Solutions

PHYS - 205B - 002 (Midterm Exam 02) 2024 Spring

Problem 1

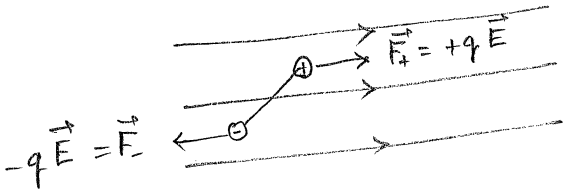
$Q_A = -2.0\mu C$ $\quad Q_B = +7.0\mu C$ $\quad Q_C = 0$

$Q'_A = Q'_C = \dfrac{Q_A + Q_C}{2}$ step 1 $\Rightarrow$ $Q'_A = -1.0\mu C$, $Q'_B = +7.0\mu C$, $Q'_C = -1.0\mu C$.

$Q''_B = Q''_C = \dfrac{Q'_B + Q'_C}{2}$ step 2 $\Rightarrow$ $Q''_A = -1.0\mu C$, $Q''_B = +3.0\mu C$, $Q''_C = +3.0\mu C$.

Answer: $Q''_B = +3.0\mu C$.

Problem 2

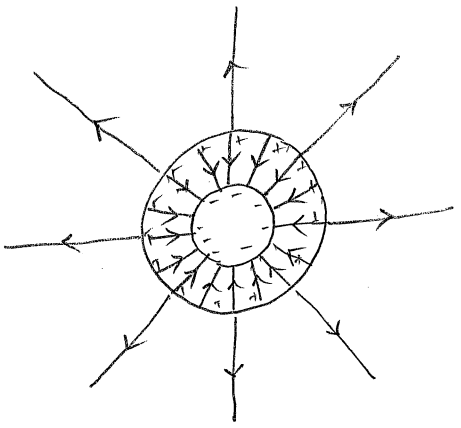


$\vec{F}_{tot} = +q\vec{E} - q\vec{E}$

$= 0$.

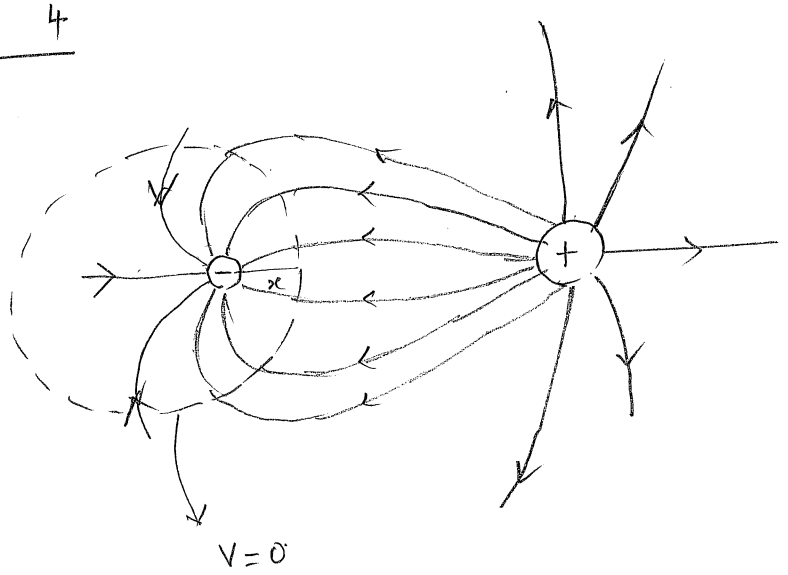
Answer: No force.

Problem 3



$$\vec{E} = \begin{cases} 0, & r<a, \\ -\hat{r}\,\dfrac{k\,2Q}{r^2}, & a<r<b, \\ +\hat{r}\,\dfrac{kQ}{r^2}, & b<r. \end{cases}$$

Problem 4



$$\frac{k|q_1|}{x} = \frac{k|q_2|}{d-x}$$

$$\frac{1.0}{x} = \frac{3.0}{d-x}$$

$$x = \frac{d}{4}$$

Problem 5

$$\vec{E}_1 = \left(+\hat{i}\cos 45 - \hat{j}\sin 45\right)\frac{kq}{x^2}$$

$$\vec{E}_2 = \left(-\hat{i}\cos 45 - \hat{j}\sin 45\right)\frac{k2q}{x^2}$$

$$\vec{E}_3 = \left(-\hat{i}\cos 45 - \hat{j}\sin 45\right)\frac{kq}{x^2}$$

$$\vec{E}_4 = \left(+\hat{i}\cos 45 - \hat{j}\sin 45\right)\frac{k2q}{x^2}$$

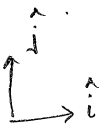
$$\vec{E}_1 + \vec{E}_3 = -\hat{j}\,2\sin 45\,\frac{kq}{x^2}$$

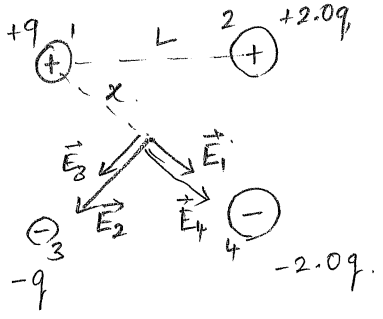
$$\vec{E}_2 + \vec{E}_4 = -\hat{j}\,2\sin 45\,\frac{k2q}{x^2}$$

$$\vec{E}_{tot} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4 = -\hat{j}\,2\sin 45\,3\,\frac{kq}{x^2}$$

$$= -\hat{j}\,\frac{6}{\sqrt{2}}\,\frac{kq}{x^2}$$

$$= -\hat{j}\,\frac{12}{\sqrt{2}}\,\frac{kq}{L^2}$$





$$x = \frac{L}{\sqrt{2}}$$

$$\sin 45 = \frac{1}{\sqrt{2}}$$

$$x^2 = \frac{L^2}{2}$$

magnitude: $\frac{12}{\sqrt{2}}\frac{kq}{L^2}$

direction: along $-\hat{j}$

Problem 6

$$a_e = \frac{eE}{m_e} \qquad \frac{a_e}{a_p} = \frac{m_p}{m_e}$$

$$a_p = \frac{eE}{m_p}$$

$V = V_i + a\,\Delta t$

$p = mv$

$$\frac{V_e}{V_p} = \frac{a_e \Delta t}{a_p \Delta t} = \frac{a_e}{a_p} = \frac{m_p}{m_e}$$

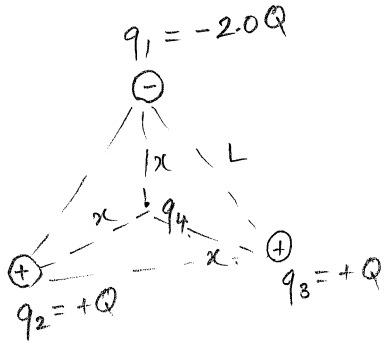
$$\frac{p_e}{p_p} = \frac{m_e V_e}{m_p V_p} = \frac{m_e}{m_p}\frac{m_p}{m_e} = 1$$

$$\frac{K_e}{K_p} = \frac{\frac{1}{2} m_e V_e^2}{\frac{1}{2} m_p V_p^2} = \frac{m_e}{m_p}\left(\frac{m_p}{m_e}\right)^2 = \frac{m_p}{m_e}$$

Problem 7

i = at ∞

f = at the center of triangle.



$$U_i = U_{12} + U_{23} + U_{31} + U_{41}^i + U_{42}^i + U_{43}^i$$

$$U_f = U_{12} + U_{23} + U_{31} + U_{41}^f + U_{42}^f + U_{43}^f$$

$U_{41}^i = U_{42}^i = U_{43}^i = 0$ (because $r \to \infty$)

$$\Delta U = U_f - U_i$$

$$= U_{41}^f + U_{42}^f + U_{43}^f$$

$$= -\frac{k q_4 2.0Q}{x} + \frac{k q_4 Q}{x} + \frac{k q_4 Q}{x}$$

$$= 0.$$