EPITA / S3 November 2021

LAST NAME : ………………………………………… FIRST NAME : ………………………………………… GROUP: ………

PHYSICS TEST

Calculators and documents are not allowed.

MCQ (3 points- No négative ponts).

Select the correct answer

1- Consider an electric potential $V(r) = a\,.\,re^{-\frac{b}{r}}$; where a and b are constants. Electric field that derives from this potential has for expression :

a) $\vec{E} = ae^{-\frac{b}{r}}\left(1 - \frac{b}{r}\right)\vec{u_r}$ b) $\vec{E} = ae^{-\frac{b}{r}}\left(-1 - \frac{b}{r}\right)\vec{u_r}$ c) $\vec{E} = ae^{-\frac{b}{r}}\,\vec{u_r}$

2- Potential difference between two points A and B is :

a) $V_B - V_A = -\int_A^B \vec{E}\,.\,\vec{dl}$ b) $V_B - V_A = \int_A^B \vec{E}\,.\,\vec{dl}$ c) None of these answers.

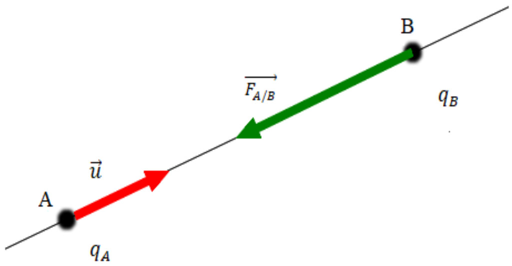
3- Electrostatic force is :

a) always attractive b) always repulsive c) always conservative

4-Consider a ring of radius R and axis Z, with a linear and constant charge density λ. A charge element dQ of a length element dl of a ring is given by :

a) $dQ = \lambda\, d\theta$ b) $dQ = \lambda\, dR$ c) $dQ = \lambda\, Rd\theta$ d) $dQ = \lambda\, dRd\theta$

5- A charge q_A exerts an electrical force on a charge q_B. Vector force $\vec{F_{A/B}}$ is :



a) $\vec{F_{A/B}} = k\,\frac{q_A}{(AB)^2}\,\vec{u}$

b) $\vec{F_{A/B}} = -\,k\,\frac{q_A q_B}{(AB)^2}\,\vec{u}$

c) $\vec{F_{A/B}} = k\,\frac{|q_A q_B|}{(AB)^2}\,\vec{u}$

d) $\vec{F_{A/B}} = k\,\frac{q_A q_B}{(AB)^2}\,\vec{u}$

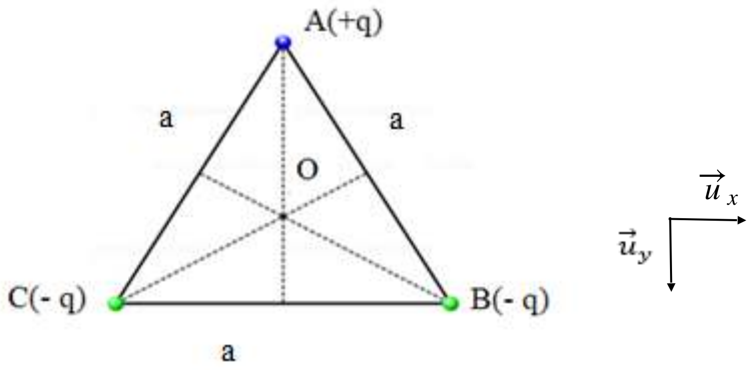
($\vec{u}$: unit vector)

6- Electric field created by a infinite rod, uniformly charged, at a point M outside the rod is

a) orthogonal to the wire fil b) Parallel to the wire c) Not defined

Exercise 1 : Discrete charges distributions (7 POINTS)

Three point charges $(+q, -q, -q)$ are respectively located at vertices A, B and C of an equilateral triangle of side a.



We recall that the angles at the vertices of an equilateral triangle ABC are equal to 60° and the lines (OA), (OB) and (OC) are bisectors and medians.

1- Represent, on the figure above, the electric field vectors $\vec{E}_A(O)$, $\vec{E}_B(O)$ and $\vec{E}_C(O)$ created at the center of the triangle.

2- a) Express the magnitudes of these vectors as functions of k, q, and a. We set $q > 0$.

b) Deduce the magnitude of the resulting vector $\vec{E}(O)$, as a function of k, q and a.

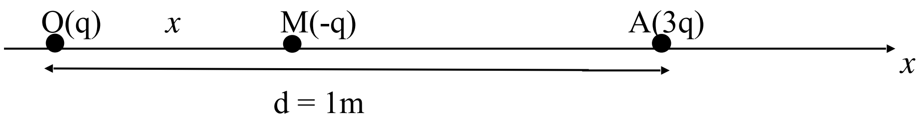
3- Express the electric potential $V(O)$ created at O, as a function of k, q and a. Make the numerical application with : $q = 4 \times 10^{-9} C$, a = 2 cm and $k = 9.10^9$ Nm$^2/C^2$.

4- a) Express the electric potential at point A, as a function of k, q and a.

b) Deduce the electrical potential energy at the same point A, as a function of k, q and a.
Make the numerical application. We have $a = 2$ cm and $k = 9 \times 10^9$ Nm^2/C^2.

Exercise 2 (4 POINTS)

We consider three point charges (q, $-q$ and $3q$) placed respectively at points O, M and A on an axis (Ox) of origin O. We have $OM = x$ and $OA = d$. We set $q > 0$ and $x > 0$.



1- Represent on the diagram above, the electric forces exerted on the negative charge ($-q$) placed at point M.

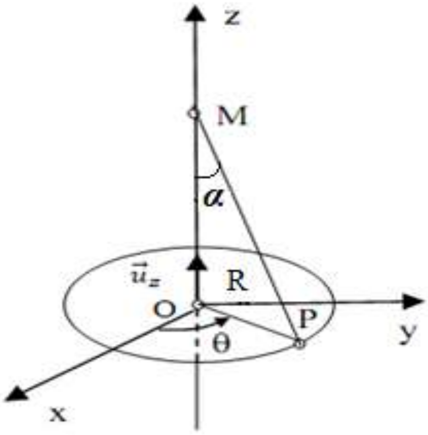
2- Express the magnitudes of each of these force vectors as a function of k, q, d and x.

3- Deduce the magnitude of the resulting force at point M, as a function of k, q, d and x.

4- Where should we place point M so that the total force exerted on the charge $(-q)$ at point M is zero? We have $d = 1$ m and $x > 0$.

Exercice 3 **Continuous charge distribution. (6 points)**

A ring of radius R and axis (Oz) is charged with a constant and positive linear density λ.



1- Study the symmetry of this charge distribution to deduce the direction of the electric field created by the ring at a point M of the Z-axis

2- a) Express the elementary electric field dE_z (component of $\vec{E}$ on the axis (Oz) of the vector), created at point M, by a charge element dQ.

b) Deduce the expression of the electric field created by the ring, as a function of k, R, λ and z.

3- a) Express the elementary potential $dV(M)$, created at point M, by a charge element dQ.

b) Deduce the electric potential $V(M)$ created by the ring, as a function of k, R, λ and z.

4- Find the expression of the electric field established in question 2b, using the potential-field mathematical relation. We give the components of the gradient operator in cylindrical coordinates:

$$\overrightarrow{grad}\left(\frac{\partial}{\partial r}\ ;\ \frac{1}{r}\ \frac{\partial}{\partial \theta};\ \frac{\partial}{\partial z}\right)$$