In the figure the particles have charges $q_1 = -q_2 = -100 \, \mu C$ and $q_3 = q_4 = 200 \, \mu C$, and distance $a = 10$ cm. What are the magnitude and direction of the net electrostatic force on particle 3 due to particles 1, 2, and 4?

\[ F_{31} = \frac{1}{4\pi\varepsilon_0} \frac{|q_1| |q_3|}{a^2} = \frac{9 \times 10^9 \times 2 \times 10^{-8}}{(0.1)^2} = 18,000 \, N \]

\[ F_{32} = \frac{1}{4\pi\varepsilon_0} \frac{|q_2| |q_2|}{2a^2} = \frac{9 \times 10^9 \times 2 \times 10^{-3}}{2(0.1)^2} = 9,000 \, N \]

\[ F_{34} = \frac{1}{4\pi\varepsilon_0} \frac{|q_3| |q_4|}{a^2} = \frac{9 \times 10^9 \times 4 \times 10^{-3}}{(0.1)^2} = 36,000 \, N \]

\[ F_{x_{net}} = -F_{34} \cos 45^\circ = -36,000 \, N - 9,000 \frac{\sqrt{2}}{2} = -42,364 \, N \]

\[ F_{y_{net}} = F_{31} - F_{32} \sin 45^\circ = 18,000 - 9,000 \frac{\sqrt{2}}{2} = 11,636 \, N \]

\[ \mathbf{F_{net}} = -42,364 \hat{i} + 11,636 \hat{j} \, (N) \]

Magnitude \quad \text{direction} \quad \theta = \tan^{-1} \left( -\frac{11,636}{42,364} \right) = -15.4^\circ

\[ F_{net} \quad -15.4^\circ \quad 164.6^\circ \]
In the figure, five charged particles surround particle 7. The charges are $q_2 = +4e$, $q_3 = +e$, $q_4 = +4e$, $q_5 = +2e$, $q_6 = +8e$, $q_7 = +3e$, with $e = 1.60 \times 10^{-19}$ C. What is the net electrostatic force on particle 7 if $d = 1.0 \mu$m?

\[
\vec{F}_{net} = \vec{F}_{76} + \vec{F}_{75} - \vec{F}_{72} = \frac{k(3e)(8e)}{4d^2} - \frac{k(3e)(2e)}{d^2} - \frac{k(3e)(4e)}{d^2}
\]

\[
= \frac{k(12e)}{d^2} - \frac{k(12e)}{d^2} = 0
\]

\[
\vec{F}_{net} = -\vec{F}_{74} - \vec{F}_{73} = -\frac{k(3e)(4e)}{4d^2} - \frac{k(3e)(e)}{d^2} - \frac{k(6e^2)}{d^2}
\]

\[
= -1.38 \times 10^{-15} \text{ N}
\]

\[
\vec{F}_{net} = -1.38 \times 10^{-15} \hat{i} + 0 \hat{j} \text{ (N)}
\]
In the figure, particle 1 of charge $q_1 = +5.0 \mu C$ and particle 2 of charge $q_2 = -3.0 \mu C$ are held at separation $L = 30.0 \text{ cm}$ on an $x$ axis. If particle 3 of unknown charge $q_3$ is to be located such that the net electrostatic force on it from particles 1 and 2 is zero, what must be the (a) $x$ and (b) $y$ coordinates of particle 3?

1. **x-coordinate calculation**

   The net force is zero, so $F_{31} - F_{32} = 0$.

   
   \[
   F_{31} = \frac{kq_1q_3}{(x-L)^2} \\
   F_{32} = \frac{kq_2q_3}{x^2}
   \]

   
   \[
   \Rightarrow \frac{kq_1q_3}{(x-L)^2} = \frac{kq_2q_3}{x^2}
   \]

   
   \[
   \frac{3 \times 10^{-6}}{(x-L)^2} = \frac{5 \times 10^{-6}}{x^2}
   \]

   
   \[
   3 \times x^2 = 5 \times (x-L)^2
   \]

   
   \[
   x = \frac{\sqrt{5} \times (x-L)}{\sqrt{3}}
   \]

   
   \[
   x(\sqrt{5} - \sqrt{3}) = \sqrt{5}L \Rightarrow x = 4.4L
   \]

   

2. **y-coordinate calculation**

   $y = 0$; the charge should be on the $x$-axis.