Physics 1112 – Quiz 2

Three charged particles are arranged on the line as shown below. Calculate the total electric force on particle 3 (the $-4.00 \, \mu\text{C}$ on the right) due to the other two charges.

\[
\begin{align*}
F_{13} &= k \frac{|Q_1||Q_3|}{r_{13}^2} = (8.99 \times 10^9 \, \text{Nm}^2/\text{C}^2)(8.00 \times 10^{-6}\, \text{C})(4.00 \times 10^{-6}\, \text{C})/(0.500 \, \text{m})^2 = 1.15 \, \text{N} \text{ to the right} \\
F_{23} &= k \frac{|Q_2||Q_3|}{r_{23}^2} = (8.99 \times 10^9 \, \text{Nm}^2/\text{C}^2)(3.00 \times 10^{-6}\, \text{C})(4.00 \times 10^{-6}\, \text{C})/(0.200 \, \text{m})^2 = 2.70 \, \text{N} \text{ to the left} \\
F_3 &= F_{13} + F_{23} = 1.15 \, \text{N} - 2.70 \, \text{N} = -1.55 \, \text{N}
\end{align*}
\]
1. Particles of charge 50.0 mC, -60.0 mC and 70.0 mC are placed in a line as shown below. The center one is 0.500 m from each of the others. Calculate the net force acting on the central charge due to the other two.

\[ q_1 = +50.0 \times 10^{-3} \text{ C} \]
\[ q_2 = -60.0 \times 10^{-3} \text{ C} \]
\[ q_3 = +70.0 \times 10^{-3} \text{ C} \]

\[ F_{12} = k \frac{|q_1||q_2|}{r_{12}^2} = (8.99 \times 10^9 \text{ N-m}^2/\text{C}^2) \frac{(50.0 \times 10^{-3} \text{ C})(60.0 \times 10^{-3} \text{ C})}{(0.500 \text{ m})^2} = 1.08 \times 10^8 \text{ N, to the left} \]

\[ F_{32} = k \frac{|q_2||q_3|}{r_{23}^2} = (8.99 \times 10^9 \text{ N-m}^2/\text{C}^2) \frac{(60.0 \times 10^{-6} \text{ C})(70.0 \times 10^{-6} \text{ C})}{(0.500 \text{ m})^2} = 1.51 \times 10^8 \text{ N, to the right} \]

\[ F_{\text{tot}} = F_{12} + F_{32} = -1.08 \times 10^8 \text{ N} + 1.51 \times 10^8 \text{ N} = 4.30 \times 10^7 \text{ N (to the right)} \]
A charge of 6.00 mC is placed at each corner of a square 0.100 m on a side. Determine the magnitude and direction of the force on charge \(q_2\).

\[
F_{12} = k \frac{q_1 q_2 / r_{12}^2}{2} = (8.99 \times 10^9 \text{ N-m}^2/\text{C}^2) \frac{(6.00 \times 10^{-3} \text{ C})(6.00 \times 10^{-3} \text{ C})}{(0.100 \text{ m})^2} = 3.24 \times 10^7 \text{ N}, \text{ to the right}
\]

\[
F_{32} = k \frac{q_3 q_2 / r_{32}^2}{2} = (8.99 \times 10^9 \text{ N-m}^2/\text{C}^2) \frac{(6.00 \times 10^{-3} \text{ C})(6.00 \times 10^{-3} \text{ C})}{(0.100 \text{ m})^2} = 3.24 \times 10^7 \text{ N}, \text{ upward}
\]

\[
F_{42} = k \frac{q_4 q_2 / r_{42}^2}{2} = (8.99 \times 10^9 \text{ N-m}^2/\text{C}^2) \frac{(6.00 \times 10^{-3} \text{ C})(6.00 \times 10^{-3} \text{ C})}{(0.141 \text{ m})^2} = 1.62 \times 10^7 \text{ N}, \text{ at 45° with the positive x-axis}
\]

\[
F_{12x} = F_{12} \cos(0) = 3.24 \times 10^7 \text{ N}
\]

\[
F_{12y} = F_{12} \sin(0) = 0
\]

\[
F_{32x} = F_{32} \cos(90°) = 0
\]

\[
F_{32y} = F_{32} \sin(90°) = 3.24 \times 10^7 \text{ N}
\]

\[
F_{42x} = F_{42} \cos(180°) = 1.14 \times 10^7 \text{ N}
\]

\[
F_{42y} = F_{42} \sin(180°) = 1.14 \times 10^7 \text{ N}
\]

\[
F_{\text{totx}} = F_{12x} + F_{32x} + F_{42x} = 4.38 \times 10^7 \text{ N}
\]

\[
F_{\text{toty}} = F_{12y} + F_{32y} + F_{42y} = 4.38 \times 10^7 \text{ N}
\]

\[
F_{\text{tot}} = (F_{\text{totx}}^2 + F_{\text{toty}}^2)^{1/2} = 6.20 \times 10^7 \text{ N}
\]
\[ \theta = \tan^{-1}\left( \frac{F_{\text{toty}}}{F_{\text{totx}}} \right) = 45^\circ \]

Name ___SOLUTION_______________________________

1. Particles of charge \( +75, +48, \) and \( -85 \, \mu\text{C} \) are placed in a line as shown below. The center one is 0.350 m from each of the others. Find the electric force on the +75 \( \mu\text{C} \) charge. Do not forget to specify magnitude and direction.

\[ q_1 = +75.0 \times 10^{-6} \, \text{C} \]
\[ q_2 = +48.0 \times 10^{-6} \, \text{C} \]
\[ q_3 = -85.0 \times 10^{-6} \, \text{C} \]

\[ F_{21} = k \frac{|q_1||q_2|}{r_1^2} = \left(8.99 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2\right) \left(75.0 \times 10^{-6} \, \text{C}\right) \left(48.0 \times 10^{-6} \, \text{C}\right) / (0.350 \, \text{m})^2 = 264 \, \text{N}, \text{ to the left} \]

\[ F_{31} = k \frac{|q_1||q_3|}{r_2^2} = \left(8.99 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2\right) \left(48.0 \times 10^{-6} \, \text{C}\right) \left(85.0 \times 10^{-6} \, \text{C}\right) / (0.700 \, \text{m})^2 = 117 \, \text{N}, \text{ to the right} \]

\[ F_{\text{tot}} = F_{21} + F_{31} = -264 \, \text{N} + 117 \, \text{N} = -147 \, \text{N} \text{ (to the left)} \]
1. Particles of charge 50.0 mC, -60.0 mC and 70.0 mC are placed in a line as shown below. The center one is 0.500 m from each of the others. Calculate the net electric field due to the charges 0.500 m to the right from third charge.

\[ q_1 = +50.0 \times 10^{-3} \text{ C} \]
\[ q_2 = -60.0 \times 10^{-3} \text{ C} \]
\[ q_3 = +70.0 \times 10^{-3} \text{ C} \]

\[ E_1 = k \frac{|q_1|}{r_1^2} = (8.99 \times 10^9 \text{ N-m}^2/\text{C}^2) \frac{(50.0 \times 10^{-3} \text{ C})}{(1.50 \text{ m})^2} = 2.00 \times 10^8 \text{ N/C}, \text{ to the right} \]
\[ E_2 = k \frac{|q_2|}{r_2^2} = (8.99 \times 10^9 \text{ N-m}^2/\text{C}^2) \frac{(60.0 \times 10^{-3} \text{ C})}{(1.00 \text{ m})^2} = 5.39 \times 10^8 \text{ N/C}, \text{ to the left} \]
\[ E_3 = k \frac{|q_3|}{r_3^2} = (8.99 \times 10^9 \text{ N-m}^2/\text{C}^2) \frac{(70.0 \times 10^{-3} \text{ C})}{(0.500 \text{ m})^2} = 25.2 \times 10^8 \text{ N/C}, \text{ to the right} \]

\[ E_{\text{tot}} = E_1 + E_2 + E_3 = 2.00 \times 10^8 \text{ N/C} - 5.39 \times 10^8 \text{ N/C} + 25.2 \times 10^8 \text{ N/C} = 2.18 \times 10^9 \text{ N/C} (\text{to the right}) \]
1. Particles of charge $+75 \mu C$, $+48 \mu C$, and $-85 \mu C$ are placed in a line as shown below. The center one is 0.350 m from each of the others. Calculate the net forces acting on two end charge due to the other two.

$q_1 = +75.0 \times 10^{-6} \text{ C}$

$q_2 = +48.0 \times 10^{-6} \text{ C}$

$q_3 = -85.0 \times 10^{-6} \text{ C}$

$F_{21} = k \frac{|q_2||q_1|}{r_{21}^2} = \left(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2\right) \left(48.0 \times 10^{-6} \text{ C}\right) \left(75.0 \times 10^{-6} \text{ C}\right) / (0.350 \text{ m})^2 = 264 \text{ N},$ to the left

$F_{31} = k \frac{|q_3||q_1|}{r_{31}^2} = \left(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2\right) \left(85.0 \times 10^{-6} \text{ C}\right) \left(75.0 \times 10^{-6} \text{ C}\right) / (0.700 \text{ m})^2 = 117 \text{ N},$ to the right

$F_1 = F_{31} + F_{21} = 117 \text{ N} - 264 \text{ N} = -147 \text{ N (to the left)}$

$F_{23} = k \frac{|q_2||q_3|}{r_{23}^2} = \left(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2\right) \left(48.0 \times 10^{-6} \text{ C}\right) \left(85.0 \times 10^{-6} \text{ C}\right) / (0.350 \text{ m})^2 = 299 \text{ N},$ to the left

$F_{13} = k \frac{|q_1||q_3|}{r_{13}^2} = \left(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2\right) \left(85.0 \times 10^{-6} \text{ C}\right) \left(75.0 \times 10^{-6} \text{ C}\right) / (0.700 \text{ m})^2 = 117 \text{ N},$ to the left

$F_3 = F_{13} + F_{23} = -117 \text{ N} - 299 \text{ N} = -416 \text{ N (to the left)}$
Name  _____SOLUTION________________________________

1. Particles of charge – 25.0, + 47.0 and – 65.0 μC are placed in a line as shown below. The center one is 0.550 m from each of the others. Find the electric force on the +47.0 μC charge. Do not forget to specify magnitude and direction.

\[ q_1 = -25.0 \times 10^{-6} \text{ C} \]
\[ q_2 = +47.0 \times 10^{-6} \text{ C} \]
\[ q_3 = -65.0 \times 10^{-6} \text{ C} \]

\[ F_{12} = k \frac{|q_1||q_2|}{r_{12}^2} = \frac{(8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2)(25.0 \times 10^{-6} \text{ C})(47.0 \times 10^{-6} \text{ C})}{(0.550 \text{ m})^2} = 34.9 \text{ N}, \] to the left

\[ F_{32} = k \frac{|q_2||q_3|}{r_{23}^2} = \frac{(8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2)(47.0 \times 10^{-6} \text{ C})(65.0 \times 10^{-6} \text{ C})}{(0.550 \text{ m})^2} = 90.8 \text{ N}, \] to the right

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Physics 1112 – Quiz 2

Name  _____SOLUTION________________________________

1. Particles of charge -20.0 μC, +35.0 μC and - 56.0 μC are placed in a line as shown below. The center one is 0.500 m from each of the others. Calculate the net electric field due to the charges 0.500 m to the right from third charge.
\( q_1 = -20.0 \times 10^{-6} \text{ C} \)

\( q_2 = +35.0 \times 10^{-6} \text{ C} \)

\( q_3 = -56.0 \times 10^{-6} \text{ C} \)

\[ E_1 = k \frac{|q_1|}{r_1^2} = (8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{(20.0 \times 10^{-6} \text{ C})}{(1.50 \text{ m})^2} = 0.799 \times 10^5 \text{ N/C}, \text{ to the left} \]

\[ E_2 = k \frac{|q_2|}{r_2^2} = (8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{(35.0 \times 10^{-6} \text{ C})}{(1.00 \text{ m})^2} = 3.14 \times 10^5 \text{ N/C}, \text{ to the right} \]

\[ E_3 = k \frac{|q_3|}{r_3^2} = (8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{(56.0 \times 10^{-6} \text{ C})}{(0.500 \text{ m})^2} = 20.1 \times 10^5 \text{ N/C}, \text{ to the left} \]

\[ E_{\text{tot}} = E_1 + E_2 + E_3 = -0.799 \times 10^5 \text{ N/C} + 3.14 \times 10^5 \text{ N/C} - 20.1 \times 10^5 \text{ N/C} = -1.78 \times 10^6 \text{ N/C} \](Net electric field points to the left.)