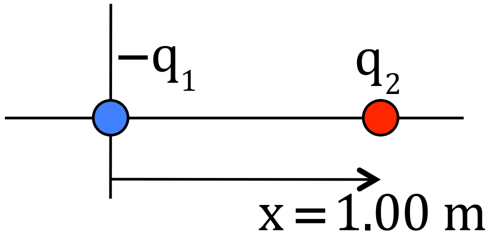
Problem 23.21



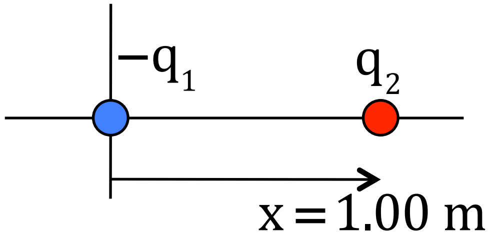
At what coordinate is the electric field zero?

I guess the first thing to notice is that the book didn't include a coordinate axis. I've put one in because it makes it easier to define distances. As usual, I will use

$$E = k\frac{q_1 q_2}{r^2}$$

to determine electric field magnitude, which means I'll use the charge *magnitudes* in the equation and let their positive or negitiveness govern whether the electric field at a particular point is in the +x or –x direction. Using our heads and noting that the magnitude of q_2 is larger than q_1, we can say:

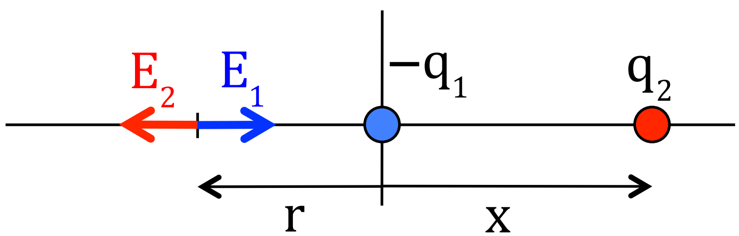
For $x > 1$: q_1 will produce an E. fld. to the left (a positive test charge would be attracted to that negative charge, so that's the direction of the E. fld there) while q_2 produces one to the right, but because q_2 is both closer and larger in magnitude, the two fields will never add to zero. Bottom line: This region will never have a net field equal to zero.



For between the charges: q_1 will produce an E. fld. to the left, but so also will q_2, so you will never have a net field equal to zero in that region.

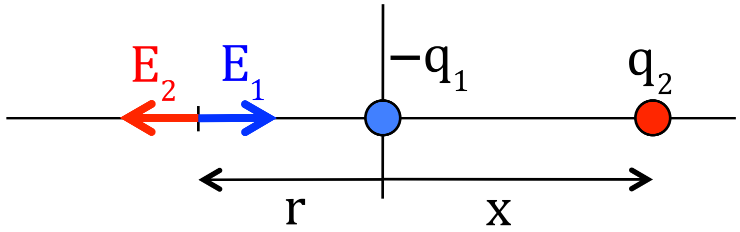
For $x < 1$: q_1 will produce an E. fld. to the right while q_2 will produce one to the left. Because q_1 is smaller in magnitude but closer to the point in question, there will be a point where the two fields will vectorially add to zero.

For the math, assuming that point is at "r":



$$\begin{aligned} E_{net} &= E_2 - E_1 \\ &= \left(k\frac{q_2}{(x+r)^2}\right) - \left(k\frac{q_1}{x^2}\right) \\ &= 0 \end{aligned}$$

Solving this, we get:



$$E_{net} = E_2 - E_1$$
$$= \left(k\frac{q_2}{(x+r)^2}\right) - \left(k\frac{q_1}{x^2}\right)$$
$$= 0$$

$$\Rightarrow \quad q_2 x^2 = q_1 (x+r)^2$$

$$\Rightarrow \quad \frac{q_2}{q_1} x^2 = (x+r)^2$$

$$\Rightarrow \quad \sqrt{\frac{q_2}{q_1}}\, x = (x+r)$$

$$\Rightarrow \quad \sqrt{\frac{6.00\text{x}10^{-6}\ \text{C}}{2.50\text{x}10^{-6}\ \text{C}}}(1.00\ \text{m}) = (1.00\ \text{m}) + r$$

$$\Rightarrow \quad r = .55\ \text{m} \qquad \text{(to the left of the origin, as "r" is defined)}$$

BIG NOTE: E_1 was not negative because it's field-producing charge was negative. It was negative because q_1 produced an electric field at that point that was in the negative direction. If q_1 had been to the left of the point, the electric field it produced would have been in the POSITIVE direction and it's E would have been positive!