Quiz 1

Friday, September 17

The following information may or may not be of use:

$$\varepsilon_0 = 8.85 \times 10^{-12} \text{C}^2 \text{ N}^{-1} \text{ m}^{-2}$$
$$k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{N m}^2 \text{ C}^{-2}$$
$$|\vec{E}_{dipole,on-axis}| \approx \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$$
$$|\vec{E}_{dipole,perp}| \approx \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$$

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1. In a certain coordinate system, a point charge $q_1 = -4$ μC is located at the position $\vec{r}_1 =< 4, -1, 0 >$ m. A second charge $q_2 = 6$ μC sits at $\vec{r}_2 =< 0, 5, 0 >$ m. Finally, a third charge $q_3 = 9$ μC is at $\vec{r}_3 =< -3, -7, 0 >$ m. What is the net force exerted on q_3 due to q_1 and q_2? Be sure to express your answer as a vector with correct units.

$\vec{F} = q\vec{E}$

$q = 9 \times 10^{-6}$ C

$\vec{E} = \vec{E}_1 + \vec{E}_2$

1) Find $\vec{E}_1$ at $\langle -3, -7, 0 \rangle$ m due to q_1

$\vec{r}_{src} = \langle 4, -1, 0 \rangle$ m

$\vec{r}_{obs} = \langle -3, -7, 0 \rangle$ m

$\vec{r} = \vec{r}_{obs} - \vec{r}_{src}$

$= \langle -3, -7, 0 \rangle$ m $- \langle 4, -1, 0 \rangle$ m

$\vec{r} = \langle -7, -6, 0 \rangle$ m

$|\vec{r}| = 9.22\ m$

$\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \frac{\langle -7, -6, 0\rangle m}{9.22\ m} = \langle -.76, -.65, 0\rangle$

$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r^2}\hat{r}$

$= \left(9\times10^9 \frac{Nm^2}{C^2}\right)\left[\frac{-4\times10^{-6}\,C}{(9.22\ m)^2}\right]\langle -.76, -.65, 0\rangle$

$\vec{E}_1 = \langle 321.6, 275.6\rangle \frac{N}{C}$

2) Find $\vec{E}_2$ @ $\langle -3, -7, 0\rangle m$ due to q_2

$\vec{r}_{src} = \langle 0, 5, 0\rangle m$

$\vec{r}_{obs} = \langle -3, -7, 0\rangle\ m$

$\vec{r} = \langle -3, -12, 0\rangle$

$|\vec{r}| = 12.37\ m$

$\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \langle -.24, -.97, 0\rangle$

$\vec{E}_2 = \left(9\times10^9 \frac{Nm^2}{C^2}\right)\left[\frac{6\times10^{-6}\,C}{(12.37m)^2}\right]\langle -.24, -.97, 0\rangle$

$$\vec{E}_2 = \langle -85.6, -342.4, 0 \rangle \frac{N}{C}$$

3) $\vec{E} = \vec{E}_1 + \vec{E}_2$

$$= \langle 321.6, 275.6 \rangle \frac{N}{C}$$

$$+$$

$$\langle -85.6, -342.4, 0 \rangle \frac{N}{C}$$

$$\vec{E} = \langle 236.0, -66.8, 0 \rangle \frac{N}{C}$$

4) $\vec{F}_3 = q_3 \vec{E}$

$$= (9 \times 10^{-6}\ C) \times \langle 236.0, -66.8, 0 \rangle \frac{N}{C}$$

$$\boxed{\vec{F}_3 = \langle 2.12, -0.60, 0 \rangle \times 10^{-3}\ N}$$