**1. Electrification experiments**

Electrification represents a charge transfer phenomenon. There are three types of electrification of an object: by friction, by contact and by influence.

**a. Electrification by friction**

**b. Contact electrification**

**c. Electrification by influence**

**2. The electrical charge**

**a. Definition of electric charge**

The electric charge is a scalar quantity, like mass, represents a fundamental property of matter, it is denoted ***q*** and its unit in SI is the Coulomb (C). There are two types of electrical charges, *positive* and *negative.*

**b. The elementary charge**

It is the smallest amount of charge **e = 1.602176634x10 -19 C** , the electric charge of an: electron: q e = -e = -1.602176634x10 -19 C and proton: q p = +e = 1.602176634x10 - 19 C.

**c. The point charge**

Is an electric charge localized at a dimensionless [point](https://fr.wikipedia.org/wiki/Point_%28g%C3%A9om%C3%A9trie%29) .

**3. Conductive materials, insulating materials**

From an electrical point of view, there are two main families of materials: conductors and insulators.

**a. Conductive materials**

**b. Insulating materials (dielectric) المواد العازلة**

**4. Coulomb's law**

**a. interaction between two point charges q 1 and q 2 التفاعل بين شحنتين نقطيتين**

$$\vec{F}\_{12}=-\vec{F}\_{21}=K\frac{q\_{1 }q\_{2}}{r^{2}} \vec{u}⇒F\_{12}=F\_{21}=K\frac{\left|q\_{1 }\right|.\left|q\_{2}\right|}{r^{2}} $$

$K=constante=\frac{1}{4πε\_{0}}=8,9875.10^{9} Nm^{2}C^{-2}$, we will often use the value: 9.10 9 Nm 2 C -2 .

$ε\_{0}$=8.8542.10 -12 C 2 /Nm 2 is the vacuum permittivity.

Noticed In a medium other than a vacuum, ε

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will be replaced by ε

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**Note** : In a medium other than vacuum, ε0 will be replaced by ε= ε0 εr where εr represents the relative permittivity : $\vec{F}\_{e}=\frac{q\_{1 }q\_{2}}{4πε\_{0}ε\_{r}r^{2}} \vec{u} $

**b. Principle of superposition**

Assuming that there exist n immobile electric charges in a vacuum. The electrostatic force exerted by the n charges on a charge q located at a point M is:

$$\vec{F}\left(M\right)=\sum\_{i=1}^{n}K\frac{q.q\_{i}}{r\_{i}^{2}}\vec{u}\_{i}$$

**5. The electrostatic field**

**a. Definition**

$$\vec{E}=K\frac{q}{r^{2}} \vec{u} $$

The unit of ***E*** in SI is Volt/meter (V/m)

**b. Electrostatic field created by a set of point charges**

$$⇒\vec{E}\left(M\right)=K\sum\_{i=1}^{n}\frac{q\_{i}}{r\_{i}^{2}}\vec{u}\_{i}$$

**c. Field lines**

Field lines are curves where the electrostatic field is tangent to each point.

**6. The electrostatic potential**

The electrostatic potential is a scalar physical quantity which defines the electrical state of a point in space. It corresponds to the electrostatic potential energy of a charged particle at this point divided by the charge of the particle.

$$V(r)=\frac{E\_{p}}{Q}=\frac{Kq}{r}$$

* The potential is expressed in Volt (V) (i.e. in J/C).

**a. Relationship between field and electrostatic potential**

In an O,x,y,z coordinate system:

$\vec{E}\left(\genfrac{}{}{0pt}{}{E\_{x}}{\begin{array}{c}E\_{y}\\E\_{z}\end{array}}\right) $and $\vec{dl}\left(\genfrac{}{}{0pt}{}{dx}{\begin{array}{c}dy\\dz\end{array}}\right)$

$$⇒\vec{E}.\vec{dl}=E\_{x}dx+ E\_{y}dy+E\_{z}dz$$

$$dV=\frac{∂V}{∂x}dx+\frac{∂V}{∂y}dy+\frac{∂V}{∂z}dz$$

by identification:$ E\_{x}=-\frac{∂V}{∂x}, E\_{y}=-\frac{∂V}{∂y} et E\_{z}=-\frac{∂V}{∂z}$

$$\vec{E}=E\_{x}\vec{i}+E\_{y}\vec{j}+E\_{z}\vec{k}=-\left(\frac{∂V}{∂x}\vec{i}+\frac{∂V}{∂y}\vec{j}+\frac{∂V}{∂z}\vec{k}\right)=-\vec{grad}V$$

$$\vec{E}=-\vec{grad}V$$

**b. Principle of superposition**

Consider n fixed point charges qi,placed at points Mi in a vacuum. The electrical potential created by the whole of these charges at a point M is written:

$$V\left(M\right)=\sum\_{i=1}^{n}V\_{i}=\sum\_{i=1}^{n}K\frac{q\_{i}}{r\_{i}}$$

**c. Equipotential surfaces**

The equipotential surface is the set of points in space having the same value of electric potential. It is therefore defined by: V(x, y, z) = V 0 = Cste

The equipotential surfaces are therefore perpendicular to the field lines.

**d. Work and potential energy of moving a charge in**

* The work of the electrostatic force $\vec{F}$, and the potential energy, when moving a charge q from point A to point B in an electrostatic field $\vec{E}$, are given by the following formulas:

***W AB (*** $\vec{F})$***= q.(V A -V B )***

**V(A)-V(B)** is the electrostatic potential difference between points A and B and is equal **to:**

$$V\left(A\right)-V\left(B\right)=\frac{W\_{A→B}}{q}=\frac{Q}{4πε\_{0}}\left(\frac{1}{r\_{1}}-\frac{1}{r\_{2}}\right)$$

***E p (A) - E p (B) = - ∆E p = W AB***

**7.** **electric dipole**

The electric dipoleis a system made up of two equal charges and opposite signs, *+q* and *–q* , separated by a distance *a* .:

$$\vec{P}=q.\vec{a}$$

**a. Electric potential produced by an electric dipole:**

We will calculate the electric potential produced by the two charges (+q) and (-q), at the point M located at the distance r 1 from the charge (+q) and at the distance r 2 from the charge (-q) . The distance a is very small compared to the distances r 1 and r 2

The electrostatic potential *V* created in M by the two electric charges is equal to

$$$$

**b. Dipole Electrostatic Field**

The electrostatic field vector$\vec{E}$ at point M is written in polar coordinates:

We also have$ \vec{E}(M)=-\vec{grad}V(M)$

$$$$

**7. Electric field created by a continuous distribution of charges**

* **Linear charge density λ:** $λ=\frac{dq}{dl}$
* **Surface charge density σ:** $σ=\frac{dq}{ds}$
* **Volume charge density ρ** : $ρ=\frac{dq}{dV}$

**a. The electrostatic field produced by a fine wire carrying a positive linear charge of density**$λ$ **constant**

Consider a finished wire AB of length L and uniform positive linear chargeλ

1- Calculate the field vector $\vec{E}$and the potential V created by the entire wire AB at any point M located at distance x from the wire.

2 - Deduce $\rightharpoonaccent{E}$and V when M is in the mediating plane of wire AB.

3- Deduce $\rightharpoonaccent{E}$when the wire AB is of infinite length.

**Solution :**

$$$$

$$$$

$$E=\sqrt{E\_{x}^{2}+E\_{y}^{2}}$$

$$.$$

**1.b-Calculation of potential**

$$$$

**2.a** - **Deduce** $\vec{E}$**and V when *M* is in the mediating plane of wire AB:**

$$$$

**2.b** - **Deduce the potential V created at point M which is located in the mediating plane of wire AB:**

$$⇒V=Kλ.ln\left(\frac{L+\sqrt{L^{2}+4x^{2}}}{-L+\sqrt{L^{2}+4x^{2}}}\right)$$

**3-** **Deduce** $\vec{E}$**when the wire AB is of infinite length:**

$$$$

**1°) a) Determination of the field** $\vec{E}\_{M}$**created by the disk at point M of the axis Ox, located at a distance x from the center O of the disk:**$\vec{E}\_{M}: $

$$ $$

**b) Calculate the electric potential V created at point M:**

$$$$

**2°) Let's check the relationship between the potential and the field:**$\vec{E}=-\vec{grad}V$

$$E\_{M}=- \frac{dV}{dx}=- 2πKσ\left(\frac{2x}{2\sqrt{x^{2}+R^{2}}}-1\right)=2πKσ\left(1-\frac{x}{\sqrt{x^{2}+R^{2}}}\right)$$

**3) let us distinguish the field 𝐸 when the radius of the disk R tends towards infinity**

$$ $$

**8. Gauss's theorem**

**a. Gauss's theorem نظرية غوص**

The field flux $\vec{E}$across a closed surface created by a charge distribution is equal to the algebraic sum of the charges present within that surface (S G ) divided by$ε\_{0}$

$$Φ\_{S}=∯\_{S}^{}\vec{E}\left(M\right)d\vec{S }\left(M\right)=\frac{\sum\_{}^{}Q\_{i}}{ε\_{0}}$$

**a) Calculation of the electrostatic field created by a wire of infinite length and constant linear density λ positive by application of Gauss' theorem.**

A wire, of infinite length, is uniformly charged by a positive linear density λ.

1)-By application of Gauss's Theorem calculate the electrostatic field created by this distribution at a point located at distance x from the wire.

$$E2πxl=\frac{λl}{ε\_{0}}⇒$$