University of KHEMIS MILIANA
Faculty of Science and Technology
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Exercise Series of GW of Physics 2, 2023-2024
Exercise Series Number 1, Part 2. Electric Field, Electric Potential Produced by Distributions of Electric Charges. Gauss's Theorem

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*Exercise 1:

Let Q_T be a positive electric charge whose partition is uniformly distributed along a straight filament of length ℓ (see **Fig. 1**).

1. What is the value of the linear charge density λ.
2. Calculate the electric potential produced at a point $M(z_0 \leq 0)$ belonging to the axis (Oz').
3. Calculate by two different methods the electric field vector produced at the point M.
4. Deduce the electric force exerted on a point charge Q placed at the point M.
5. Make a sketch of the electric field and force vector at the point M.
6. **Particular case** : How do the expressions of the potential, the field and the force at the origin, i.e., at the point $M(z_0 = 0)$.
   Assume that: $Q_T = 4\mu C$, $Q = 3\mu C$, $\ell = 20cm$ et $z_0 = -20cm$.

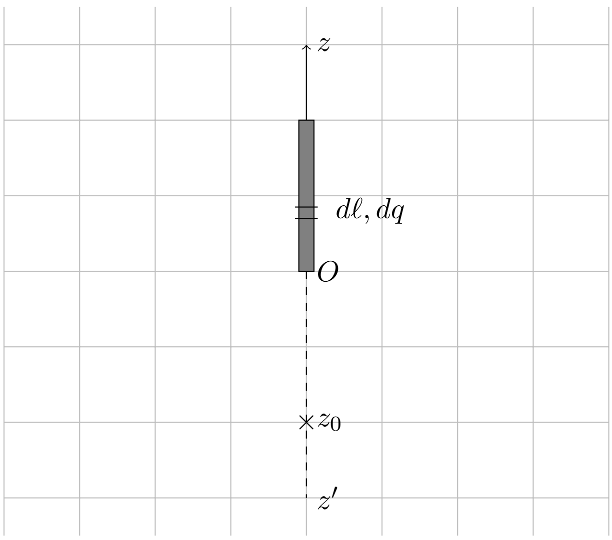

Figure 1:

*Exercice 2:

Considérons un arc d'un fil circulaire de rayon R, de densité de charge positive λ et sous-tendant un angle 2α **Fig. 2**.

1. Calculer le potentiel électrique créé en un point M situé au centre du cercle.
2. Calculer le champ électrique créé au point M.

On donne : $R = 20mm$, $\lambda = 2 \times 10^{-5} Cm^{-1}$ et $\alpha = 40°$.

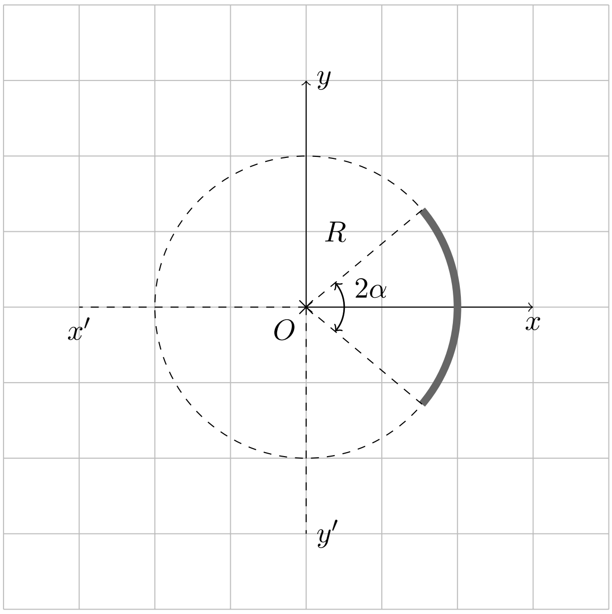

Figure 2:

Exercise 3:

A positive electric charge Q is uniformly distributed around a wire ring of radius R as shown in **Fig. 3**. Assume that the electric potential is zero at $y = infinity$ with the origin O of the $x - axis$ at the centre of the ring.

1. What is the electric potential at a point M placed at a distance y on the $y - axis$?
2. Calculate by two different method the electric field at the point M.
3. Deduce the electric potential and the electric field if the point M is situated at the centre of the ring. Same question when M is situated at a point where $y \gg R$.
4. Make a sketch of the potential V as well as the magnitude of the field E as a function of the distance y along the y-axis showing significant features.

Data : $R = 20mm$, $\lambda = 2 \times 10^{-5} Cm^{-1}$ et $y = 50mm$.

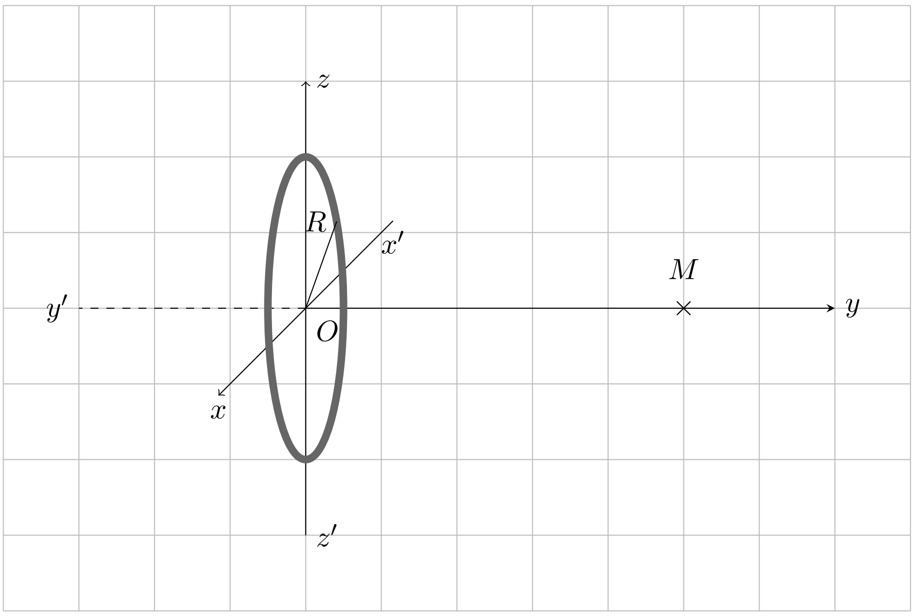

Figure 3:

*Exercice 4:

Fig. **Fig. 4** represents a uniformly charged disc of radius R, and surface charge density σ and a total charge Q.

1. Calculate the surface charge density σ.
2. Calculate the electric potential produced by the disc at a point M situated somewhere on the $y-axis$ perpendicular to the disc and passing through its centre.
3. Compute by two methods the electric field created at the point M.
4. Deduce the potential and the field at the point M when situted at the centre of the charged disc. Same question when M is situated at a point where $y \gg R$.
5. Make a sketch of the potential $V(y)$ as well as the magnitude of the field $E(y)$ as a function of the distance y along the $y-axis$ showing significant features.

Data : $R = 20mm$, $Q = 6nC$ et $y = 50mm$.

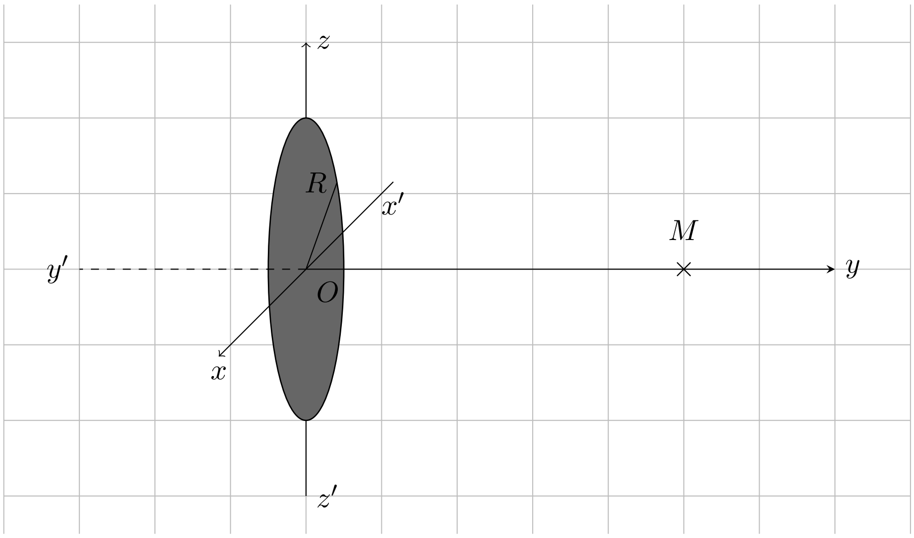

Figure 4:

*Exercise 5:

Using Gauss's law, compute the electric field created by a point charge $Q >$ at a point M situated at a distance r from the charge.
Deduce the electric potential at the point M

Exercise 6:

1. Using Gauss's law, compute the electric potential produced at a point M situated at a distance r of a long straight filament carrying a charge $\lambda > 0$ per unit length.
2. Deduce the electric potential at the same point M.

Exercise 7:

Given a cylindrical form filament of infinite length and a radius R on which a positive charge $\sigma > 0$ per unit surface is distributed on its surface.

1. Using Gauss's method, compute the electric field at any point in space.
2. Determine the electric potential produced by the cylinder. Assume that $V(R) = V_0$.
3. Make a representation of the potential and the field as a function of of r.
4. What value of r makes the potential zero?

*Exercise 8:

A positive charge of constant surface density $\sigma > 0$ is distributed uniformly on a spherical surface of a radius R.

1. Usiing Gauss's method, calculate the electric potential created at any point on space. Assume that $V(r \to \infty) = 0$
2. Make a sketch of (E) and (V).

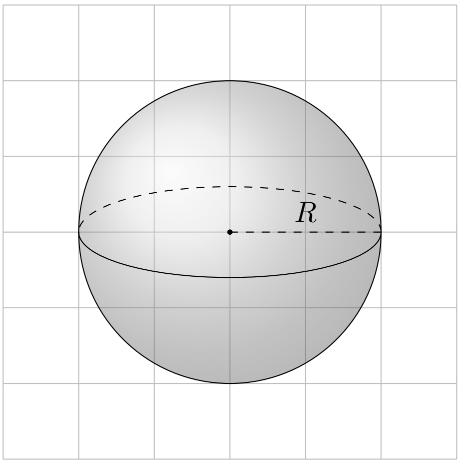

Figure 5: Sphère chargée en surface

Exercise 9:

Using Gauss's method, compute the electric potential and the electric field created by two charged asolated spheres of radius R_1 and R_2 ($R_2 > R_1$ and of charge surface density $\pm\sigma_1$ and $\pm\sigma_2$.
Data: $V(R_1) = V_0$ et $V(R_2) = 0$.

Exercice 10:

Let ze be the total charge of protons uniformly distributed into the volume of atomic nuclei assumed of spherical shape of radius R and of a volume $\tau = \dfrac{4}{3}\pi R^3$ and of a charge density, assumed constant and positive, given by $\rho = \dfrac{ze}{\frac{4}{3}\pi R^3}$. Assume that $V(r) = V_0$ et $V(r \to \infty) = 0$:

1. Using Gauss's method, calculate the electric field and the electric potential at any point in space.
2. Determine the electric potntial at any point in space.
3. Calculate the coulombian potential energy of the nucleus.