NAME: .... FIRSTNAME: .... GROUP: ....

Physics Midterm n°1

Calculators and extra-documents are not allowed.

Answer only on the exam sheets.

Remember that, except if explicitly written in the questions, the notation $E_A(M)$ corresponds to the **norm** of the field $\overrightarrow{E_A}(M)$. But the angles are **oriented**.

We will use for convenience the usual constant $k = \frac{1}{4\pi\epsilon_0}$.

MCQ *(4 points-no negative points)* ***Circle the right answer.***

1- The electric field, which is generated by a pointlike charge q located at point O, at some point M reads:

a) $\vec{E}(M) = k\frac{q}{OM^2}\overrightarrow{OM}$ b) $\vec{E}(M) = k\frac{q}{OM^3}\overrightarrow{OM}$ c) $\vec{E}(M) = k\frac{q}{OM}\overrightarrow{OM}$

2- We are looking at the electrostatic force $\vec{F}_{1\to2}$ that a charge q_1 located at A creates on a charge q_2 located at B. The norm of this force is given by:

a) $F_{1\to2} = k\frac{q_1q_2}{AB}$ b) $F_{1\to2} = k\frac{|q_1||q_2|}{AB}$ c) $F_{1\to2} = k\frac{|q_1||q_2|}{AB^2}$

3- The electrostatic force is a force which is:

a) Always attractive b) Always repulsive c) Always conservative

4- Which property does the electrostatic field $\vec{E}$ derived from the potential V satisfy?

a) $\vec{E} = -\overrightarrow{grad}(V)$ b) $\vec{E} = \overrightarrow{grad}(V)$ c) $V = \overrightarrow{grad}(\vec{E})$

5- Consider a surfacic distribution of charges σ. An infinitesimal surface element dS located at point P creates at some point M, where there is a charge q, an elementary force $\overrightarrow{dF}$ which reads:

a) $\overrightarrow{dF} = kq\frac{\sigma dS}{PM}\overrightarrow{PM}$ b) $\overrightarrow{dF} = kq\frac{\sigma dS}{PM^3}\overrightarrow{PM}$ c) $\overrightarrow{dF} = kq\frac{\sigma dS}{PM^2}\overrightarrow{PM}$

6- Consider a uniform surfacic distribution of positive charges σ on a cylinder of axis (Oz), of radius R and of length h. Which infinitesimal surface element dS is not relevant for this geometry?

a) $dS = rdrd\theta$ b) $dS = dxdy$ c) $dS = rd\theta dz$

7- We are looking at the limit case of an infinite cylinder of axis (Oz) (with a unitary vector $\overrightarrow{u_z}$), which is uniformly positively charged at its surface. We want to get the electric field $\vec{E}(M)$, where M is located on the (Oz)-axis. What can be claimed?

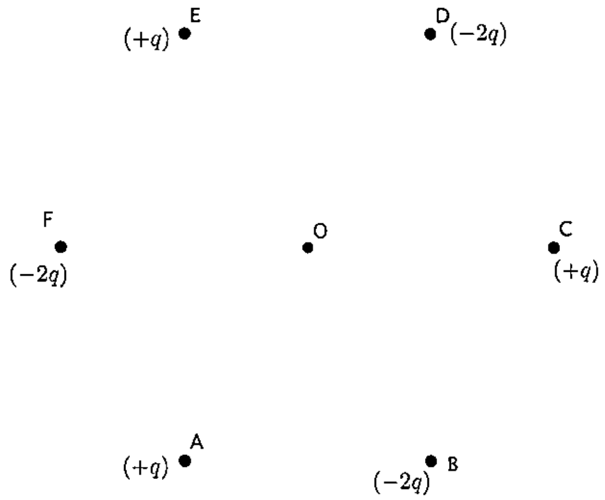
a) $\vec{E}(M) = \vec{0}$ b) $\vec{E}(M).\overrightarrow{u_z} > 0$ c) $\vec{E}(M)$ is divergent.

8- Consider again the finite cylinder of the question 6. At some point M outside the cylinder, the cylindrical components (E_ρ, E_θ, E_z) of the electrostatic field satisfy:

a) $E_\rho = 0$ b) $E_\theta = 0$ c) $E_z = 0$

Exercise 1

Consider the following charge distribution ($q > 0$), which forms a regular hexagon with edge length a and center O.



1- a) Express the electrostatic fields $\vec{E}_A(O)$, $\vec{E}_C(O)$, $\vec{E}_E(O)$ created at O by the charges which are respectively at points A, C and E. Sketch them on the drawing above.

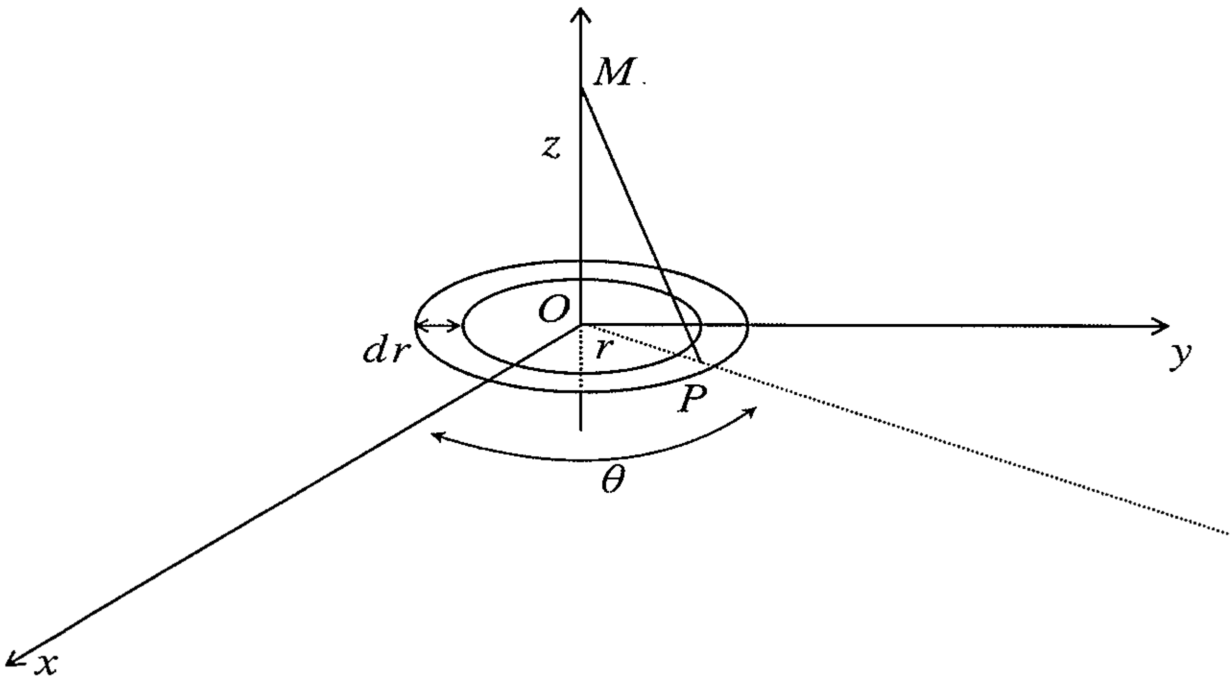
b) Compute the norm of the total electrostatic field created by these three charges at point O.

2- a) Let us put a charge $Q < 0$ at point O. First sketch the force generated by the charges which are at A, C and E on charge Q. Then express the norm of this force.

b) Express the electrostatic potential $V(O)$ created at O by the charges located at B, D and F.

c) By taking into account all the charges located at the tips of the hexagon, give the expression of the electrostatic potential energy $\mathcal{E}$ of the charge Q located at O.

Exercise 2



Consider a surfacic distribution of charges σ, which is uniformly distributed on a ring of radius r, of width dr and center O. The point M is on the (Oz)-axis.

1- Give the expression of the elementary electrostatic field $d\overrightarrow{E_P}(M)$ created at M by an elementary surfacic charge dQ centered at P.

2- Deduce the total electrostatic field created by this ring at M. Detail your reasoning.

3- We aim to determine the electrostatic field $\vec{E}(M)$ created at M by a disc of radius R, of center O and axis (Oz).

By using the question 2, first recover the expression $\vec{E}(M) = 2\pi k\sigma z\left(\frac{1}{|z|} - \frac{1}{\sqrt{(R^2+z^2)}}\right).\overrightarrow{u_z}$, and then its norm.

4- By using the symmetries of the charge distribution, comment the limit $R \to \infty$ (infinite plane).

Exercise 3

The electrostatic potential $V(x,y,z)$ is given in Cartesian coordinates by the following expression $V(x,y,z) = k\frac{q}{\sqrt{x^2+y^2+z^2}}$.

1- Express the electric field $\vec{E}(x,y,z)$ deriving from this potential in the basis $(\overrightarrow{u_x}, \overrightarrow{u_y}, \overrightarrow{u_z})$.

2- Recover, using the question 1, the expression of the unitary radial vector $\overrightarrow{u_r}$ of the spherical basis. You can use the following expression of the gradient given in spherical coordinates, where $f(r)$ is a function of the coordinate r: $\overrightarrow{grad}f = \frac{\partial f}{\partial r}\overrightarrow{u_r}$.