Name: KEY

Period: ____
Pre-AP Physics

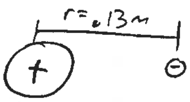
Coulomb's Law Problems

Solve each problem in the space provided. Be sure to show all work and box your answer(s).

$$F_E = \frac{kq_1q_2}{r^2}$$

$$k = 9.00 \times 10^9 \frac{Nm^2}{C^2}$$

1. An electron (with a charge of –1.6 x 10^{-19} Coulombs) is placed 0.13 meters from a small metal sphere that is given a charge of +9.9 x 10^{-4} Coulombs. What is the magnitude of the electric force acting on the charges?



$q_1 = +9.9 \times 10^{-4} C$

$q_2 = -1.6 \times 10^{-19} C$

$$F_E = \frac{kq_1q_2}{r^2} = \frac{(9\times10^9)(9.9\times10^{-4})(1.6\times10^{-19})}{(.13)^2}$$

$$\boxed{F_E = 8.4\times10^{-11} N}$$

2. A charge of +7 µC is placed 150 centimeters away from a charge of +4 µC.
   a. What is the magnitude of the electrostatic force between the charges?

$q_1 = +7\mu C = +7\times10^{-6} C$

$q_2 = +4\mu C = +4\times10^{-6} C$

$r = 150cm = 1.5m$

$$F_E = \frac{kq_1q_2}{r^2} = \frac{(9\times10^9)(7\times10^{-6})(4\times10^{-6})}{(1.5)^2}$$

$$\boxed{F_E = 0.112 N}$$

   b. Is this force attractive or repulsive?

Repulsive Both charges are positive.

3. An electron is placed 1.2 millimeters away from a charged metal block. The block and electron each feel a repulsive force of 7.1 x 10^{-7} Newtons.
   a. What is the net charge on the block?

$r = 1.2mm = 1.2\times10^{-3} m$

$F = 7.1\times10^{-7} N$

$q_1 = -1.6\times10^{-19} C$ (electron)

$q_2 = ?$

$$F_E = \frac{kq_1q_2}{r^2}$$

$$q_2 = \frac{F_E r^2}{kq_1}$$

$$q_2 = \frac{(7.1\times10^{-7})(1.2\times10^{-3})^2}{(9\times10^9)(1.6\times10^{-19})}$$

$$q_2 = \boxed{7.1\times10^{-4} C}$$

   b. Is the metal block positively charged or negatively charged?

Negative The force is repulsive so it must have the same sign as the electron.

4. A charge of -5μC and a charge of +4μC are placed so that they exert a force of 5.5 Newtons on one another. How far apart are the charges?

$q_1 = -5\mu C = -5\times10^{-6} C$

$q_2 = +4\mu C = +4\times10^{-6} C$

$F_E = 5.5 N$

$r = ?$

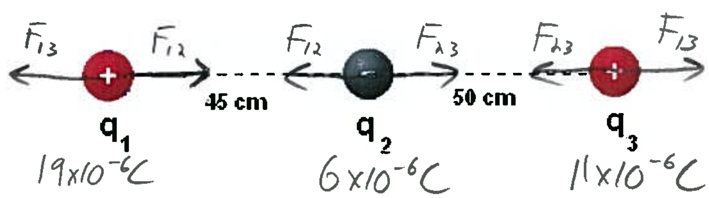
$F_E = \frac{kq_1q_2}{r^2}$

$r = \sqrt{\frac{kq_1q_2}{F_E}}$

$r = \sqrt{\frac{(9\times10^9)(5\times10^{-6})(4\times10^{-6})}{5.5}}$

$\boxed{r = 0.18 m}$

5. Three charges are arranged along a single axis as in the diagram below.
q_1 = +19μC, q_2 = -6μC, and q_3 = +11μC



a. What is the magnitude of the net force on q_1?

$\sum F_1 = F_{12} - F_{13}$

$= \frac{kq_1q_2}{(r_{12})^2} - \frac{kq_1q_3}{(r_{13})^2}$

$= \frac{(9\times10^9)(19\times10^{-6})(6\times10^{-6})}{(.45)^2} - \frac{(9\times10^9)(19\times10^{-6})(11\times10^{-6})}{(.95)^2}$

$\boxed{\sum F_1 = 2.98 N}$

$F_{12} = \frac{kq_1q_2}{(r_{12})^2}$ $\quad r_{12} = 45cm = 0.45m$

$F_{23} = \frac{kq_2q_3}{(r_{23})^2}$ $\quad r_{23} = 50cm = 0.5m$

$F_{13} = \frac{kq_1q_3}{(r_{13})^2}$ $\quad r_{13} = 95cm = 0.95m$

b. What is the magnitude of the net force on q_2?

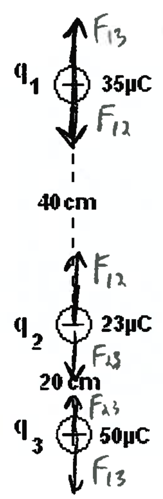
$\sum F_2 = F_{23} - F_{12}$

$= \frac{kq_2q_3}{(r_{23})^2} - \frac{kq_1q_2}{(r_{12})^2}$

$= \frac{(9\times10^9)(6\times10^{-6})(11\times10^{-6})}{(.5)^2} - \frac{(9\times10^9)(19\times10^{-6})(6\times10^{-6})}{(.45)^2} = -2.69$

$\boxed{\sum F_2 = 2.69 N}$

6. Three charges are arranged as shown in the diagram to the right.
What is the magnitude and direction of the net force acting on q_3 from the other charges?



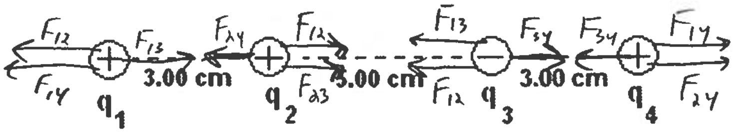
$\sum F_3 = F_{23} - F_{13}$

$= \frac{kq_2q_3}{(r_{23})^2} - \frac{kq_1q_3}{(r_{13})^2}$

$= \frac{(9\times10^9)(23\times10^{-6})(50\times10^{-6})}{(.2)^2} - \frac{(9\times10^9)(35\times10^{-6})(50\times10^{-6})}{(.6)^2}$

$\boxed{\sum F_3 = 215 N, \text{Upwards}}$

7. The diagram below shows four charges arranged along a line.
   $q_1 = 75\mu C$, $q_2 = 180\ \mu C$, $q_3 = 50\ \mu C$, and $q_4 = 250\mu C$



What is the magnitude and direction of the net electrostatic force on q_4?

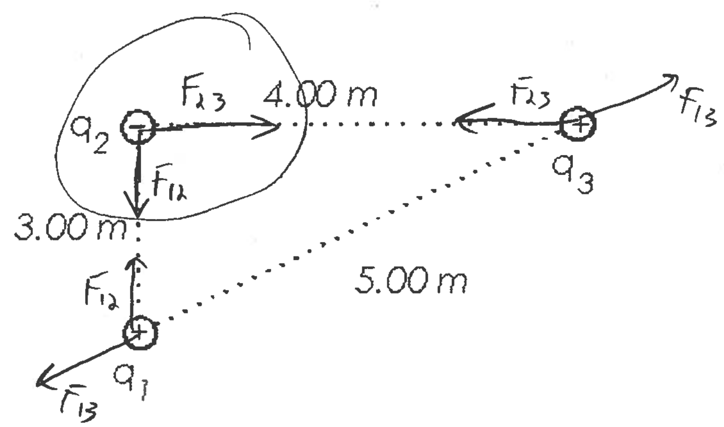
$$\sum F_4 = F_{14} + F_{24} - F_{34}$$

$$= \frac{kq_1q_4}{(r_{14})^2} + \frac{kq_2q_4}{(r_{24})^2} - \frac{kq_3q_4}{(r_{34})^2}$$

$$= \frac{(9\times10^9)(75\times10^{-6})(250\times10^{-6})}{(.11)^2} + \frac{(9\times10^9)(180\times10^{-6})(250\times10^{-6})}{(.08)^2} - \frac{(9\times10^9)(50\times10^{-6})(250\times10^{-6})}{(.03)^2} = -4.8\times10^4$$

$$\boxed{\sum F_4 = 4.8\times10^4 N \text{ to the left}}$$

8. Three charges are arranged to form a right triangle, as in the diagram below. Their charges are $q_1 = 6.00$ C, $q_2 = 2.00$ C, and $q_3 = 5.00$ C. What is the magnitude of the net electric force acting on q_2 from the other charges? (and direction)



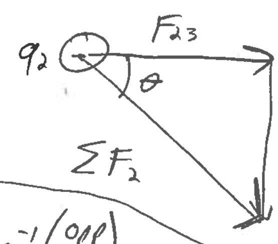
$$\sum F_2 = \sqrt{(F_{12})^2 + (F_{23})^2}$$

$$= \sqrt{(1.2\times10^{10})^2 + (5.625\times10^9)^2}$$

$$= 1.3\times10^{10} N$$

$$F_{12} = \frac{kq_1q_2}{(r_{12})^2} = \frac{(9\times10^9)(6)(2)}{(3)^2} = 1.2\times10^{10} N$$

$$F_{23} = \frac{kq_2q_3}{(r_{23})^2} = \frac{(9\times10^9)(2)(5)}{(4)^2} = 5.625\times10^9 N$$



$$a^2 + b^2 = c^2$$

$$c = \sqrt{a^2 + b^2}$$

$$\sum F_2 = \sqrt{(F_{12})^2 + (F_{23})^2}$$

$$\theta = \tan^{-1}\left(\frac{opp}{adj}\right)$$

$$= \tan^{-1}\left(\frac{F_{12}}{F_{23}}\right)$$

$$= \tan^{-1}\left(\frac{1.2\times10^{10}}{5.625\times10^9}\right)$$

$$\theta = 64.9° \text{ below } +x$$

$$\boxed{\sum F_2 = 1.3\times10^{10} N @ 64.9° \text{ below } +x}$$

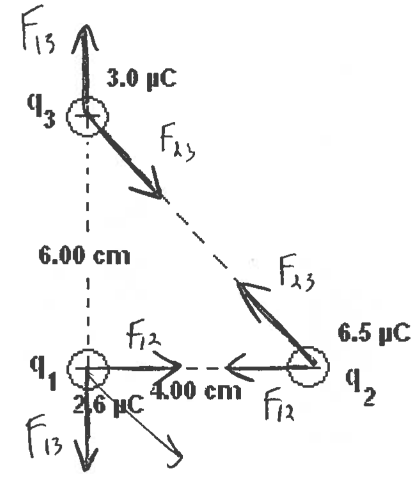
9. Three charges are arranged as shown. What is the magnitude and direction of the force acting on q_1 by the other two charges?

$$\sum F_1 = \sqrt{(F_{12})^2 + (F_{13})^2}$$

$$\sum F_1 = \sqrt{(95)^2 + (19.5)^2} = 97N$$

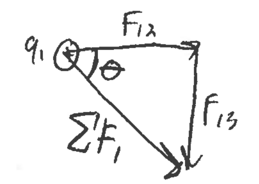
$$F_{12} = \frac{k q_1 q_2}{(r_{12})^2} = \frac{(9\times10^9)(2.6\times10^{-6})(6.5\times10^{-6})}{(.04)^2} = 95N$$

$$F_{13} = \frac{k q_1 q_3}{(r_{13})^2} = \frac{(9\times10^9)(2.6\times10^{-6})(3\times10^{-6})}{(.06)^2} = 19.5N$$



$$\theta = \tan^{-1}\left(\frac{opp}{adj}\right) = \tan^{-1}\left(\frac{F_{13}}{F_{12}}\right) = \tan^{-1}\left(\frac{19.5}{95}\right)$$

$$\theta = 11.6° \text{ below } +x$$



$$\boxed{\sum F_1 = 97N \text{ @ } 11.6° \text{ below } -x}$$

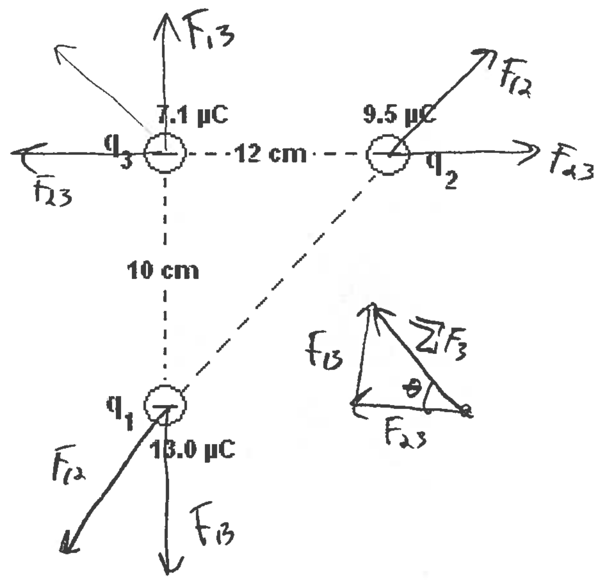
10. Three charges are arranged as shown. What is the magnitude and direction of the force acting on q_3 by the other two charges?

$$\sum F_3 = \sqrt{(F_{23})^2 + (F_{13})^2}$$

$$\sum F_3 = \sqrt{(42.16)^2 + (83.07)^2} = 93.2N$$

$$F_{23} = \frac{k q_2 q_3}{(r_{23})^2} = \frac{(9\times10^9)(9.5\times10^{-6})(7.1\times10^{-6})}{(.12)^2} = 42.16N$$

$$F_{13} = \frac{k q_1 q_3}{(r_{13})^2} = \frac{(9\times10^9)(13\times10^{-6})(7.1\times10^{-6})}{(.1)^2} = 83.07N$$



$$\boxed{\sum F_3 = 93.2N \text{ @ } 63° \text{ above } -x}$$

$$\theta = \tan^{-1}\left(\frac{opp}{adj}\right) = \tan^{-1}\left(\frac{F_{13}}{F_{23}}\right) = \tan^{-1}\left(\frac{83.07}{42.16}\right)$$

$$\theta = 63° \text{ above } -x$$