3. Since the magnitude of the electric field produced by a point charge $q$ is given by $E = \frac{|q|}{4\pi\varepsilon_0 r^2}$, where $r$ is the distance from the charge to the point where the field has magnitude $E$, the magnitude of the charge is

$$|q| = 4\pi\varepsilon_0 r^2 E = \frac{(0.50\text{ m})^2 (2.0 \text{ N/C})}{8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2} = 5.6 \times 10^{-11} \text{ C.}$$

6. With $x_1 = 6.00 \text{ cm}$ and $x_2 = 21.00 \text{ cm}$, the point midway between the two charges is located at $x = 13.5 \text{ cm}$. The values of the charge are $q_1 = -q_2 = -2.00 \times 10^{-7} \text{ C}$, and the magnitudes and directions of the individual fields are given by:

$$\vec{E}_1 = -\frac{|q_1|}{4\pi\varepsilon_0 (x-x_1)^2} \hat{i} = -\frac{(8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2)(-2.00 \times 10^{-7} \text{ C})}{(0.135 \text{ m} - 0.060 \text{ m})^2} \hat{i} = (3.196 \times 10^5 \text{ N/C}) \hat{i},$$

$$\vec{E}_2 = -\frac{q_2}{4\pi\varepsilon_0 (x-x_2)^2} \hat{i} = \frac{(8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2)(2.00 \times 10^{-7} \text{ C})}{(0.135 \text{ m} - 0.210 \text{ m})^2} \hat{i} = (3.196 \times 10^5 \text{ N/C}) \hat{i}.$$ 

Thus, the net electric field is

$$\vec{E}_{\text{net}} = \vec{E}_1 + \vec{E}_2 = -(6.39 \times 10^5 \text{ N/C}) \hat{i}.$$ 

11. (a) The vertical components of the individual fields (due to the two charges) cancel, by symmetry. Using $d = 3.00 \text{ m}$ and $y = 4.00 \text{ m}$, the horizontal components (both pointing to the $-x$ direction) add to give a magnitude of

$$E_{x,\text{net}} = \frac{2 |q| d}{4\pi\varepsilon_0 (d^2 - y^2)^{3/2}} = \frac{2(8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2)(3.20 \times 10^{-19} \text{ C})(3.00 \text{ m})}{[(3.00 \text{ m})^2 + (4.00 \text{ m})^2]^{3/2}} = 1.38 \times 10^{-10} \text{ N/C}.$$ 

(b) The net electric field points in the $-x$ direction, or $180^\circ$ counterclockwise from the $+x$ axis.

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(b) The net electric field points in the $-x$ direction, or $180^\circ$ counterclockwise from the $+x$ axis.
14. The field of each charge has magnitude

\[ E = \frac{ke}{r^2} = \frac{e}{(0.020 \text{ m})^2} \left[ (8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \times 1.60 \times 10^{-19} \text{ C} \right] / (0.020 \text{ m})^2 = 3.6 \times 10^{-5} \text{ N/C}. \]

The directions are indicated in standard format below. We use the magnitude-angle notation (convenient if one is using a vector-capable calculator in polar mode) and write (starting with the proton on the left and moving around clockwise) the contributions to \( \vec{E}_{\text{net}} \) as follows:

\[ (E \angle -20^\circ) + (E \angle 130^\circ) + (E \angle -100^\circ) + (E \angle -150^\circ) + (E \angle 0^\circ). \]

This yields \( 3.93 \times 10^{-6} \angle -76.4^\circ \), with the N/C unit understood.

(a) The result above shows that the magnitude of the net electric field is

\[ |\vec{E}_{\text{net}}| = 3.93 \times 10^{-6} \text{ N/C}. \]

(b) Similarly, the direction of \( \vec{E}_{\text{net}} \) is \(-76.4^\circ\) from the x axis.