*Exercise 1:

1. Calculate the intensity of the electric field created by a proton at a point M located at a distance of $r = 0.53\mathring{A}$.
2. Calculate the electric potential produced by the proton at the same point M.
3. Calculate the mutual force exerted between an electron and a proton separated by a distance $r = 0.53\mathring{A}$.

Exercise 2:

Given the charge arrangement of **Fig. 1** in which $q_1 = q = 1\mu C$ and $q_2 = 2q = 2\mu C$, placed at the summit of an isosceles triangle.

1. Compute the distance d_{12} separating the two charges.
2. Determine the total electric potential V_{12} created by the two charges at a point M placed on the third summit of the triangle at the same distance, $d_1 = d_2 = d = 4\,\text{cm}$, from the charges.
3. Calculate the magnitudes of the electric fields, E_1 and E_2, produced by the two charges at point M.
4. Calculate the total electric field $\overrightarrow{E_{12}}$ produced by the two charges at point M. Compute its magnitude.
5. Deduce the electric force exerted on an electron placed at point M.
6. Make a sketch of the electric fields and the electric force with the scale $\mathbf{E} : 1\,\text{cm} \rightarrow 2 \times 10^6\,\text{V/m}$ and $\mathbf{F} : 1\,\text{cm} \rightarrow 5 \times 10^{-11}\,\text{N}$.

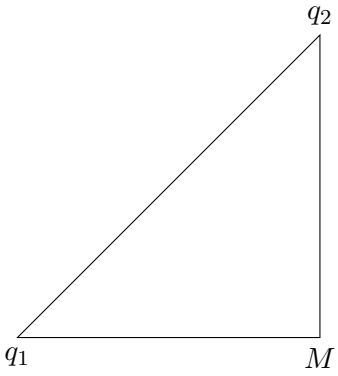

Figure 1: Two points charge system

*Exercise 3:

Referring to the **Fig. 1**, let $q_1 = 2\mu C$ and $q_2 = -2\mu C$ be two charges placed at the two summit of an isosceles triangle, where $d_1 = d_2 = d = 2cm$:

1. Calculate the distance d_{12} separating the two charges.
2. Determine the total electric potential V_{12} created by the two charges at a point M placed on the third summit of the triangle at the same distance from the two charges.
3. Calculate the total electric field $\overrightarrow{E_{12}}$ produced by the two charges at point M. Compute its magnitude.
4. Deduce the electric force exerted on an electron placed at point M.
5. Make a sketch of the electric fields and the electric force with the scale $\mathbf{E} : 1\text{ cm} \rightarrow 2 \times 10^7\text{ V/m}$ and $\mathbf{F} : 1\text{ cm} \rightarrow 5 \times 10^{-12}\text{ N}$. Remember that the charge of the electron is $q_e = -1.66 \times 10^{-19}\text{ C}$ and $k = 9 \times 10^9 \text{SI}$.

*Exercise 4:

Three point charges, $q_1 = q_2 = q = 1\mu C$, $q_3 = -2q = -2\mu C$, are placed on a quadrant of a circle with centre O and radius $r = 1cm$ as indicated in **Fig.** 2. If $\alpha = 60°$ and $k = 9 \times 10^9 (SI)$:

1. Calculate the total electric potential V_T created by the three charges at point O.
2. Calculate the magnitudes of the static electric fields E_1, E_2, and E_3 produced individually by the three charges at point O.
3. Calculate the total static electric field $\overrightarrow{E_T}$ (and its magnitude) produced by the three charges at O.
4. Deduce the electric force exerted on a charge $Q = 5\mu C$ placed at point O.
5. Represent the electric field and the electric force with the scales $\mathbf{E} : 1cm \rightarrow 9 \times 10^7 V/m$ et $\mathbf{F} : 1cm \rightarrow 300N$.

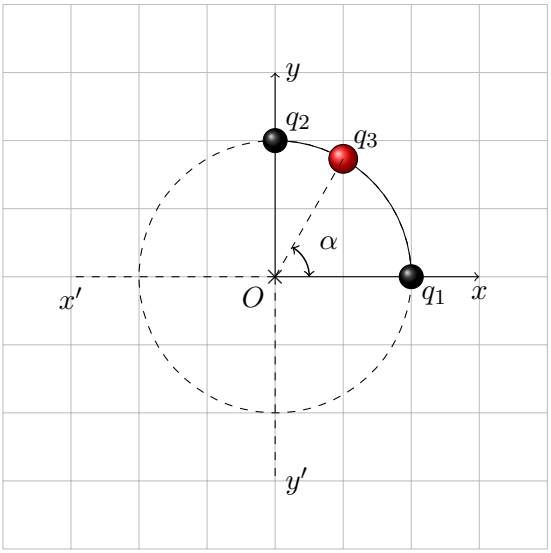

Figure 2: Charges Ponctuelles

Exercise 5:

An electric dipole consists of two equal and opposite charges $q_1 = q = 1\mu C$ et $q_2 = -q = -1\mu C$ separated by a distance $d = 2cm$, as shown in **Fig.** 3. We would like to study the influence of the system composed of the two charges at point M very far from the system.

1. Calculate the electric dipole moment of the system.
2. Calculate the electric potential created by the system at point M.
3. In the cylindrical frame of reference[1], determine the electric field produced at point M. Deduce the particular case when the electric field is along the identical axes to the direction of the electric dipole and that on the bisector of the segment $[q_1, q_2]$

[1] The justification for choosing a three-dimensional system instead of two, a system of polar coordinates, will become apparent during the calculation of the moment of electric forces (see exercise ***).

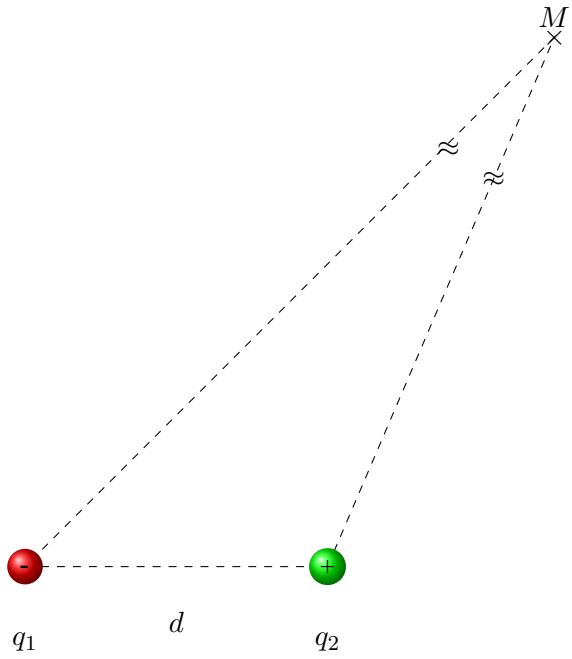

Figure 3: Dipôle électrique

*Exercise 6:

An electric dipole is immersed in a uniform external electric field $\overrightarrow{E_{ext}}$, due to another electric charge. **Fig.** 4 is a representation of the dipole-field system befor interaction.

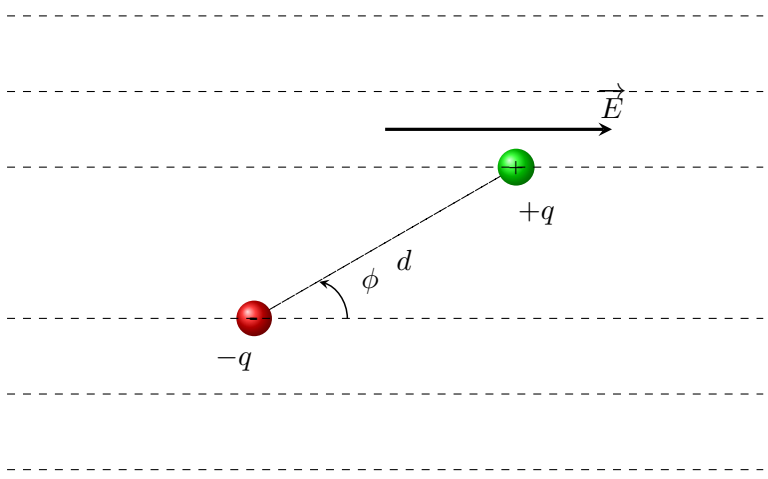

Figure 4: Dipôle électrostatique plongé dans un champ électrique uniforme

1. Calculate the torque of the couple of the two charges exerted on the dipole.
2. Calculate the potential energy of the dipole in that case.
3. Calculate the work required to turn the dipole at an angle ϕ_0 from a parallel position to the field. Deduce the case when the dipole turns with an angle $\phi_0 = \pi$.
4. Now consider an exterior electric field produced by a point charge Q. Study the total force exerted on the dipole depending its orientation with respect to the electric field.