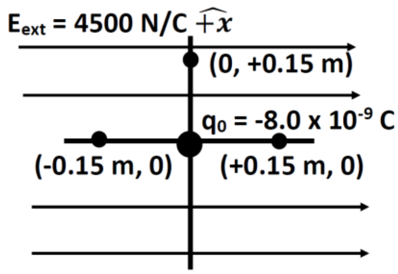
18. A uniform electric field exists everywhere in the *x*, *y* plane. This electric field has a magnitude of 4500 N/C and is directed in the positive *x* direction. A point charge -8.0 x 10^{-9} C is placed at the origin. Determine the magnitude of the net electric field at **(a)** *x* = -0.15 m, **(b)** *x* = +0.15 m, and **(c)** *y* = +0.15 m.



The net electric field is the vector sum of the electric field external and the electric field created by the charge at the origin.

(a) (-0.15m, 0)

$$\overrightarrow{E_{Net\to a}} = \overrightarrow{E_{ext}} + \overrightarrow{E_{0\to a}}$$

$$\overrightarrow{E_{ext}} = 4500\ {}^{N}/_{C}\ \widehat{+x} = 4.50\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{+x}$$

$$\overrightarrow{E_{0\to a}} = k\frac{q_0}{r_a^2}\widehat{+x} = \left(8.99\ x\ 10^{9}\ {}^{Nm^2}/_{C^2}\right)\frac{(8.00\ x\ 10^{-9}C)}{(0.150\ m)^2}\widehat{+x} = 3.196\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{+x}$$

$\widehat{+x}$ **direction is due to charge at origin** q_0 **is negative**

$$\overrightarrow{E_{Net\to a}} = \overrightarrow{E_{ext}} + \overrightarrow{E_{0\to a}} = 4.50\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{+x} + 3.196\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{+x}$$

$$\overrightarrow{E_{Net\to a}} = 7.696\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{+x} = 7700\ {}^{N}/_{C}\ \widehat{+x}$$

(b) (0.15m, 0)

$$\overrightarrow{E_{Net\to b}} = \overrightarrow{E_{ext}} + \overrightarrow{E_{0\to b}}$$

$$\overrightarrow{E_{ext}} = 4500\ {}^{N}/_{C}\ \widehat{+x} = 4.50\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{+x}$$

$$\overrightarrow{E_{0\to b}} = k\frac{q_0}{r_b^2}\widehat{-x} = \left(8.99\ x\ 10^{9}\ {}^{Nm^2}/_{C^2}\right)\frac{(8.00\ x\ 10^{-9}C)}{(0.150\ m)^2}\widehat{-x} = 3.196\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{-x}$$

$\widehat{-x}$ **direction is due to charge at origin** q_0 **is negative**

$$\overrightarrow{E_{Net\to b}} = \overrightarrow{E_{ext}} + \overrightarrow{E_{0\to b}} = 4.50\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{+x} + 3.196\ x\ 10^{3}\ {}^{N}/_{C}\ \widehat{-x}$$

$$\overrightarrow{E_{Net\to b}} = 4.50\ x\ 10^3\ {}^{N}/_{C}\ \widehat{+x} + 3.196\ x\ 10^3\ {}^{N}/_{C}\ \widehat{-x}$$
$$= 4.50\ x\ 10^3\ {}^{N}/_{C}\ \widehat{+x} - 3.196\ x\ 10^3\ {}^{N}/_{C}\ \widehat{+x}$$

$$\overrightarrow{E_{Net\to b}} = 1.304\ x\ 10^3\ {}^{N}/_{C}\ \widehat{+x} = 1300\ {}^{N}/_{C}\ \widehat{+x}$$

(c) (0, 0.15m)

$$\overrightarrow{E_{Net\to c}} = \overrightarrow{E_{ext}} + \overrightarrow{E_{0\to c}}$$

$$\overrightarrow{E_{ext}} = 4500\ {}^{N}/_{C}\ \widehat{+x} = 4.50\ x\ 10^3\ {}^{N}/_{C}\ \widehat{+x}$$

$$\overrightarrow{E_{0\to c}} = k\frac{q_0}{r_c^2}\widehat{-y} = \left(8.99\ x\ 10^9\ {}^{Nm^2}/_{C^2}\right)\frac{(8.00\ x\ 10^{-9}C)}{(0.150\ m)^2}\widehat{-y} = 3.196\ x\ 10^3\ {}^{N}/_{C}\ \widehat{-y}$$

$\widehat{-y}$ direction is due to charge at origin q_0 is negative

$$\overrightarrow{E_{Net\to c}} = \overrightarrow{E_{ext}} + \overrightarrow{E_{0\to b}} = 4.50\ x\ 10^3\ {}^{N}/_{C}\ \widehat{+x} + 3.196\ x\ 10^3\ {}^{N}/_{C}\ \widehat{-y}$$

This time we need to use Pythagorean theorem.

$$\left|\overrightarrow{E_{Net\to c}}\right| = \sqrt{\left(4.50\ x\ 10^3\ {}^{N}/_{C}\right)^2 + \left(3.196\ x\ 10^3\ {}^{N}/_{C}\right)^2} = 5.519\ x\ 10^3\ {}^{N}/_{C}$$

$$\theta = \tan^{-1}\left(\frac{3.196\ x\ 10^3\ {}^{N}/_{C}}{4.50\ x\ 10^3\ {}^{N}/_{C}}\right) = \tan^{-1}(0.7102) = 35.38°$$

$$\overrightarrow{E_{Net\to c}} = 5500\ {}^{N}/_{C}\ @\ 35.4°\ below\ \widehat{+x}$$

$$\overrightarrow{E_{Net\to a}} = 7700\ {}^{N}/_{C}\ \widehat{+x}$$
$$\overrightarrow{E_{Net\to b}} = 1300\ {}^{N}/_{C}\ \widehat{+x}$$
$$\overrightarrow{E_{Net\to c}} = 5500\ {}^{N}/_{C}\ @\ 35.4°\ below\ \widehat{+x}$$

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This page last updated on January 7, 2021