

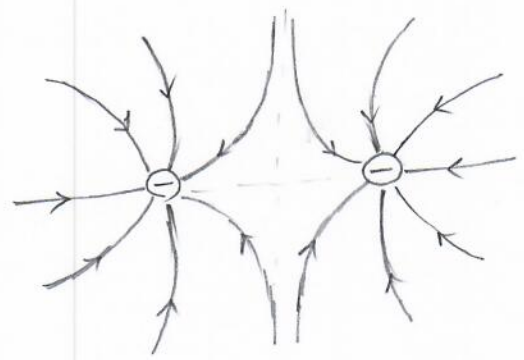
# Solutions

## Problem 1

<u>A</u>	<u>B</u>	<u>C</u>
Q	2Q	3Q
$\frac{Q+3Q}{2} = 2Q$	2Q	$\frac{Q+3Q}{2} = 2Q$
2Q	$\frac{2Q+2Q}{2} = 2Q$	$\frac{2Q+2Q}{2} = 2Q$

The charge on B is 2Q.

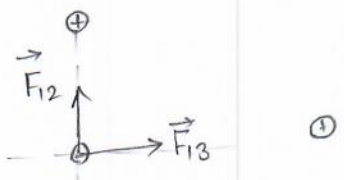
## Problem 2



## Problem 3

$$E = 0$$

## Problem 4



$$|\vec{F}_{12}| = \frac{k |q_1| |q_2|}{r_{12}^2} = \frac{9.0 \times 10^9 \times 4.0 \times 10^{-6} \times 6.0 \times 10^{-6}}{(0.040)^2} = 140 \text{ N}$$

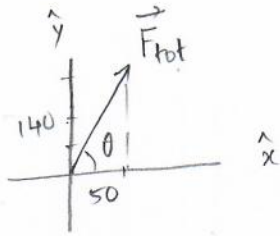
$$|\vec{F}_{13}| = \frac{k |q_1| |q_3|}{r_{13}^2} = \frac{9.0 \times 10^9 \times 4.0 \times 10^{-6} \times 5.0 \times 10^{-6}}{(0.06)^2} = 50. \text{ N}$$

### Problem 4 (contd.)

$$\vec{F}_{12} = 0 \hat{i} + 140 \hat{j}$$

$$\vec{F}_{13} = 50 \hat{i} + 0 \hat{j}$$

$$\vec{F}_{\text{tot}} = 50 \hat{i} + 140 \hat{j}$$



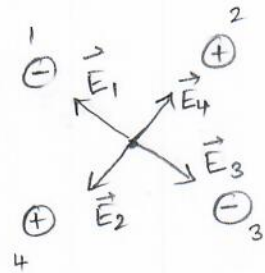
magnitude:  $|\vec{F}_{\text{tot}}| = \sqrt{50^2 + 140^2} = 150 \text{ N}$

direction:  $\theta = \tan^{-1}\left(\frac{140}{50}\right) = 70^\circ$  counterclockwise with respect to  $+\hat{x}$

### Problem 5

$$|\vec{E}_1| = |\vec{E}_2| = |\vec{E}_3| = |\vec{E}_4| = \frac{kq}{(L/2)^2}$$

$$\vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4 = 0$$



### Problem 6

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

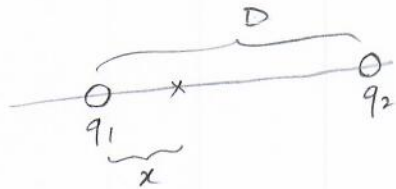
$$\frac{k|q_1|}{x^2} = \frac{k|q_2|}{(D-x)^2}$$

$$\sqrt{\frac{1.0 \times 10^{-6}}{x^2}} = \sqrt{\frac{4.0 \times 10^{-6}}{(D-x)^2}}$$

$$\frac{1}{x} = \frac{2.0}{D-x}$$

$$D-x = 2.0x$$

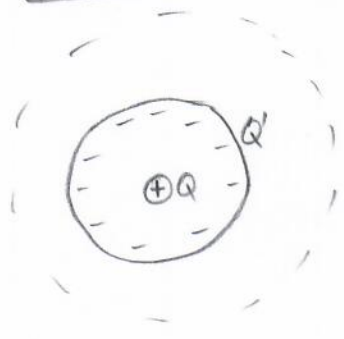
$$x = \frac{D}{3.0} = 3.3 \text{ cm to the right of } q_1$$



Problem 7

$$\begin{aligned}
 m_e a_e &= q_e E & \Rightarrow & a_e = \frac{eE}{m_e} \\
 m_p a_p &= q_p E & \Rightarrow & a_p = \frac{eE}{m_p} \\
 \frac{a_e}{a_p} &= \frac{\left(\frac{eE}{m_e}\right)}{\left(\frac{eE}{m_p}\right)} \\
 &= \frac{m_p}{m_e} \\
 &= 1800.
 \end{aligned}$$

Problem 8



$$\begin{aligned}
 \phi_E &= \frac{Q+Q'}{\epsilon_0} \\
 &= \frac{+1.0\mu\text{C} - 2.0\mu\text{C}}{8.9 \times 10^{-12}} \\
 &= -1.1 \times 10^5 \frac{\text{N}}{\text{C}} \text{ m}^2.
 \end{aligned}$$