21-16. Apply Coulombs law and find the vector sum of the two forces on q_1. $\vec{\mathbf{F}}_{2\text{on}1}$is in the $+y$-direction; $\vec{\mathbf{F}}_{Q\text{on}1}$is at an angle $(180° - \alpha)$ relative to the $+x$-direction. We will need to do vector addition—knowing how to use your vector-capable calculator will make this easier. Begin by finding force magnitudes using Coulomb's law; notice that "r" for $\vec{\mathbf{F}}_{2\text{on}1}$ is .6 m whereas "r" for $\vec{\mathbf{F}}_{Q\text{on}1}$ is .5 m.

$$F_{2\text{on}1} = k\frac{|q_1||q_2|}{r^2} = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \; \frac{2 \times 10^{-6} \text{ C} \cdot 2 \times 10^{-6} \text{ C}}{(0.6 \text{ m})^2} = .0999 \text{ N}$$

$$F_{Q\text{on}1} = k\frac{|q_1||Q|}{r^2} = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \; \frac{2 \times 10^{-6} \text{ C} \cdot 4 \times 10^{-6} \text{ C}}{(0.5 \text{ m})^2} = .288 \text{ N}$$

Now $\alpha = \arctan(.3/.4) = 36.9°$, so using a vector-capable calculator we immediately have:

$$\vec{\mathbf{F}}_{Q\text{on}1} = (-.230, .173) \text{ N}$$

and of course:

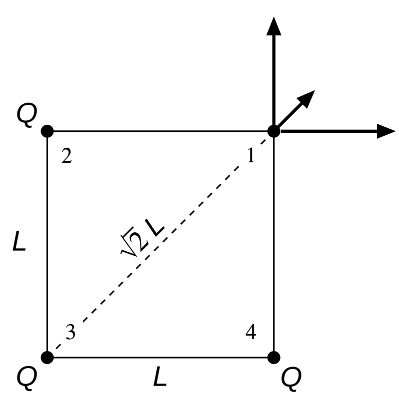
$$\vec{\mathbf{F}}_{2\text{on}1} = (0, .0999) \text{ N}$$

so

$$\vec{\mathbf{F}}_{Q\text{on}1} + \vec{\mathbf{F}}_{2\text{on}1} = (-.230, .273) \text{ N}$$

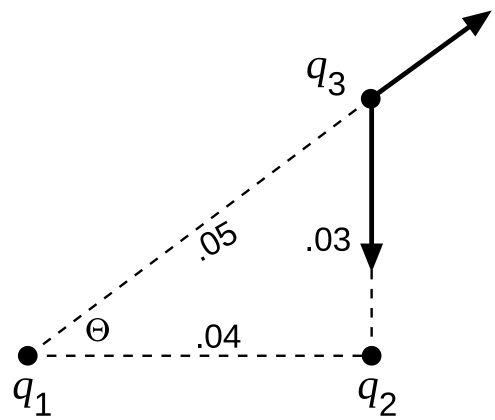
which (again using your vector-capable calculator) has magnitude/angle: .357 N$\angle$130°. (FYI: Angles reported without comment are assumed to be counter-clockwise from the $+x$-axis. Note that if you applied the "usual" formula: $\theta = \arctan(F_y/F_x)$ you would have produced the incorrect answer because of the quadrant problem discussed on p.19 of the textbook—a vector-capable calculator knows and corrects for this situation.)

21-23. Apply Coulombs law to calculate the force exerted on one of the charges by each of the other three and then add these forces as vectors. The charges are placed as shown; the arrows denote the force on #1 due to the charges #2, #3, and #4.



Clearly $F_{2\text{on}1}$ and $F_{4\text{on}1}$ have the same magnitude: kQ^2/L^2 but directions of $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$ respectively. These two forces will combine to form a vector along the diagonal with magnitude $\sqrt{2}\, kQ^2/L^2$. $\vec{\mathbf{F}}_{3\text{on}1}$ is also along the diagonal with "r" of $\sqrt{2}L$, and hence a magnitude of $\frac{1}{2}\, kQ^2/L^2$. If we combine all three vectors, clearly the result will point along the diagonal with magnitude: $(\sqrt{2} + \frac{1}{2})\, kQ^2/L^2$

21-72. Note that q_3 lies .03 m directly above q_2 and that there will be an attractive force between these two, whereas q_3 lies .05 m from q_1 at an angle $\theta = \arctan(.03/.04) = 36.9°$ and there will be a repulsive force between these two.



The force magnitudes can be found from Coulomb's law:

$$F_{1on3} = k\frac{|q_1||q_3|}{r^2} = 8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2\ \frac{5\times10^{-9}\ \text{C}\ \cdot 6\times10^{-9}\ \text{C}}{(0.05\ \text{m})^2} = 1.08\times10^{-4}\ \text{N}$$

$$F_{2on3} = k\frac{|q_2||q_3|}{r^2} = 8.99\times10^9\ \text{N}\cdot\text{m}^2/\text{C}^2\ \frac{2\times10^{-9}\ \text{C}\ \cdot 6\times10^{-9}\ \text{C}}{(0.03\ \text{m})^2} = 1.20\times10^{-4}\ \text{N}$$

Now $\theta = 36.9°$, so using a vector-capable calculator we immediately have:

$$\vec{\mathbf{F}}_{1on3} = (8.63, 6.47)\ \times 10^{-5}\ \text{N}$$

and of course:

$$\vec{\mathbf{F}}_{2on3} = (0, -12.0)\times10^{-5}\ \text{N}$$

so

$$\vec{\mathbf{F}}_{1on3} + \vec{\mathbf{F}}_{2on3} = (8.63, -5.51)\times10^{-5}\ \text{N}$$

which (again using your vector-capable calculator) has magnitude/angle:
$10.2\times10^{-5}\ \text{N}\angle-32.6°$.