PHYS 102: General Physics II - Spring 2017
Koç University, College of Sciences
Quiz 1 - February 13, 2017

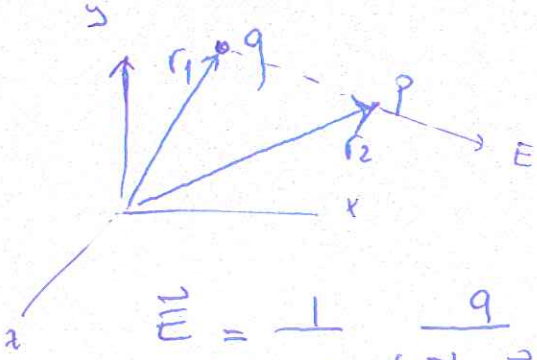
Closed book. No calculators are to be used for this quiz.

Name: Student ID: Signature:

S4

Q. Find the electric field at the origin due to two identical point charges with charge Q each, one located at $(x, y, z) = (a, a, 0)$ and the other at $(x, y, z) = (0, a. a)$.

To find E field at obs. point P.



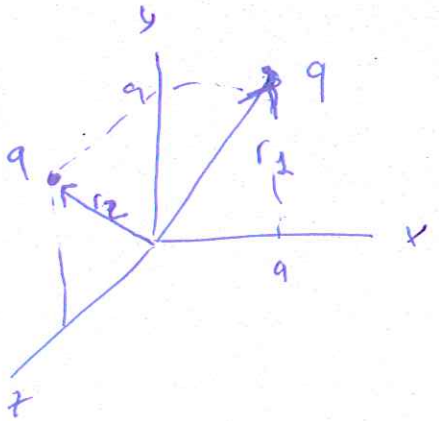
$$\vec{E} = \frac{k\,q}{|\vec{r}_2 - \vec{r}_1|^2} \frac{(\vec{r}_2 - \vec{r}_1)}{|r_2 - r_1|}$$

directer vector

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{(|\vec{r}_2 - \vec{r}_1|)^3} (\vec{r}_2 - \vec{r}_1)$$

for this question P at origin so $\vec{r}_2 = 0$

$$\vec{E} = \frac{q}{4\pi\epsilon_0} \frac{-\vec{r}_1}{|r_1|^3}$$



$r_1 = a\hat{x} + a\hat{y}$ $\quad |r_1| = a\sqrt{2}$

and $\vec{E}_1 = \frac{-q}{4\pi\epsilon_0} \frac{(\hat{x} + \hat{y})}{2\sqrt{2}\,a^2}$ //

for second charge

$\vec{r}_2 = a\hat{y} + a\hat{z}$ $\quad |r_2| = a\sqrt{2}$

$$\vec{E}_2 = \frac{-q}{4\pi\epsilon_0} \frac{(\hat{y} + \hat{z})}{2\sqrt{2}\,a^2}$$

$\Rightarrow$ Total E field $\vec{E}_1 + \vec{E}_2 = \frac{-q}{4\pi\epsilon_0} \cdot \frac{1}{2\sqrt{2}\,q^2} (\hat{x} + 2\hat{y} + \hat{z})$ //

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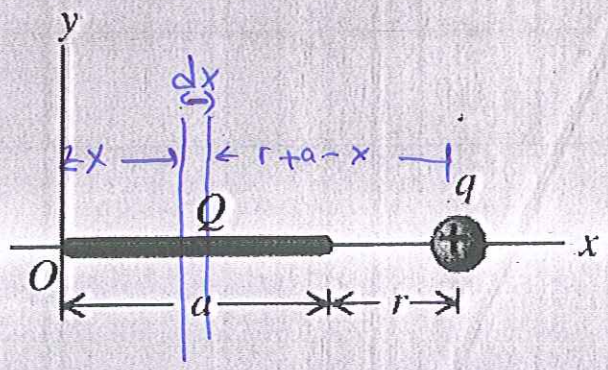
S2

Q. A uniformly charged, thin rod with length a and a total charge Q is placed horizontally on the x-axis, as shown. Express the force on a point charge q also on the x-axis and at a distance r from the rod, as an integral. Make sure to indicate the limits of your integral.



$dQ = dx \cdot \lambda$ λ = charge density per length

$\lambda = \frac{Q}{a}$

$dQ = dx \cdot \frac{Q}{a}$

$$dF = \frac{1}{4\pi\epsilon_0} \frac{dQ \cdot q}{(r+a-x)^2}$$

$$\int dF = \frac{1}{4\pi\epsilon_0} \frac{Q q}{a} \int_0^a \frac{dx}{(r+a-x)^2}$$

* Note that boundaries & integration may be different depending on where your x measurement is.

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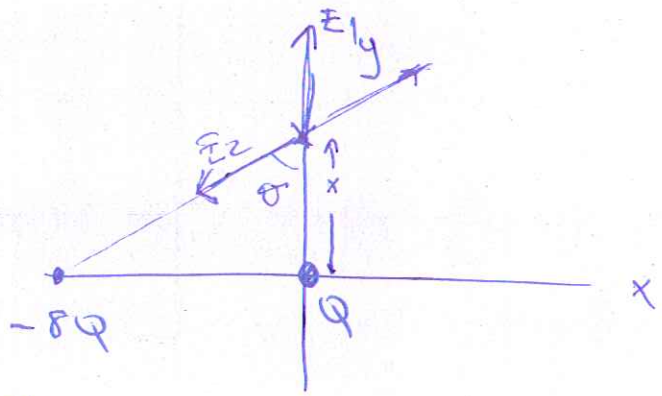
S1

Q. A positive point charge Q is located at the origin. Another point charge $-8Q$ is at point $(x, y, z) = (-a, 0, 0)$ where $a > 0$. Find the point on the positive y-axis where only the x-component of the electric field is nonzero. (At such a point, a charge that can only slide along the y-axis will remain stationary.)

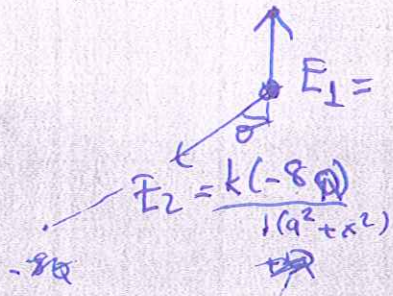


condition

$E_y = 0$ one point is origin! but question ask on positive y-axis. cozy!!

Arbitrary point x distance

$E_1 = E_2 \cos\theta$ condition



$$\frac{kQ}{x^2} = \frac{k\,8Q}{a^2+x^2} \cdot \frac{x}{(a^2+x^2)^{1/2}}$$

$$(a^2+x^2)^{3/2} = 8x^3$$

$$\left((a^2+x^2)^{1/2}\right)^3 = (2x)^3 \qquad x>0$$

$$a^2 + x^2 = 4x^2$$

$$x = a/\sqrt{3}$$

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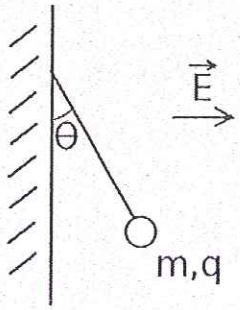
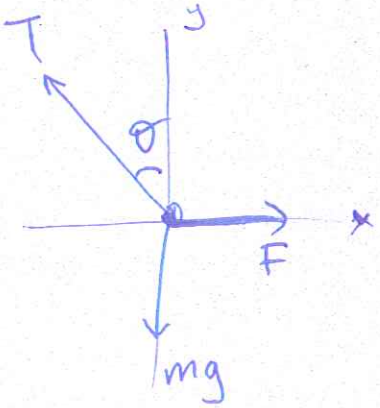
S3

Q. A tiny sphere is in equilibrium, suspended from a string attached to a wall. The sphere has a positive charge q and mass m, and is subject to a uniform electric field pointing to the right as shown in the figure. Show the forces acting on the sphere in a free-body diagram. Calculate the charge q in terms of the given quantities and the physical constants g and ϵ_0.



FBD



$F = E \cdot q$

equilibrium

$\Sigma F_x = 0, \quad \Sigma F_y = 0$

$F - T\sin\theta = 0$

$T\cos\theta - mg = 0$

$\Rightarrow T = mg/\cos\theta$

$F - mg\sin\theta/\cos\theta = 0 \Rightarrow F = mg\tan\theta$

$F = Eq = mg\tan\theta$

$q = mg\tan\theta / E$