PHYS 102: General Physics 2 **KOÇ UNIVERSITY** **Fall Semester 2015**

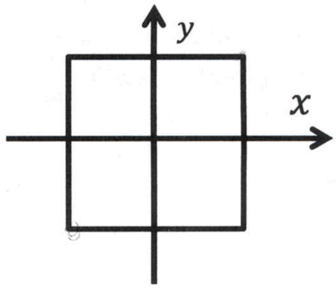
College of Sciences

Section 1 **Quiz** **October 2, 2015**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: Ongun ARISEV **Student ID:** oarisev14@ku.edu.tr **Signature:** Ongun

Four point charges $q, -2q, 3q, -4q$ will be placed at the corners of a square of side length $2a$. The square is centered about the origin in the x-y plane as shown in the figure. Find the configuration of charges for which the electric field at the origin is only in the $+\hat{y}$ direction and calculate its magnitude. (The constant in Coulomb's law is $\frac{1}{4\pi\varepsilon_0}$)



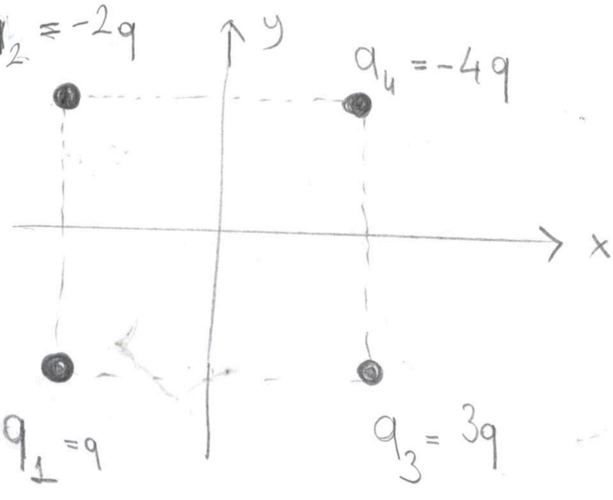
$q_1 = q$

$q_2 = -2q$

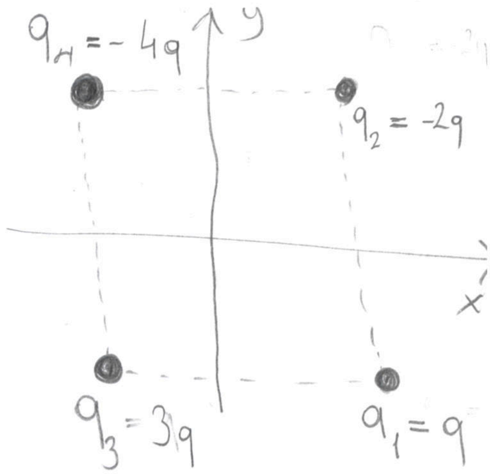
$q_3 = 3q$

$q_4 \quad -4q$

The differences between $q_3 - q_2$ and $q_1 - q_4$ are the same in magnitude. Therefore the configuration is as follow



Alternative solution



$$E_y = E_{1y} + E_{2y} + E_{3y} + E_{4y} = \frac{\sin 45^\circ \, (q_1 + q_3 - q_2 - q_4)}{4\pi\varepsilon_0 \, (a\sqrt{2})^2} = \frac{\sqrt{2} \; 10q}{8\pi\varepsilon_0 a^2 \; 2} = \frac{5\sqrt{2}\, q}{8\pi\varepsilon_0 a^2}$$

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Section 2 **Quiz** **October 2, 2015**

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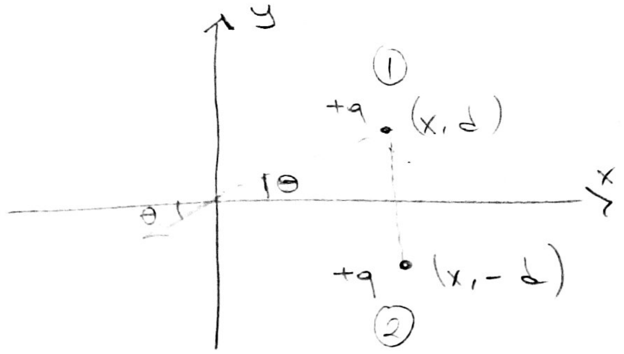
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

Two identical charges of +q are placed at points (x, d) and $(x, -d)$ respectively in the x-y plane. Find x such that the electric field at the origin is maximum. (The constant in Coulomb's law is $\frac{1}{4\pi\varepsilon_0}$)

$$k = \frac{1}{4\pi\varepsilon_0}$$



$$\sin\theta = \frac{d}{\sqrt{x^2+d^2}}$$

$$\cos\theta = \frac{x}{\sqrt{x^2+d^2}}$$

$$\vec{E}_1 = -\frac{kq}{x^2+d^2}\frac{x}{\sqrt{x^2+d^2}}\,\hat{i} - \frac{kq}{x^2+d^2}\frac{d}{\sqrt{x^2+d^2}}\,\hat{j}$$

$$\vec{E}_2 = -\frac{kq}{x^2+d^2}\frac{x}{\sqrt{x^2+d^2}}\,\hat{i} + \frac{kq}{x^2+d^2}\frac{d}{\sqrt{x^2+d^2}}\,\hat{j}$$

$$\vec{E}_{total} = \vec{E}_1 + \vec{E}_2 = -\frac{2kqx}{(x^2+d^2)^{3/2}}\,\hat{i} \Rightarrow |E_{total}| = \frac{2kqx}{(x^2+d^2)^{3/2}}$$

for maximum

$$\frac{\partial E_{total}}{\partial x} = 0 = \cancel{2k}q\,(x^2+d^2)^{-3/2} - \frac{3}{2}\,\cancel{2k}qx\,(2x)\,(x^2+d^2)^{-5/2} = 0$$

$$x^2+d^2-3x^2 = 0 \Rightarrow x = \pm\frac{d\sqrt{2}}{2}$$

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Section 3 **Quiz** **October 2, 2015**

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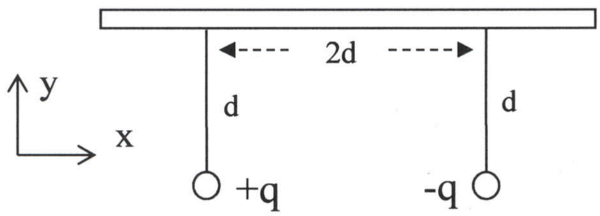
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

Two particles have the same mass m but opposite charges $\pm q$. The particles are fixed at the ends of two equal ropes of length d and suspended from two points separated by $2d$ as shown in the figure. Under a uniform constant electric field $\vec{E}_0$, the ropes stay vertical and the tension on each rope is equal to mg. Find the direction and the magnitude of $\vec{E}_0$.



The tension being equal to mg mean that the uniform constant electric field $\vec{E}_0$ cancels out the horizontal force caused by Coulomb attraction of two opposite charges on each charge.

Therefore on the positive charge

$$0 = \frac{kq^2}{(2d)^2}\hat{i} + q\vec{E}_0 \Rightarrow \vec{E}_0 = -\frac{kq}{(4d^2)} = \boxed{\frac{-q}{16\pi\varepsilon_0 d^2}\hat{i}}$$

$\vec{E}_0$ is in the minus x-direction.