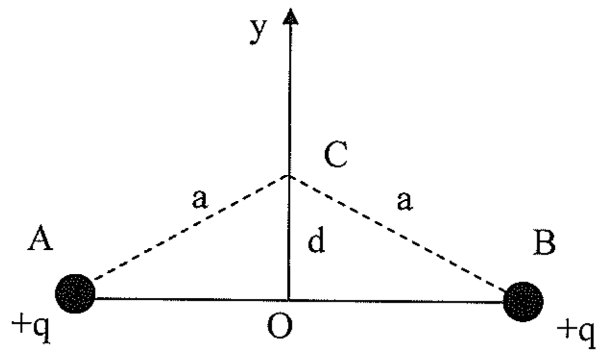
Physics Exam n°1

Calculators and extra-documents are not allowed.
Answer only on exam sheet please.

Exercise 1 (4 points)

Let's consider two positively charged point-like particles such that their positions are A and B. Point C belongs to AB's bisector and satisfies CA=CB=a. Let's denote OC=d.



1- On the above picture sketch the vectors of the electrostatic fields created at C by each charges separately. Then sketch the total field created at C.

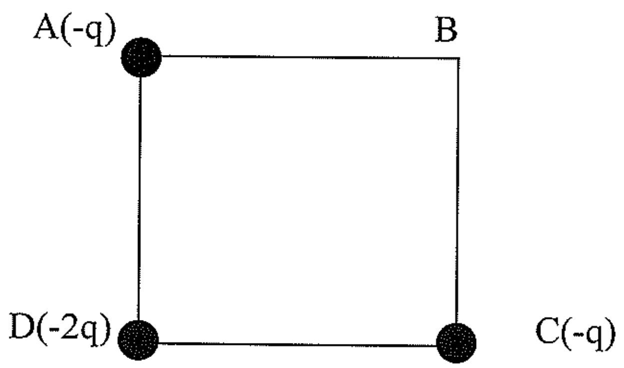
2- Write explicitly the intensity of the two fields $E_A(C)$ and $E_B(C)$ as function of k, q and a. Write then the total field $E(C)$ as function of k, q, a and d.

3- From now on a negative charge (-q) is placed at C. On the same picture above sketch the total electrostatic force acting on this charge (-q).

Deduce the expression of the norm of this force and write it as function of k, q, a and d.

Exercise 2 (6 points)

One considers fours point-like charges placed at points A, C and D such that ABCD is a square whose edge lenght equals to a.



1- Sketch on this picture electrostatic fields created by each charge at point B.

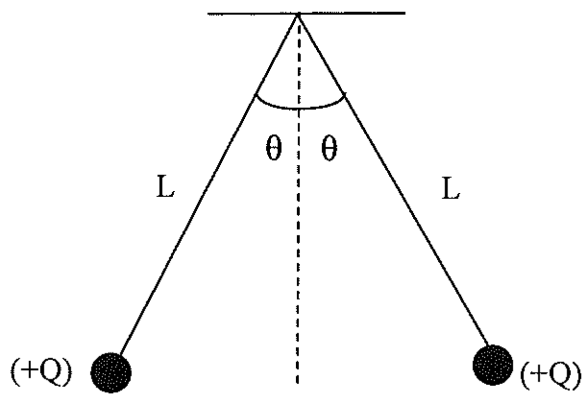
2- Write intensities of each of these vectors and deduce the intensity of the total field E(B) (as function of k, q and a).

3- Write the electrostatic potential V(0) created by this charge distribution at point O center of the square.

4- What is the value of the charge one must place at point B in order to make V(O) vanishing ?

Exercise 4 (6 points)

In an electroscope two identical spheres with mass m repulse one another due to their positive charge Q. At equilibrium the strings of length L describe an angle θ according to vertical axis.



1- Summarize the forces acting on one sphere and sketch them on the picture.

2- Write the equilibrium condition of one sphere m. (It may be useful to project equations onto a basis $(M\vec{x}, M\vec{y})$ where M is the center of the sphere).

3- a) Deduce the expression of the charge Q of such sphere : $Q = 2L.\sin(\theta)\sqrt{\frac{m.g.\tan(\theta)}{k}}$

where k is Coulomb's constant, g the gravitational field, L the string length, θ the angle between string and vertical axis, and m the mass of the sphere.

b) Compute Q for : $g = 10ms^{-2}$, $m = 10\sqrt{3}$ g, $\theta = 30°$, $L = 70cm$, $k = 9.10^9 SI$.

Exercise 4 (4 points)

Spherically distributed charges create an electric potential V(M) given by

$$V(r,\theta,\varphi) = \frac{C_1}{r}\sin(\theta)\exp(-C_2.\varphi)$$

1- Write the components E_r, E_θ et E_φ of the electric field which comes from that potential. Remember that the components of the gradient are given in spherical coordinates by: $\vec{grad}\left(\frac{\partial}{\partial r};\frac{1}{r}\frac{\partial}{\partial \theta};\frac{1}{r\sin\theta}\frac{\partial}{\partial \varphi}\right)$

2- Compute these components at point M ($r = 10^{-2}$m, $\theta = \pi/2$, $\varphi = 0$, $C_1 = 10^{-3}$V.m et C_2=1rad^{-1}), and the norm of the field $\vec{E}$.