Solution

Physics 2220
Spring 2005
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FIRST MIDTERM

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Name:_____

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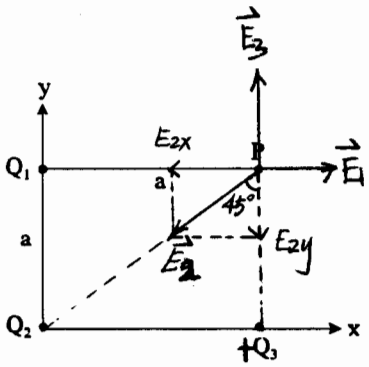
SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

The four points shown are at the corners of a square of side a. Given the values shown, calculate (numerical values),

(a) the x and y components of the electric field at point P;
(b) the direction of the electric field at point P, measured as an angle counter-clockwise from the positive x-axis.



$Q_1 = +4.76 \times 10^{-6}$ C
$Q_2 = -6.35 \times 10^{-6}$ C
$Q_3 = 2.37 \times 10^{-6}$ C
a = 1.35 cm

$k = 8.99 \times 10^9 \, N \cdot m^2/C^2$

(a) 4' $\vec{E}_1 = \frac{kQ_1}{a^2}\hat{x} = \frac{8.99\times10^9 \times 4.76\times10^{-6}}{(1.35\times10^{-2})^2}\hat{x} = 2.348\times10^8 \, N/C \, \hat{x}$

4' $\vec{E}_3 = \frac{kQ_3}{a^2}\hat{y} = \frac{8.99\times10^9 \times 2.37\times10^{-6}}{(1.35\times10^{-2})^2}\hat{y} = 1.169\times10^8 \, N/C \, \hat{y}$

6' $\vec{E}_2 = \frac{kQ_3}{(\sqrt{2}a)^2}(\cos45^\circ \hat{y} + \sin45^\circ \hat{x}) = \frac{8.99\times10^9 \times (-6.35\times10^{-6})}{(\sqrt{2}\times1.35\times10^{-2})^2}\left(\frac{\sqrt{2}}{2}\hat{x} + \frac{\sqrt{2}}{2}\hat{y}\right)$

$= -1.106\times10^8 \frac{N}{C}\hat{x} - 1.106\times10^8 \frac{N}{C}\hat{y}$.

3' $E_{x\,total} = E_1 + E_{2x} = (2.348 - 1.106)\times10^8 \frac{N}{C} = 1.24\times10^8 \frac{N}{C}$

3' $E_{y\,total} = E_3 + E_{2y} = (1.169 - 1.106)\times10^8 \frac{N}{C} = 6.30\times10^6 \frac{N}{C}$

(b) $\tan\alpha = \frac{E_{y\,total}}{E_{x\,total}}$

5' $\therefore \alpha = \tan^{-1}\frac{E_{y\,total}}{E_{x\,total}} = \tan^{-1}\left(\frac{6.30\times10^6}{1.24\times10^8}\right)$

$= 2.89$ (degree).