

10. The individual magnitudes  $|\vec{E}_1|$  and  $|\vec{E}_2|$  are figured from Eq. 23-3, where the absolute value signs for  $q_2$  are unnecessary since this charge is positive. Whether we add the magnitudes or subtract them depends on if  $\vec{E}_1$  is in the same, or opposite, direction as  $\vec{E}_2$ . At points left of  $q_1$  (on the  $-x$  axis) the fields point in opposite directions, but there is no possibility of cancellation (zero net field) since  $|\vec{E}_1|$  is everywhere bigger than  $|\vec{E}_2|$  in this region. In the region between the charges ( $0 < x < d$ ) both fields point leftward and there is no possibility of cancellation. At points to the right of  $q_2$  (where  $x > d$ ),  $\vec{E}_1$  points leftward and  $\vec{E}_2$  points rightward so the net field in this range is

$$\vec{E}_{\text{net}} = |\vec{E}_2| - |\vec{E}_1| \quad \text{in the } \hat{i} \text{ direction.}$$

Although  $|q_1| > q_2$  there is the possibility of  $\vec{E}_{\text{net}} = 0$  since these points are closer to  $q_2$  than to  $q_1$ . Thus, we look for the zero net field point in the  $x > d$  region:

$$\begin{aligned} |\vec{E}_1| &= |\vec{E}_2| \\ \frac{1}{4\pi\epsilon_0} \frac{|q_1|}{x^2} &= \frac{1}{4\pi\epsilon_0} \frac{q_2}{(x-d)^2} \end{aligned}$$

which leads to

$$\frac{x-d}{x} = \sqrt{\frac{q_2}{|q_1|}} = \sqrt{\frac{2}{5}} \quad .$$

Thus, we obtain  $x = \frac{d}{1-\sqrt{2/5}} \approx 2.7d$ . A sketch of the field lines is shown below.

