathbf{0.25})$$

$$E_x = \frac{K\lambda}{r}\int_{-\pi/2}^{\pi/2} \cos\theta \, d\theta (\mathbf{0.25}) = \frac{2K\lambda}{r} = \frac{\lambda}{2\pi\varepsilon_0 r} \left(K = \frac{1}{4\pi\varepsilon_0}\right) (\mathbf{0.25})$$



$(\mathbf{0.25})$

1.2. En utilisant le théorème de Gauss :

Symétrie cylindrique (le champ est radial) : $\vec{E} = E(r)\vec{e}_r$ $(\mathbf{0.25})$

On choisit comme surface de Gauss un cylindre de rayon r et de longueur h $(\mathbf{0.25})$.

$$\Phi_{cyl} = \Phi_{\substack{surface \\ latérale}} (\mathbf{0.25}) = \int E dS_l (\mathbf{0.25}) = E \int dS_l = ES_l (\mathbf{0.25}) = E(2\pi rh)(\mathbf{0.25})$$

Théorème de Gauss :

$$\Phi_{cyl} = \frac{Q_{int}}{\varepsilon_0} (\mathbf{0.25}) \Rightarrow E(2\pi rh) = \frac{\lambda h}{\varepsilon_0} \Rightarrow E(r) = \frac{\lambda}{2\pi\varepsilon_0 r} (\mathbf{0.25})$$

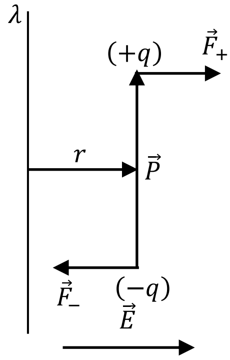
2. Dipôle :

2.1. Moment du couple agissant sur le dipôle :

$$\vec{M} = \vec{p} \wedge \vec{E} \ (\mathbf{0.25}) \ ; M = pEsin(\vec{p}, \vec{E})(\mathbf{0.25}) = pEsin(\pi/2)(\mathbf{0.25}) = pE = \frac{\lambda p}{2\pi\varepsilon_0 r} (\mathbf{0.25})$$

2.2. Les forces qui agissent sur le dipôle (voir figure ci-contre).

2.3. Le dipôle tend à s'orienter parallèlement au champ $(\mathbf{0.25})$.



$(\mathbf{0.25})$

<u>Exercice 3 :</u> (04 points)

1. La capacité équivalente :

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2 + C_3} \ (\mathbf{0.5}) \Rightarrow C_{eq} = \frac{C_1(C_2 + C_3)}{C_1 + (C_2 + C_3)} \ (\mathbf{0.5}) = 10 \ \mu F \ (\mathbf{0.25})$$

2. Charge des condensateurs et tensions de leurs bornes :

$$Q_{eq} = U.C_{eq} = \ 1200 \ \mu C \ (\mathbf{0.25}); \ Q_1 = Q_{eq} = 1200 \ \mu C \ (\mathbf{0.25}) \ ; \ Q_1 = C_1 U_1 (\mathbf{0.25}) \Rightarrow U_1 = \frac{Q_1}{C_1} = 40 \ V \ (\mathbf{0.25})$$

$$U_2 = U - U_1 (\mathbf{0.25}) = 80 \ V \ (\mathbf{0.25}); \ Q_2 = C_2 U_2 (\mathbf{0.25}) = 800 \ \mu C (\mathbf{0.25})$$

$$Q_3 = Q_{eq} - Q_2 (\mathbf{0.25}) = 400 \mu C (\mathbf{0.25}); \ U_3 = U_2 = 80 \ V (\mathbf{0.25})$$

<u>Exercice4 :</u> (04 points)

1. A l'équilibre, les charges se répartissent uniformément sur la surface de la sphère **(0.5).**

2. A l'intérieur de la sphère, le champ électrostatique est nul **(0.5).**

3. $$\begin{cases} V_1 = V_2 \ (\mathbf{0.5}) \\ Q_0 = Q_1 + Q_2 \ (\mathbf{0.5}) \end{cases} \Longrightarrow \begin{cases} K\frac{Q_1}{R_1} = K\frac{Q_2}{R_2} (\mathbf{0.5}) \\ Q_0 = Q_1 + Q_2 \end{cases} \Longrightarrow \begin{cases} \frac{Q_1}{R_1} = \frac{Q_2}{R_2} \\ Q_0 = Q_1 + Q_2 \end{cases} \Longrightarrow \begin{cases} Q_1 = \left(\frac{R_1}{R_1 + R_2}\right) Q_0 \ (\mathbf{0.25}) = 0.77 \ nC \ (\mathbf{0.25}) \\ Q_2 = \left(\frac{R_2}{R_1 + R_2}\right) Q_0 \ (\mathbf{0.25}) = 0.23 \ nC \ (\mathbf{0.25}) \end{cases}$$

La relation entre les densités superficielles :

$$V_1 = V_2 \Longrightarrow K\frac{Q_1}{R_1} = K\frac{Q_2}{R_2} \Longrightarrow \frac{\sigma_1 4\pi R_1^2}{R_1} = \frac{\sigma_2 4\pi R_2^2}{R_2} \ (\mathbf{0.25}) \Longrightarrow \sigma_1 R_1 = \sigma_2 R_2 \Longrightarrow \frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1} \ (\mathbf{0.25})$$

<u>Questions du cours :</u> (02 points)

$$\Phi = \oiint_{(S_G)} \vec{E}.\vec{ds} = \frac{Q_{int}(S_G)}{\varepsilon_0} \ (\mathbf{01}); \ \Phi = \frac{Q_{int}}{\varepsilon_0} = \frac{-14e + 7e}{\varepsilon_0} = \frac{-7e}{\varepsilon_0} = -1.26.10^{-7} SI \ (\mathbf{01})$$