NAME: ………………………………………… FIRSTNAME:……………………………………………… GROUP:………

Physics Final

Calculators and documents are not allowed. The scoring scale is just indicative.
Answers exclusively on the subject. If you don't have enough place please use the back.

MCQ (4 points ; no negative points)

Circle the right answer.

1- For any surface S, the flux ϕ of the field $\vec{E}$ is given by:

a) $\phi = \iint_S \vec{E}.\overrightarrow{dS}$ b) $\frac{\partial\phi}{\partial t} = \iint_S \vec{E}.\overrightarrow{dS}$ c) $\phi = \iint_S \frac{\partial\vec{E}}{\partial t}.\overrightarrow{dS}$

2 – An infinite wire of length H carried by the Oz axis of the cylindrical frame, has a constant and positive lineic charge density λ. We consider as Gaussian surface the cylinder with height H and centered around the wire.

The Gaus surface S is composed by three open surfaces (the top disc D1 with the surface vector $\overrightarrow{dS_1}$, the bottom disc D2 with the surface vector $\overrightarrow{dS_2}$ and the side surface L3 with the surface vector $\overrightarrow{dS_3}$). How the Gauss theorem can be written ?

a) $\frac{Qint}{\varepsilon_0} = \iint_{D1} \vec{E}.\overrightarrow{dS_1}$
b) $\frac{Qint}{\varepsilon_0} = \iint_{D2} \vec{E}.\overrightarrow{dS_2}$
c) $\frac{Qint}{\varepsilon_0} = \iint_{L3} \vec{E}.\overrightarrow{dS_3}$

3- Still considering the infinite wire of question 2, which affirmation is correct?

a) $\overrightarrow{dS_3} = r\,.d\theta.dr.\overrightarrow{u_r}$ b) $\overrightarrow{dS_3} = r\,.d\theta.dz.\overrightarrow{u_r}$ c) $\overrightarrow{dS_3} = r\,.d\theta.dr.dz.\overrightarrow{u_z}$

4- The expression of the electric field (question 2) at an arbitrary point M created by the infinite charged wire is :

a) $\overrightarrow{E(M)} = \frac{\lambda}{2\pi\, r\, \varepsilon_0}.\overrightarrow{u_r}$ b) $\overrightarrow{E(M)} = \frac{\lambda}{3\pi\, r^2\, \varepsilon_0}.\overrightarrow{u_r}$ b) $\overrightarrow{E(M)} = \frac{\lambda}{2\pi\, r\, \varepsilon_0}.\overrightarrow{u_z}$

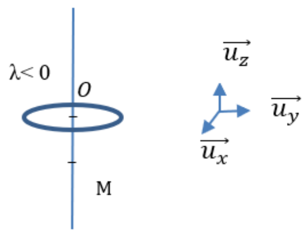
5- Considering a spherical Gauss surface, the unit vector $\vec{n}$ of the Gauss surface vector $\overrightarrow{dS}$ is identical to which spherical basis unit vector ?

a) $\overrightarrow{u_\theta}$ b) $\overrightarrow{u_z}$ c) $\overrightarrow{u_r}$

s

6 - Consider a lineic constant density λ<0 on a circle about Oz axis (see figure). By symetrical analysis, the electric field $\vec{E}(M)$ created on a point M is towards :

a) $-\overrightarrow{u_z}$
b) $+\overrightarrow{u_z}$
c) Neither of these answers

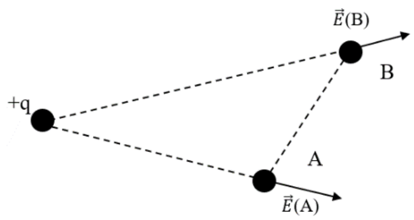


7 - The electric field $\vec{E}(r) = k\frac{Qr}{a_0^3}e^{-\frac{r^2}{a_0^2}}.\overrightarrow{u_r}$, where Q and a_0 are some constants, derives from the following potential:

a) $V(r) = k\frac{Q}{2a_0}e^{-\frac{r^2}{a_0^2}}$ b) $V(r) = -k\frac{Q}{a_0}e^{-\frac{r^2}{a_0^2}}$ c) $V(r) = k\frac{Q}{a_0^2}e^{-\frac{r^2}{a_0^2}}$

8 - Two distant points A and B are subject to the electric field $\vec{E}$ created by a positive charge q as sketched in the figure. The difference of electric potential between A and B VB-VA is equal to:

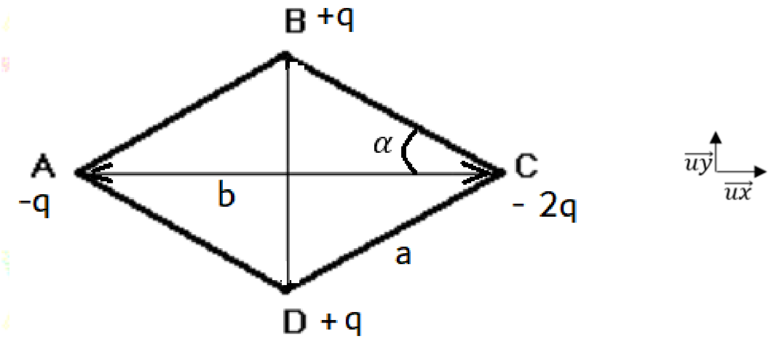
a) $\int_A^B \vec{E}.\overrightarrow{dl}$
b) $-\int_A^B \vec{E}.\overrightarrow{dl}$
c) Neither of both suggestions



<u>Exercise 1</u> ***DISCRETES CHARGES*** (4 points)

Four point charges are located on the summits A, B, C and D of a losange having a side length a. The edge [AB] has the length b an the angle between the segmet [BC] and the horizontal is $\alpha = \frac{\pi}{6}$. The charges are -q at A, +q at B, -2q at C and +q at D with q a positive constant.

1) Sketch on the figure the forces vectors created at the point C by each charge A, B and D.



2) Express the components in the $(\overrightarrow{u_x}, \overrightarrow{u_y})$ frame of each of these forces. Deduce the components of the resultant force vector on C in function of q, k, and a (as b can be expressed in function of a).

3) Express the electrical potential V(C) at the point C in fonction of k, q, a and b.

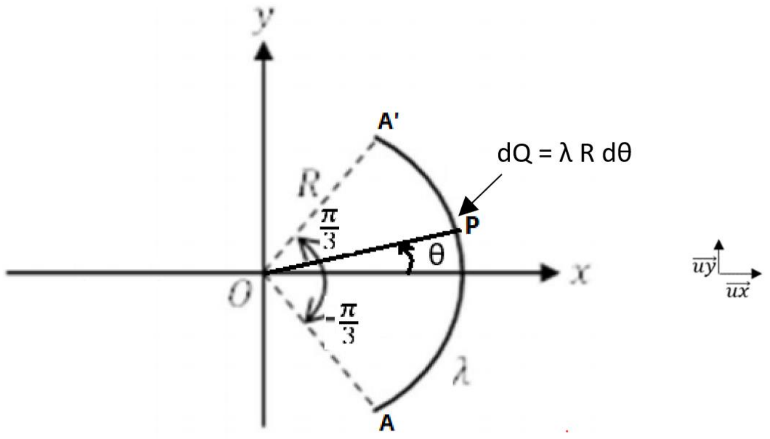
4) Express the electric potential energy $E_p(C)$ of the charge located at C in the electric field created by A, B and D.

Exercise 2 ***COUNTINUOUS DISTRIBUTION*** (5 points)

A part of a circle is considered (as sketched in the figure) contained in the xOy plan and having a curvature radius R. The arc is charged with a lineic charge density λ positive and constant.

The part of the circle between the points A and A' is bounded by the angles $-\frac{\pi}{3}$ and $+\frac{\pi}{3}$ with the horizontal.

1) Sketch on the figure below the elementary electric field vector $\overrightarrow{dE}(O)$ created at the point O (curvature center) by an elementary charge dQ coming from a point P on the charged arc. From a charge distribution summetrical analysis, sketch **also** the resultant electric field $\vec{E}(O)$ created by the charged arc on the point O.



2) Express the projection on the Ox axis of the elementary field dE_x created on O by an elementary charge dQ = λ R dθ coming from an arbitrary point P on the arc in fonction of R, θ, k and λ. With θ the angle between the segment OP and the horizontal.

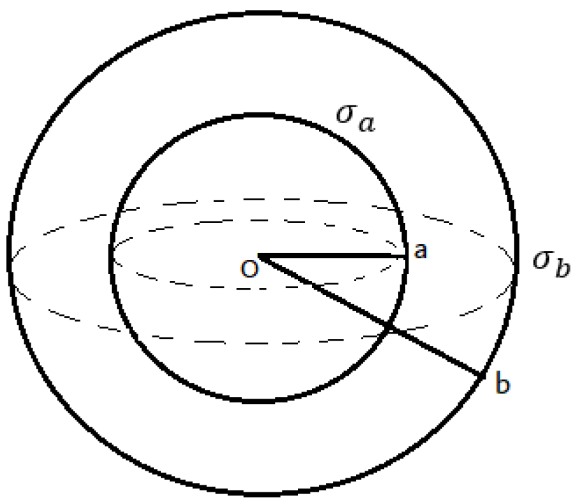
3) Deduce the norm **and** the vector of the resultant electric field $\vec{E}(O)$ created by the charged arc on O.

Exercise 3 ***GAUSS THEOREM*** (7 points)

Two empty spheres with the same center O and with respectives radiuses a and b, are charged on the surfaces with respectives surface density charges σ_a and σ_b. The total charges uniformly distributed on the surface of the sphere with radius a and the sphere with radius b are the same but with opposite signs (positive for the one with a radius and negative for the one with b radius).

The surfacic charge density negative and constant of the sphere with radius b is $\sigma_b = -\left(\frac{a}{b}\right)^2 \sigma_a$ with σ_a the surfacic charge density positive and constant of the sphere with radius a.

The study is done in spherical coordinate system (r, θ,ϕ). Remark: it is possible to use the following general expression of the elementary surface of a sphere with constant radius R if needed: dS= $R^2.\sin\theta.d\theta.d\phi$. With θ from 0 to π and ϕ from 0 to 2π.



PART I*: Electric field calculation*

1) Use the symmetries and invariances to find the direction and the dependence variables of the electric field in the three zones considered : $r<a$; $a<r<b$ et $r>b$.s

2- Sketch the Gauss Surface when $r<a$; $a<r<b$ and $r>b$.

Answer this question on the figure above.

3) For each case, express Qint the charge that is included.

4) From the Gauss theorem appliqcation, express the norm **and** the vector of the electric field at any point in space.

PART II: *Electric potential calculation*
Reminder: here is the gradiant expression in spherical coordinate system.

$$gra\vec{d}f = \left(\frac{\partial f}{\partial r};\frac{1}{r}.\frac{\partial f}{\partial \theta};\frac{1}{r\,sin(\theta)}.\frac{\partial f}{\partial \phi}\right)$$

5) Express the electric potential V at any point in space. Remark: you don't need to determine the constants that are going to be involved in these expressions.