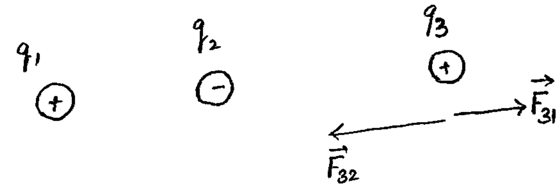
PHYS 203B Sec 001 (2017 Spring) Midterm Exam 1

Prob. 1

$$1.0\,\mu C = 1.0 \times 10^{-6}\, C \; \frac{1 \text{ electron}}{1.60 \times 10^{-19}\, C} = 6.3 \times 10^{12} \text{ electrons}$$

Prob. 2



$\vec{F}_{ij}$ on i by j

$$\vec{F}_{31} = +\hat{x}\, \frac{k\,|q_3|\,|q_1|}{b^2}$$

$$= +\hat{x}\, \frac{8.99 \times 10^{9} \times 3.0 \times 10^{-6} \times 1.0 \times 10^{-6}}{(3.0 \times 10^{-1})^2}$$

$$= +\hat{x}\; 3.0 \times 10^{-1}\ N$$

$$\vec{F}_{32} = -\hat{x}\, \frac{k\,|q_3|\,|q_2|}{(b-a)^2}$$

$$= -\hat{x}\, \frac{8.99 \times 10^{9} \times 3.0 \times 10^{-6} \times 2.0 \times 10^{-6}}{(2.0 \times 10^{-1})^2}$$

$$= -\hat{x}\; 13.5 \times 10^{-1}\ N$$

$$\vec{F} = \vec{F}_{31} + \vec{F}_{32}$$

$$= +\hat{x}\; 0.30 - \hat{x}\; 1.35$$

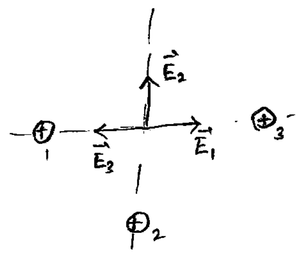
$$= -\hat{x}\; 1.1\ N$$

Magnitude : 1.1 Newton

Direction : towards q_2 (in the $-\hat{x}$ direction)

Prob. 3

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3$$



$$\vec{E}_1 = +E\,\hat{i} + 0\,\hat{j}$$

$$\vec{E}_2 = 0\,\hat{i} + E\,\hat{j}$$

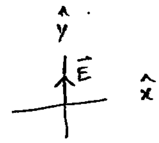
$$\vec{E}_3 = -E\,\hat{i} + 0\,\hat{j}$$

$$\vec{E} = 0\,\hat{i} + E\,\hat{j}$$

$$E = \frac{kq}{L^2} = \frac{8.99\times10^{9} \times 1.0\times10^{-6}}{(1.0\times10^{-1})^2} = 8.99\times10^{5}\ \frac{N}{C}.$$

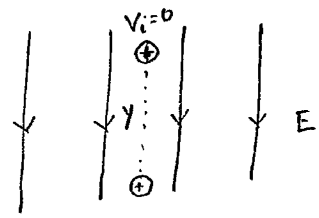
Magnitude : $8.99\times10^{5}\ \frac{N}{C}$

Direction : along $+\hat{j}$



Prob. 4

$$a = \frac{q}{m}E$$



$$y = \underbrace{v_i}_{=0} t + \frac{1}{2}at^2$$

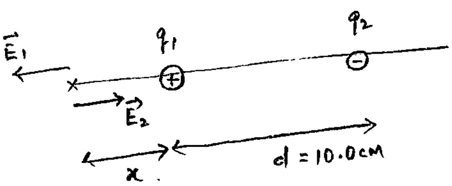
$$y = \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2y}{a}}$$

$$\frac{t_1}{t_2} = \frac{\sqrt{\frac{2y}{a_1}}}{\sqrt{\frac{2y}{a_2}}} = \sqrt{\frac{a_2}{a_1}} = \sqrt{\frac{\left(\frac{q_2}{m_2}E\right)}{\left(\frac{q_1}{m_1}E\right)}} = \sqrt{\frac{q_2}{q_1}} = \sqrt{2.0} = 1.4$$

Prob. 5

→ Argue that it is to the left of charge q_1



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

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

$$\frac{1.0}{x^2} = \frac{4.0}{(d+x)^2}$$

$$\pm\frac{1.0}{x} = \frac{2.0}{d+x}$$

$$d + x = \pm 2.0x$$

$$x = +d = +10\text{cm} \quad \text{or} \quad x = -\frac{d}{3} = -3.3\text{cm}.$$

↳ does not fit our first argument and $|\vec{E}_1| = |\vec{E}_2|$.

<u>Answer</u>: 10cm to left of q_1.

Prob. 6

$$\phi_E^{closed} = \frac{Q_{enclosed}}{\epsilon_0}$$

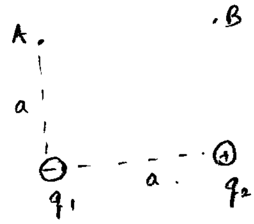
$$\phi_1 + \phi_2 + \phi_3 + \phi_4 + \phi_5 + \phi_6 = \frac{Q}{\epsilon_0}$$

$$Q = \epsilon_0 (\phi_1 + \phi_2 + \phi_3 + \phi_4 + \phi_5 + \phi_6)$$

$$= 8.85\times10^{-12} (+1650 + 2220 + 4380 - 1660 - 3750 - 5550)$$

$$= -2.40 \times 10^{-8}\ C$$

Prob. 7



$$V_A = -\frac{k|q_1|}{a} + \frac{k|q_2|}{\sqrt{2}\,a}$$

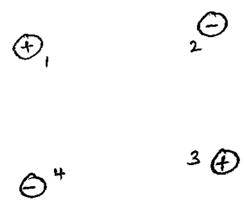
$$V_B = +\frac{k|q_2|}{a} - \frac{k|q_1|}{\sqrt{2}\,a}$$

$$V_A - V_B = -\frac{8.99\times10^{9}\times1.0\times10^{-6}}{1.0\times10^{-1}} + \frac{8.99\times10^{9}\times2.0\times10^{-6}}{1.4\times10^{-1}} - \frac{8.99\times10^{9}\times2.0\times10^{-6}}{1.0\times10^{-1}} + \frac{8.99\times10^{9}\times1.0\times10^{-6}}{1.4\times10^{-1}}$$

$$= -8.99\times10^{4}\ V + 12.8\times10^{4}\ V - 18.0\times10^{4}\ V + 6.42\times10^{4}\ V$$

$$= -7.8\times10^{4}\ V$$

Prob. 8



$$\Delta U = -\frac{k|q_1||q_2|}{L} + \frac{k|q_1||q_3|}{\sqrt{2}\,L} - \frac{k|q_1||q_4|}{L} - \frac{k|q_2||q_3|}{L} + \frac{k|q_2||q_4|}{\sqrt{2}\,L} - \frac{k|q_4||q_3|}{L}$$

$$= -4\frac{kq^2}{L} + \frac{2}{\sqrt{2}}\frac{kq^2}{L}$$

$$= (-4+\sqrt{2})\frac{kq^2}{L} = (-4+\sqrt{2})\frac{8.99\times10^{9}\times(1.0\times10^{-6})^2}{(1.0\times10^{-1})}$$

$$= -0.23\ \text{Joule}.$$