Midterm Exam 01 – Solutions (2015 Summer, 203B)

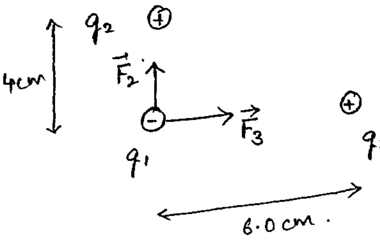
prob. 1, MT01

$$F = \frac{1}{4\pi\epsilon_0}\frac{Q^2}{r^2} \Rightarrow [\epsilon_0] = \frac{[Q]^2}{[F][r]^2} = \frac{C^2}{MLT^{-2}L^2} = \frac{C^2T^2}{ML^3}$$

prob. 2, MT01

$q_1 = -4\mu C$
$q_2 = +6.0\mu C$
$q_3 = +5.0\mu C$

$$|\vec{F}_2| = \frac{kq_1q_2}{r_{12}^2} = \frac{9\times10^9\times4\times10^{-6}\times6\times10^{-6}}{(4\times10^{-2})^2}$$
$$= 135\ N$$

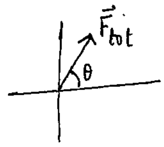


$$|\vec{F}_3| = \frac{kq_1q_3}{r_{13}^2} = \frac{9\times10^9\times4\times10^{-6}\times5\times10^{-6}}{(6\times10^{-2})^2}$$
$$= 50\ N$$

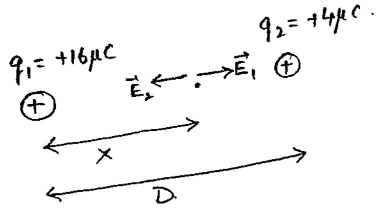
$$|\vec{F}_{tot}| = \sqrt{50^2+135^2} = 144\ N$$

$$\vec{F}_2 = 0\ \hat{i} + 135\ N\ \hat{j}$$
$$\vec{F}_3 = 50\ N\ \hat{i} + 0\ \hat{j}$$
$$\vec{F}_{tot} = 50\ N\ \hat{i} + 135\ N\ \hat{j}$$

$$\theta = \tan^{-1}\left(\frac{135}{50}\right)$$
$$= 69.7^\circ \quad \text{(direction).}$$



prob. 3, MT01

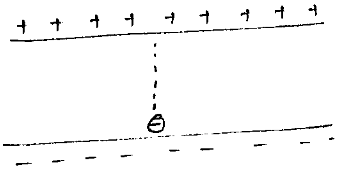


$$|\vec{E}_1| = |\vec{E}_2|$$
$$\frac{kq_1}{x^2} = \frac{kq_2}{(D-x)^2}$$
$$\frac{16}{x^2} = \frac{4}{(3-x)^2}$$
$$\frac{4}{x} = \pm\frac{2}{(3-x)}$$
$$12 - 4x = \pm 2x$$
$$x = \frac{12}{4\pm2} = \frac{12}{6} \text{ and } \frac{12}{2}$$
$$= 2.0\,m \text{ and } 6.0\,m.$$

not allowed because the point has to be between the charges.

Solution: $\underline{\underline{x = 2.0\,m}}$

prob. 4, MT01



$$V_f^2 = V_i^2 + 2a\,\Delta x$$
$$= 0 + 2a\,(1.8\times10^{-2}\,m)$$

$$a = \frac{qE}{m} = \frac{1.6\times10^{-19}\times4.3\times10^{6}}{9.1\times10^{-31}}$$
$$= 7.6\times10^{17}\ \frac{m}{s^2}.$$

$$V_f^2 = 2\times7.6\times10^{17}\times1.8\times10^{-2}$$
$$= 2.74\times10^{16}\ \frac{m}{s}$$

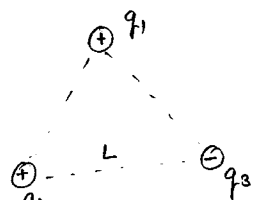
$$\Rightarrow\quad V_f = 1.7\times10^{8}\ \frac{m}{s}$$

prob. 5, MT01

$$\phi_{tot} = 6\,\phi_{face} = \frac{Q}{\epsilon_0}$$

$$\phi_{face} = \frac{Q}{6\epsilon_0} = \frac{1.6\times10^{-19}\,C}{6\times8.85\times10^{-12}\,\frac{C^2}{Nm^2}} = 3.0\times10^{-9}\ \frac{Nm^2}{C}.$$

prob. 6, MT01



$q_1 = +15.0\mu C$
$q_2 = +25.0\mu C$
$q_3 = -20.0\mu C$.

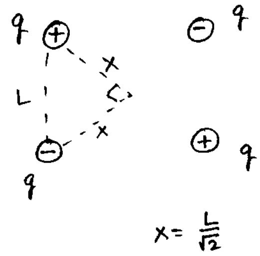
$$U = \frac{k\,q_1q_2}{L} + \frac{k\,q_1q_3}{L} + \frac{k\,q_2q_3}{L}$$

$$= \frac{9\times10^{9}\times15\times10^{-6}\times25\times10^{-6}}{0.50} - \frac{9\times10^{9}\times15\times10^{-6}\times20\times10^{-6}}{0.50}$$
$$- \frac{9\times10^{9}\times25\times10^{-6}\times20\times10^{-6}}{0.50}$$

$$= \frac{9\times10^{-3}}{0.50}\left[15\times25 - 15\times20 - 25\times20\right]$$

$$= -7.65\ J$$

prob. 7, MT01



(a) $V_{center} = +\frac{kq}{(L/\sqrt{2})} - \frac{kq}{(L/\sqrt{2})} + \frac{kq}{(L/\sqrt{2})} - \frac{kq}{(L/\sqrt{2})}$

$= 0$

(b) $V_\infty = 0$

$\Delta U = q \; \Delta V$

$= q \left(V_{center} - V_\infty \right)$

$= 0$.

prob. 8, MT01

$U = \frac{1}{2} C V^2$

$69 \, J = \frac{1}{2} \; 121 \times 10^{-6} F \times V^2$

$V^2 = 1.14 \times 10^6 \quad \Rightarrow \quad V = 1.1 \times 10^3$ volt