# *Chapter I*
# *Electrostatics*

## *Course 3*

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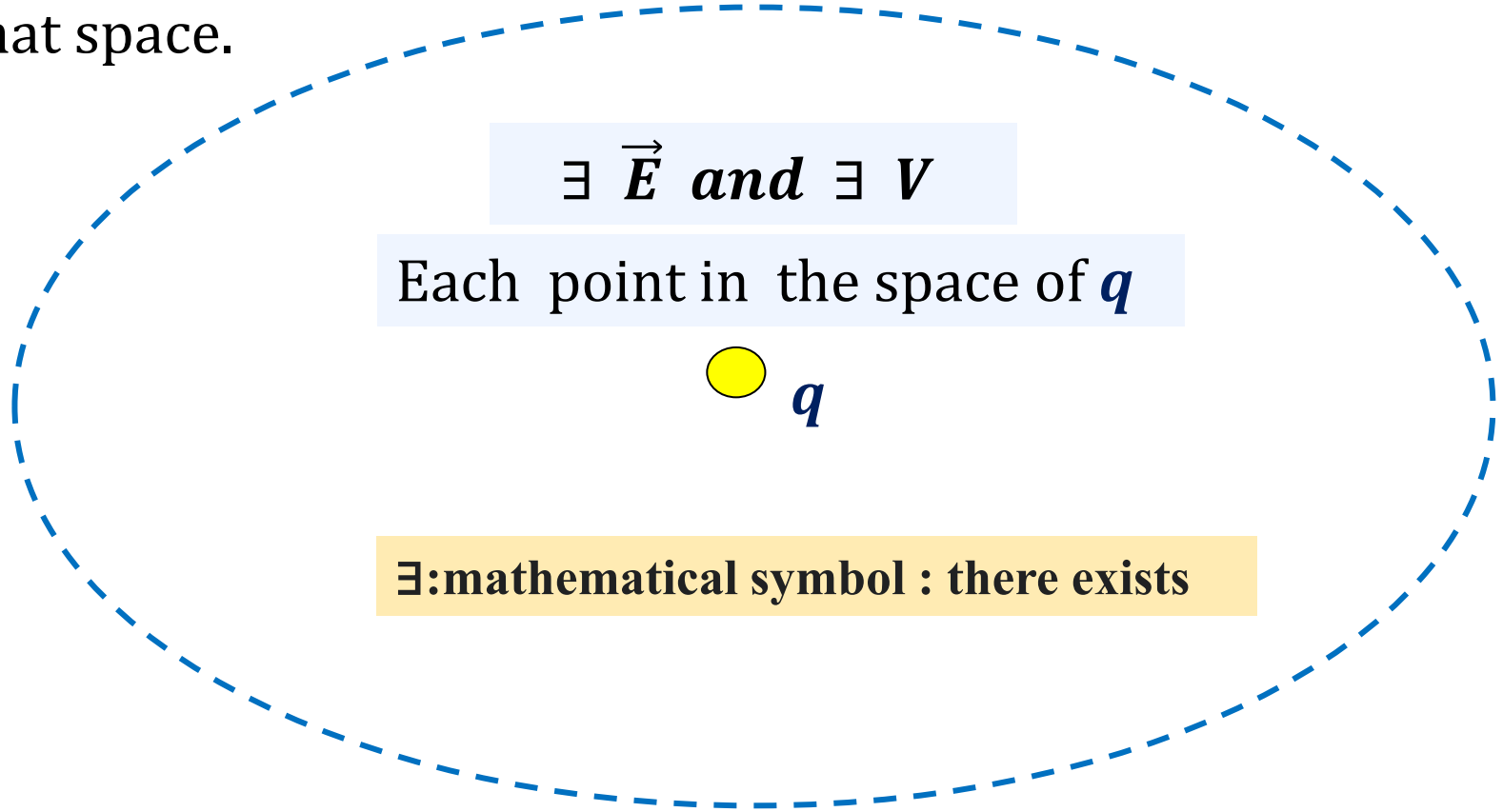
# I.3 The Electric Field and Electric potential Due to a Point Charge

The presence of a point charge **q** in a space results in the generation of **an electric field (الحقل الكهربائي)** $\vec{E}$ and **electrical potentiel (الكمون الكهربائي)** $V$ at every point within that space.



## 1) Mathematical expression of the electric field due to a Point Charge

The electric field created by point charge is a vector quantity defined by:

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

In magnitude : $$\left\|\vec{E}(M)\right\| = K\frac{|q|}{r^2}$$

where :

**r** : is the distance between **q** and point (or position) where we want to calculate electriical field.

$\vec{u}$ : is unit vector pointing outwards from the charge **q** towards the point **M.**

Its unit in the International System is Newton per coulomb (**N/C**) or volt per meter (**V/m**).

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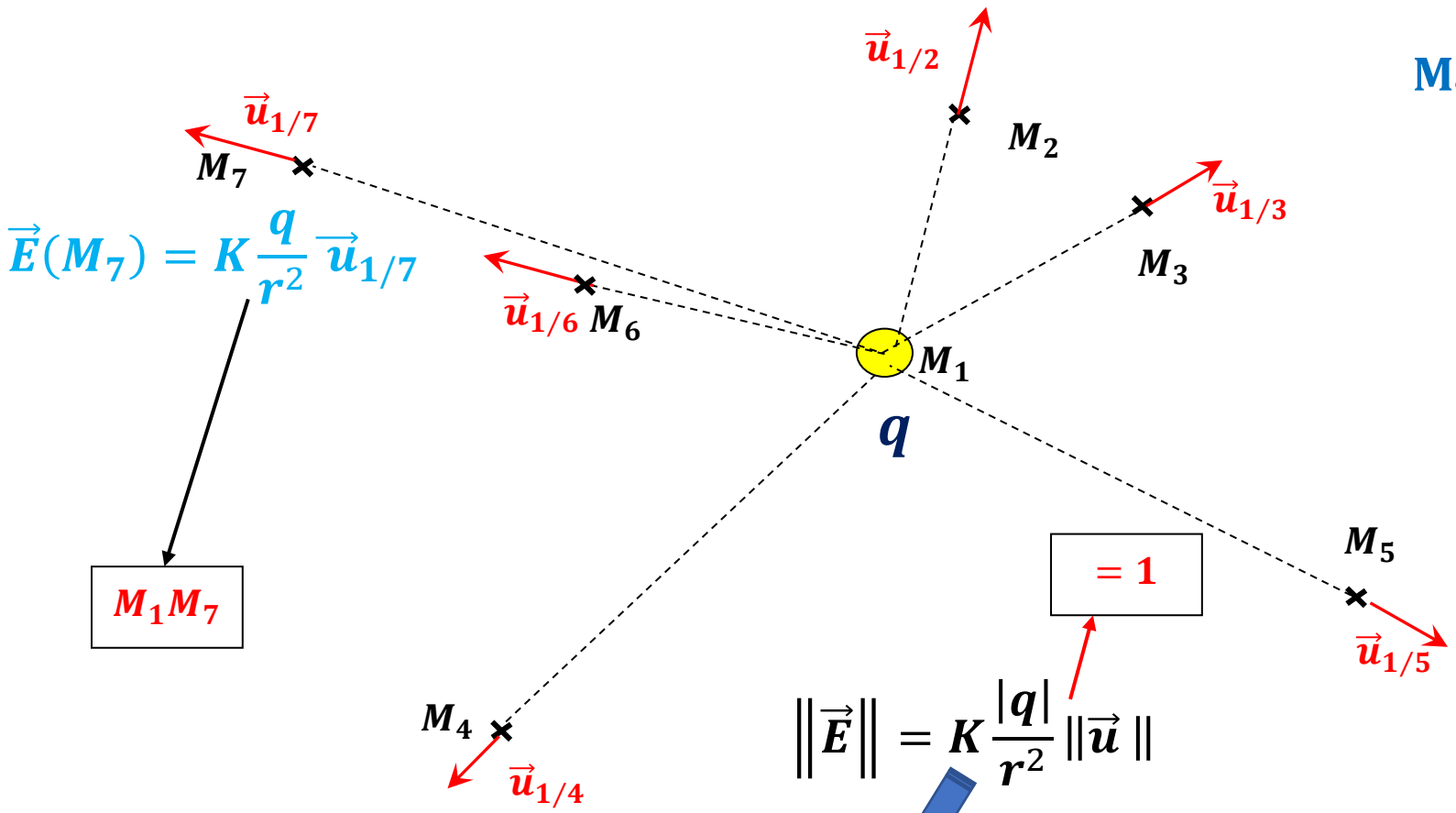
# The Electric Field




## Mathematical expression

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

$$\vec{E}(M_7) = K\frac{q}{r^2}\vec{u}_{1/7}$$

$M_1M_7$

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

$= 1$

$$\left\|\vec{E}\right\| = K\frac{|q|}{r^2}$$

$$\vec{E}(M_5) = K\frac{q}{r^2}\vec{u}_{1/5}$$

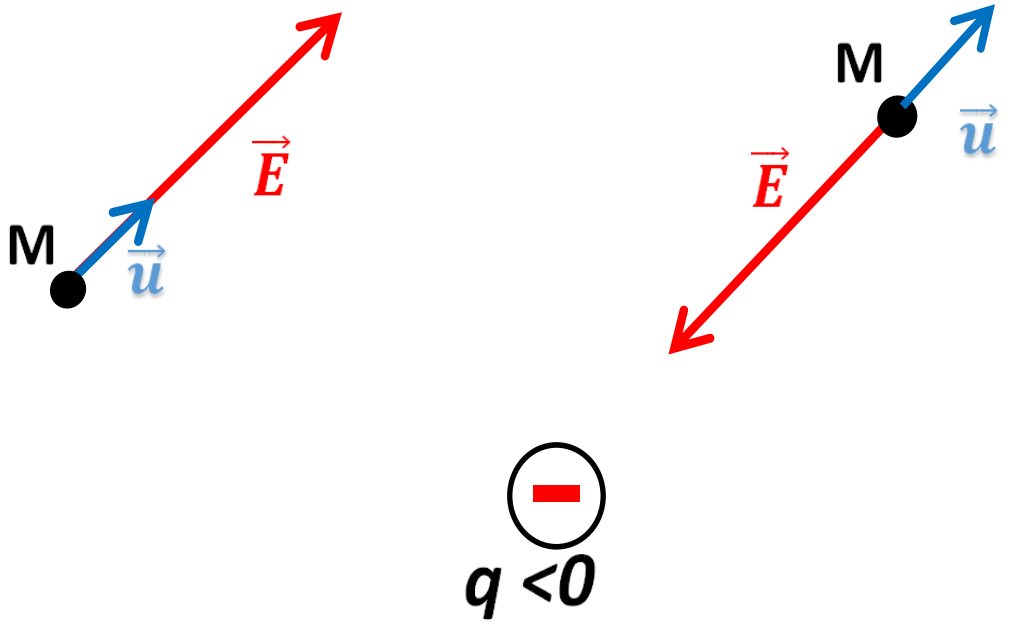
$M_1M_5$

## The electric field created by a point charge

As shown in Figure I.10:

- The field created by a positive charge is outward (in the direction of $\vec{u}$).

- The field created by a negative charge is inward (opposite to the direction of $\vec{u}$).



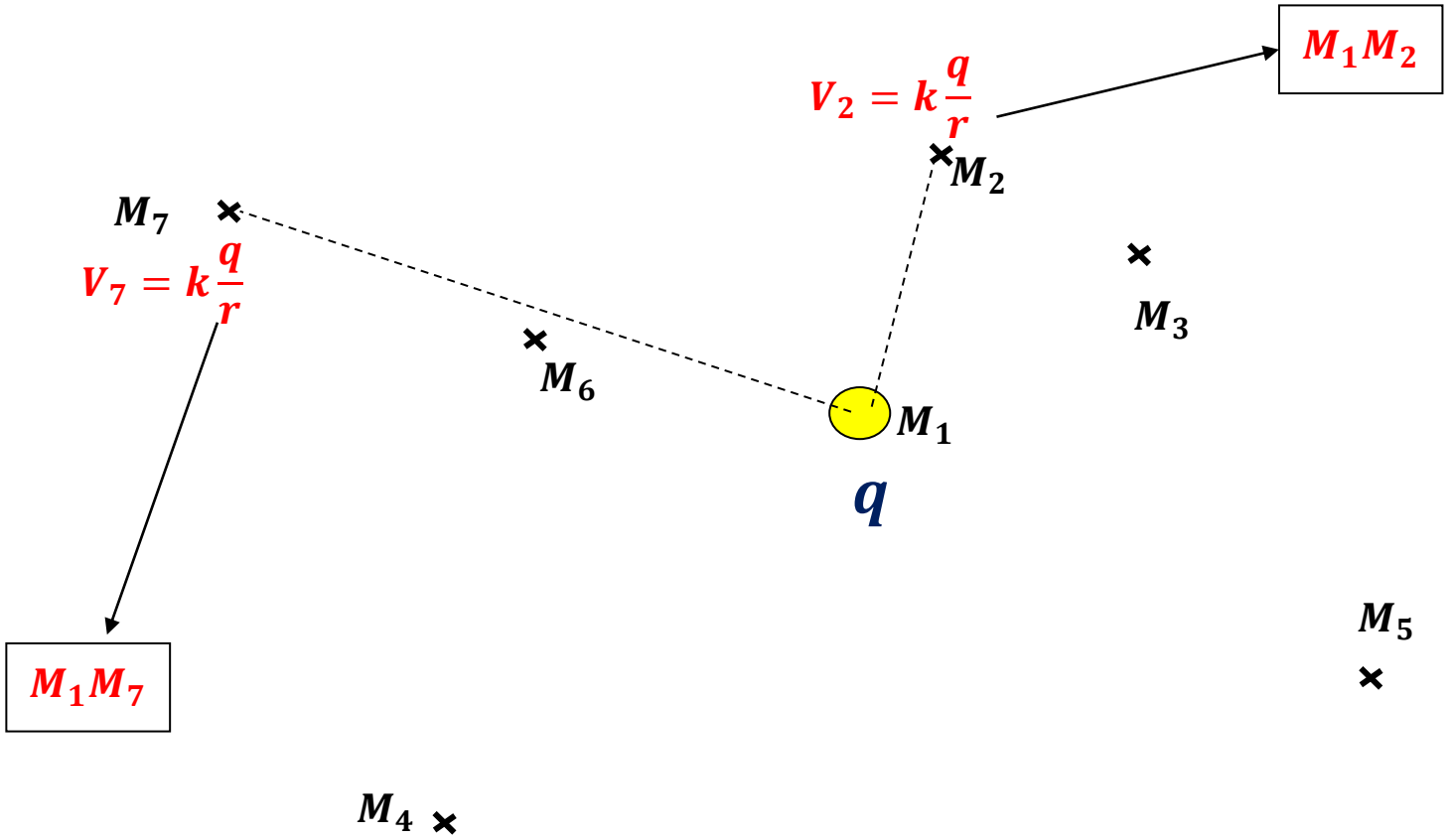
## 1) Mathematical Expression of the Electric Potential V due to a Point Charge

The electric potential is a scalar quantity, defined by the following expression:

$$V(r) = K\frac{q}{r}$$

**r** : It is the distance between the charge **q** and the point where we want to calculate the electric potential. Its unit in the International System is the volt **(V)**.

# Electric potentiel *V*




$$V(M) = K\frac{q}{r}$$

## 1) Electric Field and Potential Created by Multiple Point Charges

### (Principle of Superposition)

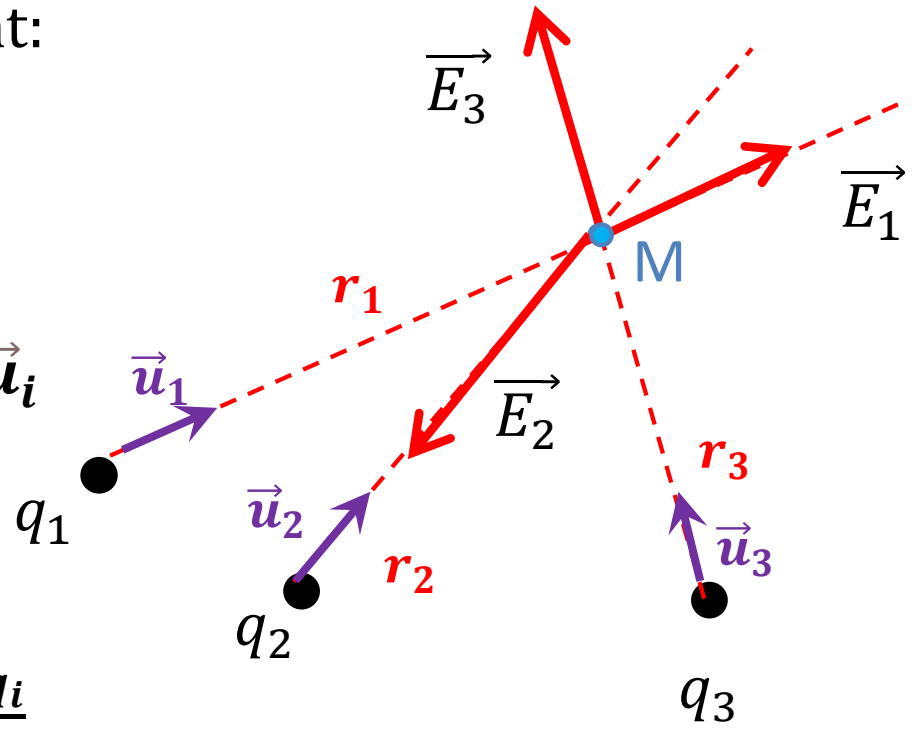
The collection of point charges $\mathbf{q_i}$ in space (Figure I-16) creates an electric field $\vec{E}(M)$ and an electric potential **V(M)** , such that:

Electric field $\vec{E}(M)$

$$\vec{E}(M) = \vec{E}_1 + \vec{E}_2 + \cdots + \vec{E}_N = \sum_{i=1}^{N} \vec{E}_i = \sum_{i=1}^{N} K \frac{q_i}{r_i^2} \vec{u}_i$$

Electric potentiel **V(M)** :

$$V(M) = V_1 + V_2 + \cdots + V_N = \sum_{i=1}^{N} V_i = \sum_{i=1}^{N} K \frac{q_i}{r_i}$$



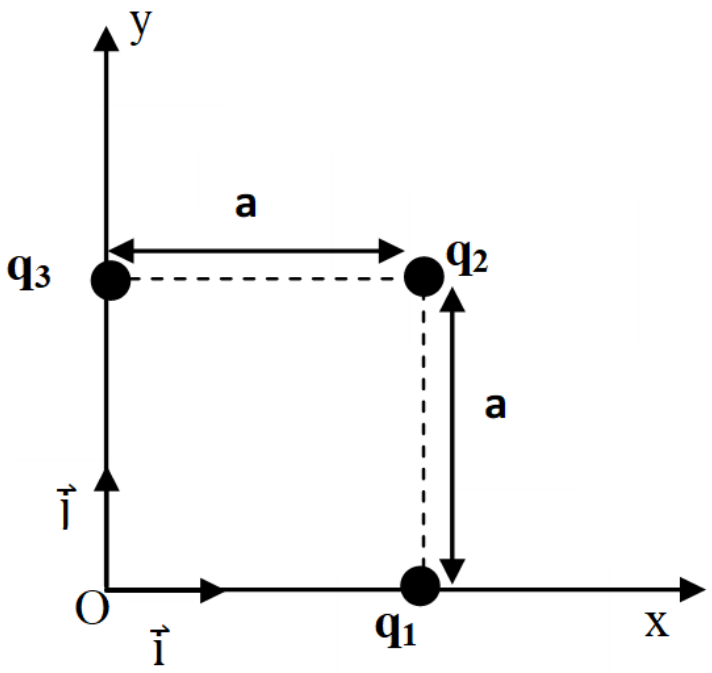
## Example 1 :

Let's consider three-point charges placed at coiner of a square with length a, as shown in the figure opposite.

1- Find and draw the electric field at point O. Indicate the unit vectors on the figure.

2- Calculate the electric potential created at point O.

Given : $q_1=q_3=-q$ ; $q_2=q=8.10^{-9}C$ ; a=5cm.
K=9 $10^{+9}$(UI).



## Solution

1- Find and draw the electric field at point O.

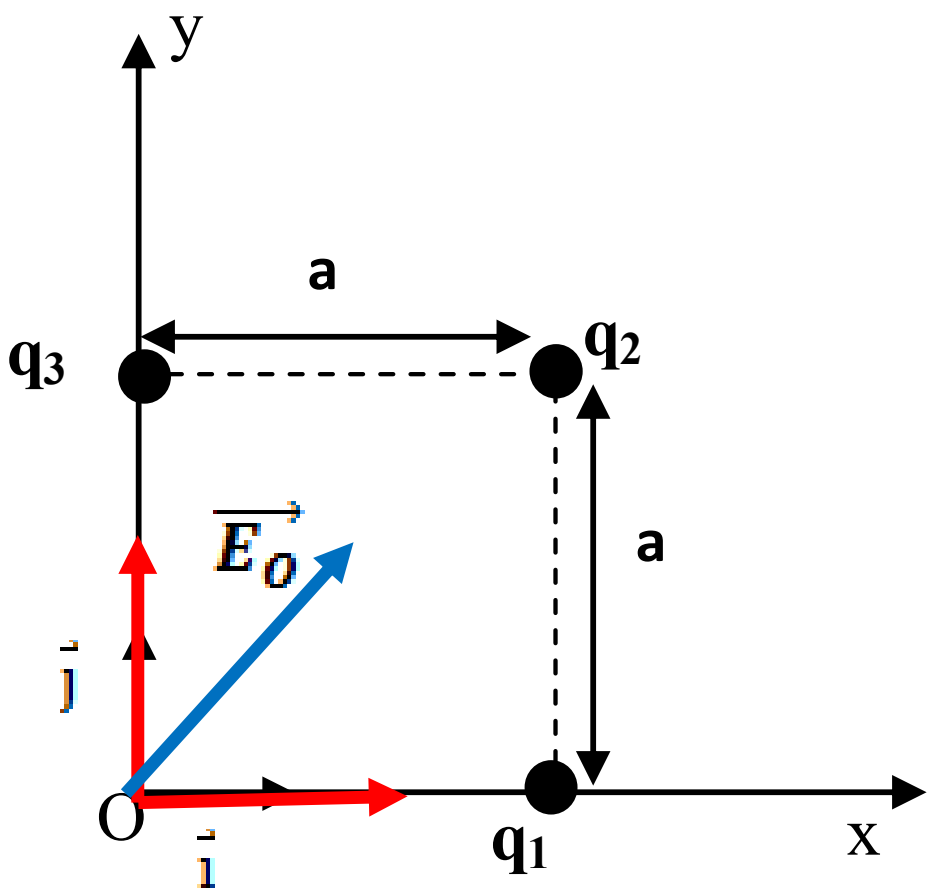
$$\vec{E}_o = \vec{E}_1(o) + \vec{E}_2(o) + \vec{E}_3(o)$$

$$\vec{E}_1(o) = \frac{kq_1}{r_{o1}^2}\,\vec{u}_{1/O}, \qquad \vec{u}_{1/O} = -\vec{i}, \qquad r_{o1} = a$$

$$\vec{E}_2(o) = \frac{kq_2}{r_{o2}^2}\,\vec{u}_{2/O}, \qquad \vec{u}_{2/O} = -\frac{\sqrt{2}}{2}\vec{i} - \frac{\sqrt{2}}{2}\vec{j}, \qquad r_{o2} = \sqrt{2}\ a$$

$$\vec{E}_3(o) = \frac{kq_3}{r_{o3}^2}\,\vec{u}_{3/O}, \qquad \vec{u}_{3/O} = -\vec{j}, \qquad r_{o3} = a$$

$$\vec{E}_o = \frac{(1-\frac{\sqrt{2}}{4})kq}{a^2}\left(\vec{i}+\vec{j}\right) \qquad \rightarrow \vec{E}_o = 1.86\ 10^{+4}\left(\vec{i}+\vec{j}\right) \rightarrow \left\|\vec{E}_o\right\| = 2.63\ \ 10^{+4}\ \mathrm{V/m}$$


y
a
q3
q2
a
$\overrightarrow{E_O}$
$\vec{j}$
O
$\vec{i}$
q1
x

2- Calculate the electric potential created at point O.

$$V_o = V_1(o) + V_2(o) + V_3(o)$$

$$V_o = -\frac{kq}{a} + \frac{kq}{\sqrt{2}a} - \frac{kq}{a} \qquad \rightarrow \quad V_o = -1861{,}77V$$