Solutions to Midterm Exam 01 (PHYS 2038, 2015 Fall)

Prob. 1

$$\frac{F_g}{F_e} = \frac{\left(\frac{G m_e m_p}{\cancel{R^2}}\right)}{\left(\frac{k e^2}{\cancel{R^2}}\right)} = \frac{G m_e m_p}{k e^2}$$

$$= \frac{6.7\times10^{-11} \times 9.1\times10^{-31} \times 1.67\times10^{-27}}{8.99\times10^{9} \times (1.6\times10^{-19})^2} = 4.4\times10^{40}$$

Prob. 2

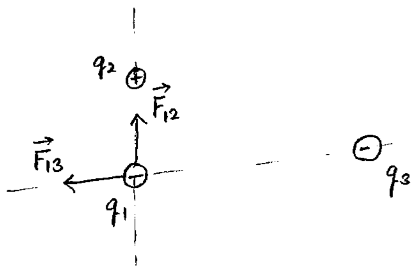
$$q_1' = q_2' = \frac{q_1+q_2}{2} = \frac{+2.0\mu C - 8.0\mu C}{2} = -3.0\,\mu C$$

$$F = \frac{k q_1' q_2'}{r^2} = \frac{8.99\times10^{9} \times (3.0\times10^{-6})^2}{(10.0\times10^{-2})^2} = 8.1\text{ N}$$ (repulsive)

Prob. 3

$$|\vec{F}_{12}| = \frac{k|q_1||q_2|}{(r_{12})^2} = \frac{8.99\times10^{9} \times 5.0\times10^{-6} \times 4.0\times10^{-6}}{(4.0\times10^{-2})^2}$$

$$= 112\text{ N}$$



$$|\vec{F}_{13}| = \frac{k|q_1||q_3|}{(r_{13})^2} = \frac{8.99\times10^{9} \times 5.0\times10^{-6} \times 6.0\times10^{-6}}{(6.0\times10^{-2})^2}$$

$$= 74.9\text{ N}$$

$$\vec{F}_{12} = 0\,\hat{i} + 112\,\hat{j}$$

$$\vec{F}_{13} = -74.9\,\hat{i} + 0\,\hat{j}$$

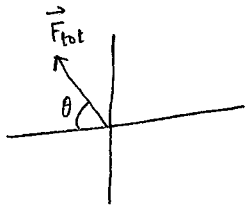
$$\vec{F}_{tot} = -74.9\,\hat{i} + 112\,\hat{j}$$

$$|\vec{F}_{tot}| = \sqrt{(-74.9)^2 + 112^2}$$

$$= 135\text{ N}$$

$$\theta = \tan^{-1}\left(\frac{112}{74.9}\right)$$

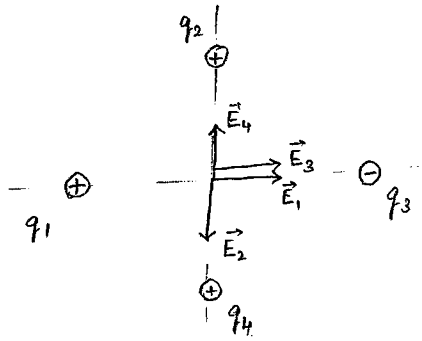
$$= 56.2^\circ$$



magnitude : 135 N

direction : 56.2° clockwise w.r.t $-x$.

Prob. 4



$$|\vec{E}_1| = \frac{k|q_1|}{L^2} = \frac{8.99\times10^9 \times 1.0\times10^{-6}}{(40.0\times10^{-2})^2} = 5.62\times10^4\ \frac{N}{C}$$

$$|\vec{E}_2| = \frac{k|q_2|}{L^2} = \frac{8.99\times10^9 \times 2.0\times10^{-6}}{(40.0\times10^{-2})^2} = 11.2\times10^4\ \frac{N}{C}.$$

$$|\vec{E}_3| = \frac{k|q_3|}{L^2} = \frac{8.99\times10^9 \times 3.0\times10^{-6}}{(40.0\times10^{-2})^2} = 16.9\times10^4\ \frac{N}{C}$$

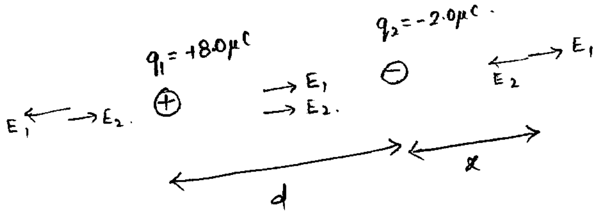
$$|\vec{E}_4| = \frac{k|q_4|}{L^2} = |\vec{E}_2|$$

$$\vec{E}_1 = 5.62\times10^4\ \hat{i} + 0\ \hat{j}$$
$$\vec{E}_2 = 0\ \hat{i} - 11.2\times10^4\ \hat{j}$$
$$\vec{E}_3 = 16.9\times10^4\ \hat{i} + 0\ \hat{j}$$
$$\vec{E}_4 = 0\ \hat{i} + 11.2\times10^4\ \hat{j}$$
$$\vec{E}_{tot} = 23\times10^4\ \hat{i}\ \frac{N}{C} + 0\ \hat{j}$$

magnitude: $23\times10^4\ \frac{N}{C}$

direction: along $+x$.

Prob. 5



Argue that the spot is on the right of q_2.

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

$$\frac{k|q_1|}{(d+x)^2} = \frac{k|q_2|}{x^2}$$

$$\frac{\cancel{k}\ 8.0\cancel{\mu C}}{(d+x)^2} = \frac{\cancel{k}\ 2.0\cancel{\mu C}}{x^2}.$$

$$4.0\,x^2 = (d+x)^2$$

$$\pm 2.0\,x = 1.0 + x.$$

$$x = \cancel{-0.33\text{ m}} \quad \text{or} \quad 1.0\text{ m}$$

does not match with x being on right

Answer: $\vec{E} = 0$ at a distance of 1.0 m to the right of q_2.

Prob. 6

$$\frac{a_e}{a_p} = \frac{\left(\frac{q_e}{m_e} E\right)}{\left(\frac{q_p}{m_p} E\right)} = \frac{m_p}{m_e} = 1835$$

Prob. 7

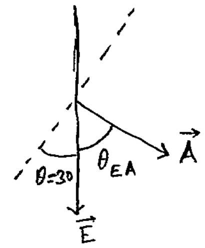
$$a = \frac{q}{m} E = \frac{1.6 \times 10^{-19} \times 4.0 \times 10^{3}}{1.67 \times 10^{-27}} = 3.8 \times 10^{11} \ \frac{m}{s^2}$$

$$x = V_i t + \frac{1}{2} a t^2$$

$$= 0 + \frac{1}{2} \ 3.8 \times 10^{11} \left(1.0 \times 10^{-9}\right)^2$$

$$= 1.9 \times 10^{-7} \ m$$

Prob. 8



$$\phi_E = \vec{E} \cdot \vec{A} = E A \cos \theta_{EA}$$

$$= 3.0 \times 10^{2} \times 2.0 \cos 60$$

$$= 3.0 \times 10^{2} \ \frac{N}{C} \ m^2$$

Prob. 9

$$\phi_E = \frac{Q_{en}}{\epsilon_0} = \frac{-1.6 \times 10^{-19}}{8.85 \times 10^{-12}} = -1.8 \times 10^{-8} \ \frac{N}{C} \ m^2$$

Prob. 10

Charge on a conductor resides on its surface. Thus, there is no charge inside the sphere of radius 5.0 cm.

So, $\phi_E = \frac{Q_{en}}{\epsilon_0} = 0.$