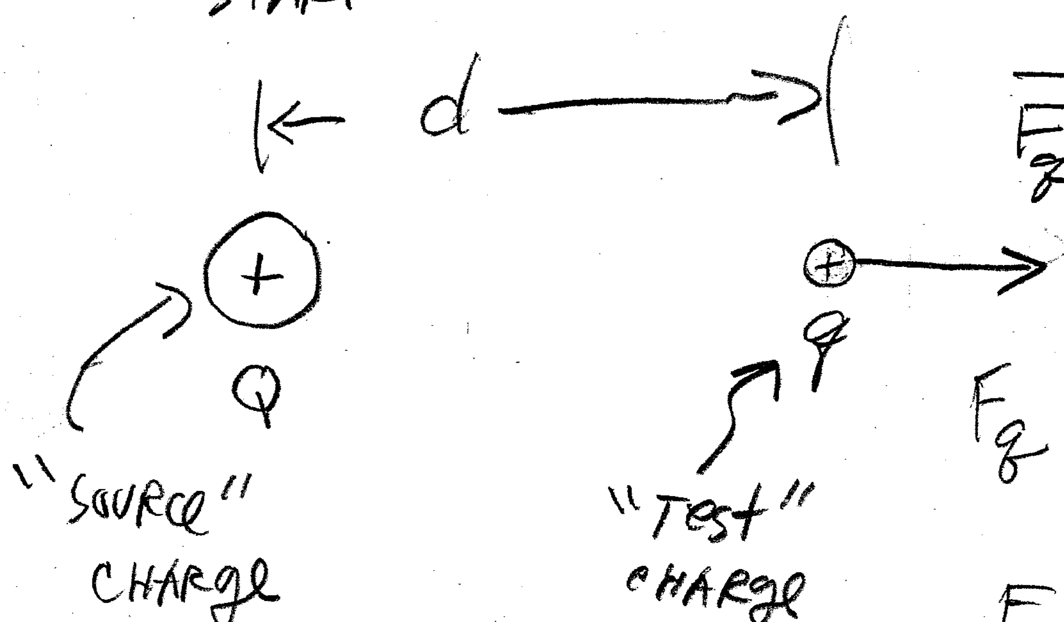
4B 1-24-14

Electric FIELDS Sec. 21.4

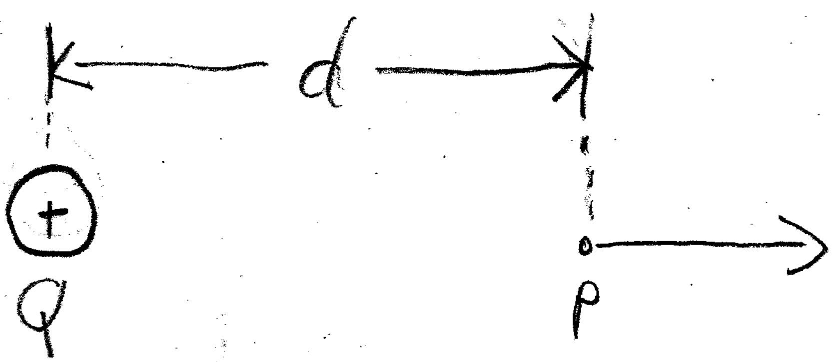
start with force



$$F_q = \frac{k|Q \cdot q|}{d^2}$$

$$F_q = |\vec{F}_q|$$

Remove q from its location at P.



$\vec{E}$ = electric field at P.

P = former location of q. P = point (location) definition

$$\vec{E} \equiv \frac{\vec{F}_q}{q}$$ = electric field **vector** at P.

$$|\vec{E}| = \frac{|\vec{F}_q|}{q}$$

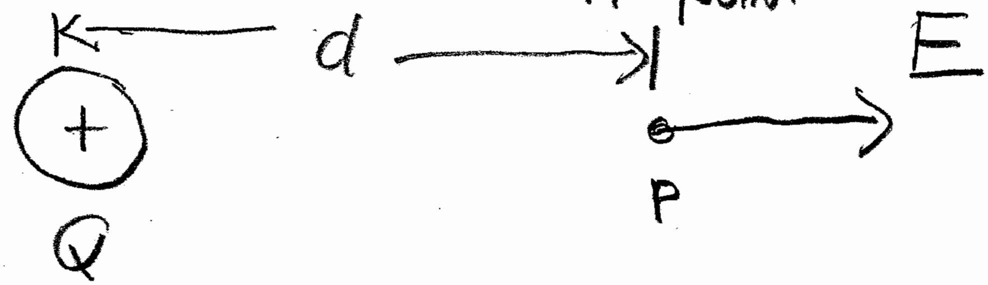
$$|\vec{E}| = \frac{k|Q \cdot q|/d^2}{q}$$

$\boxed{\text{NOTE: } |\vec{E}| = \text{magnitude}}$

$$|\vec{E}| = E = \frac{k|Q|}{d^2}$$

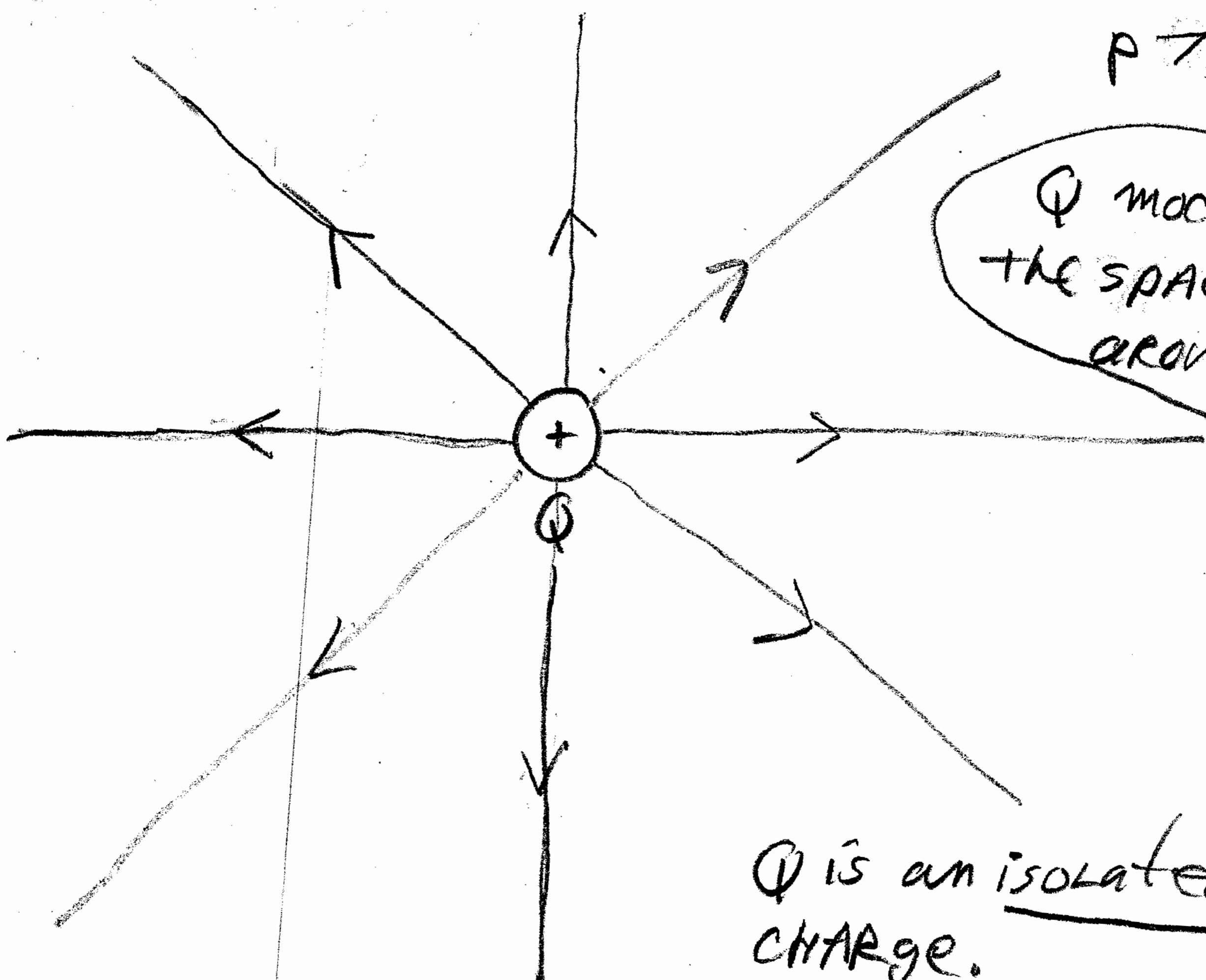
$\vec{E}$ = electric field at point P.

(Fig. 21.15
Fig. 21.16
pp. 699–700)



$\vec{E}$ is due to "source" charge Q.

<u>Electric field lines</u> (fig 21.28) p 709

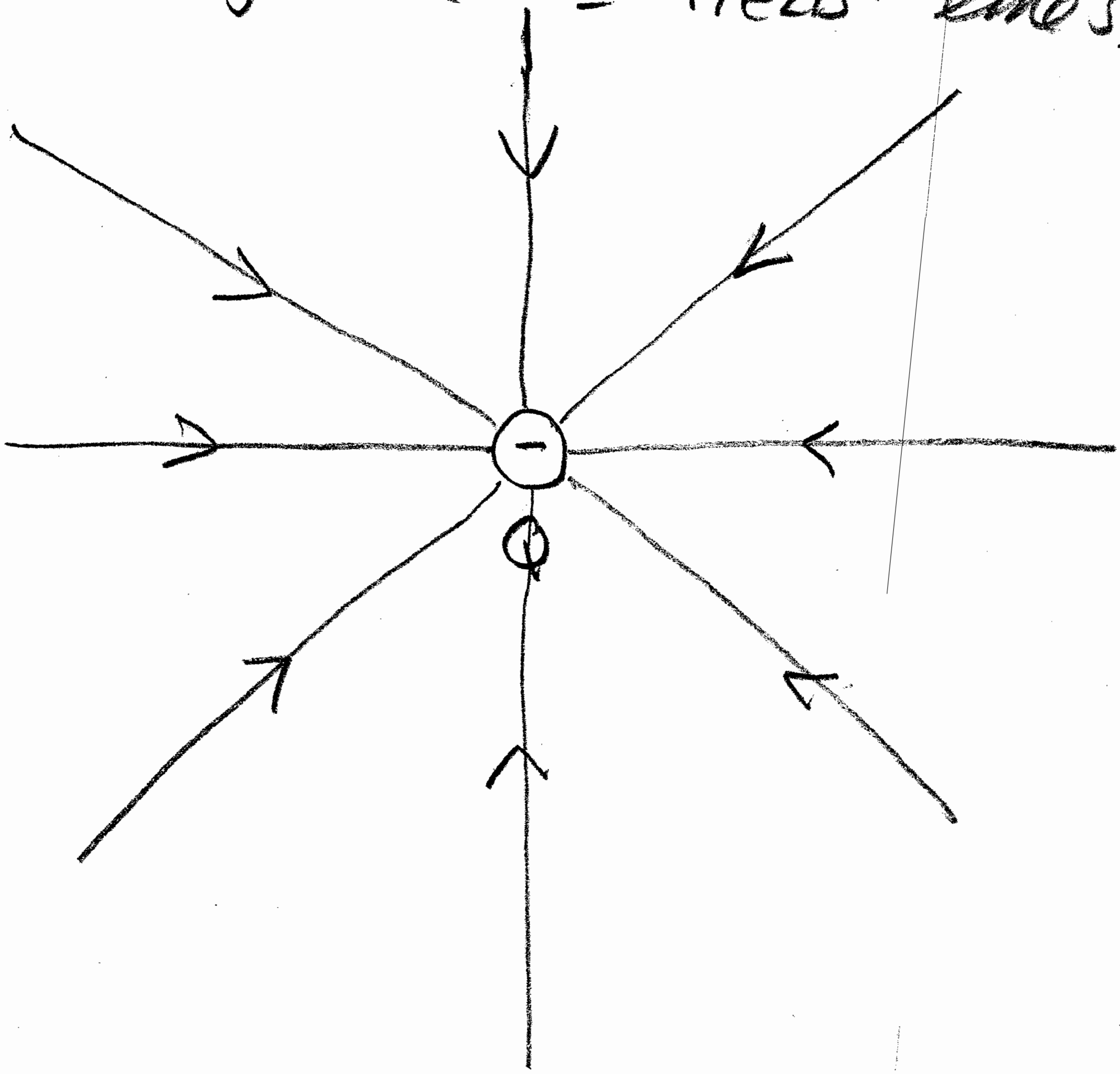


Q modifies the space around it.

Q is an <u>isolated</u> charge.

Field lines <u>leave</u> a positive charge; <u>enter</u> a negative charge.

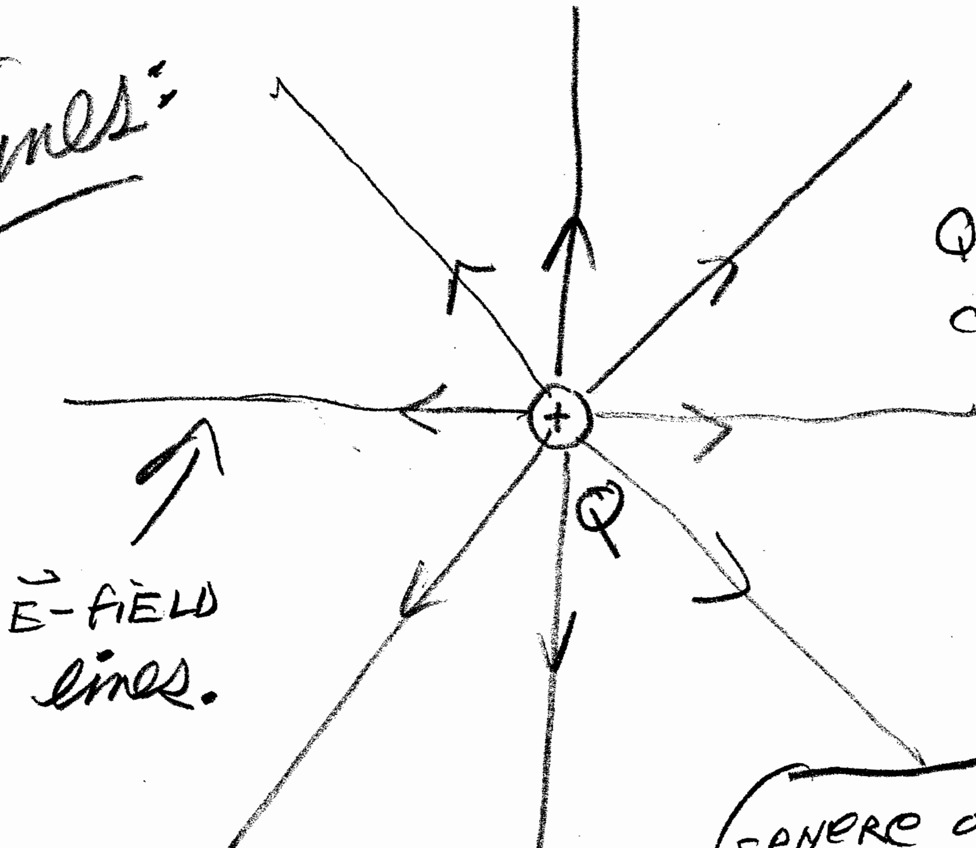
IF SOURCE CHARGE Q WAS negative: $\vec{E}$-field lines.



Q is an isolated charge.

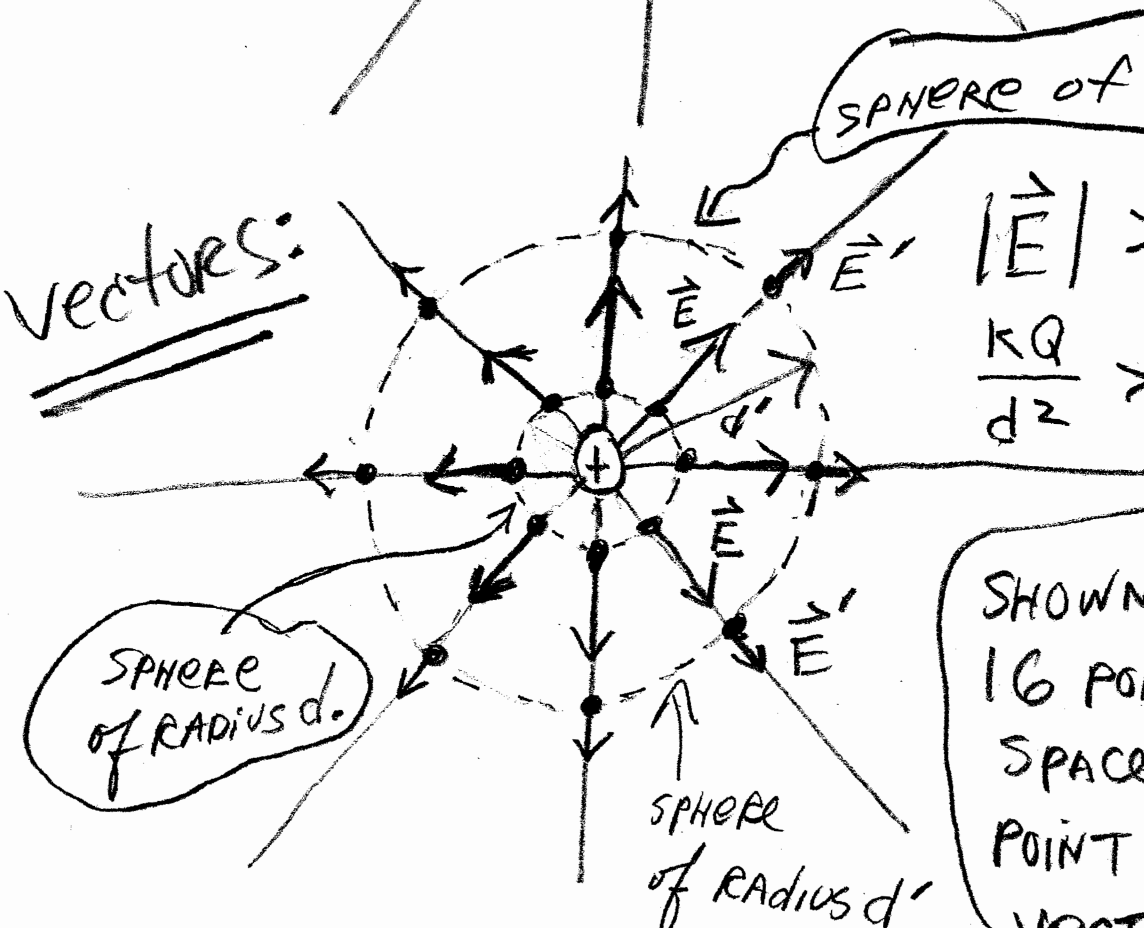
Lines vs. vectors (sec. 21.4) (sec. 21.6)

lines:



Q is an ISOLATED CHARGE.

vectors:



$$|\vec{E}| > |\vec{E}'|$$

$$\frac{kQ}{d^2} > \frac{kQ}{d'^2}$$

SHOWN ARE 16 POINTS IN SPACE. at EACH POINT is a VECTOR.

Sec. 21.6: PROPERTIES of $\vec{E}$-lines. p 708

(1.) where the density of lines is LARGE, $\vec{E}$ vector is LARGE in magnitude.

(2.) $\vec{E}$ vector is always tangent to the line.

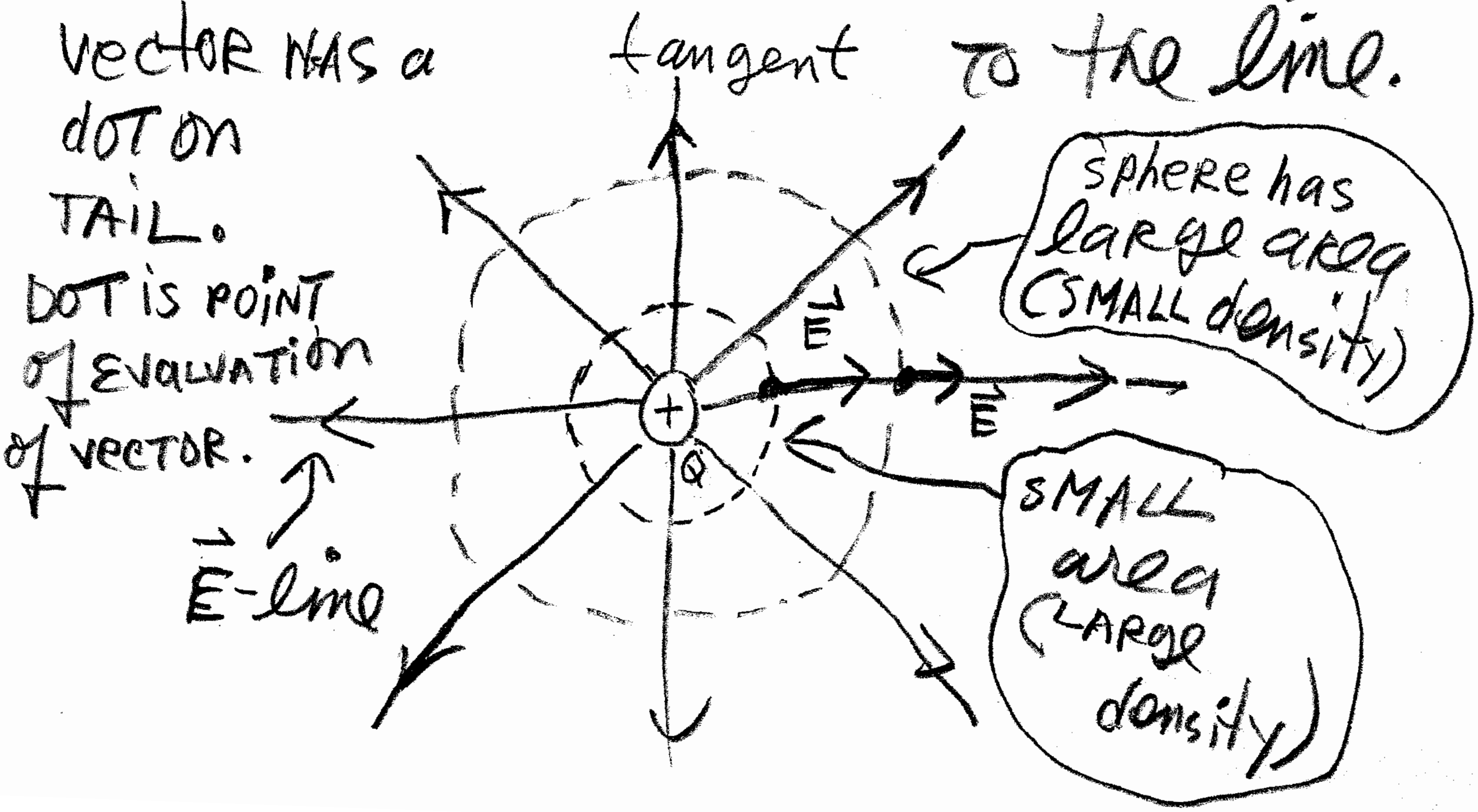
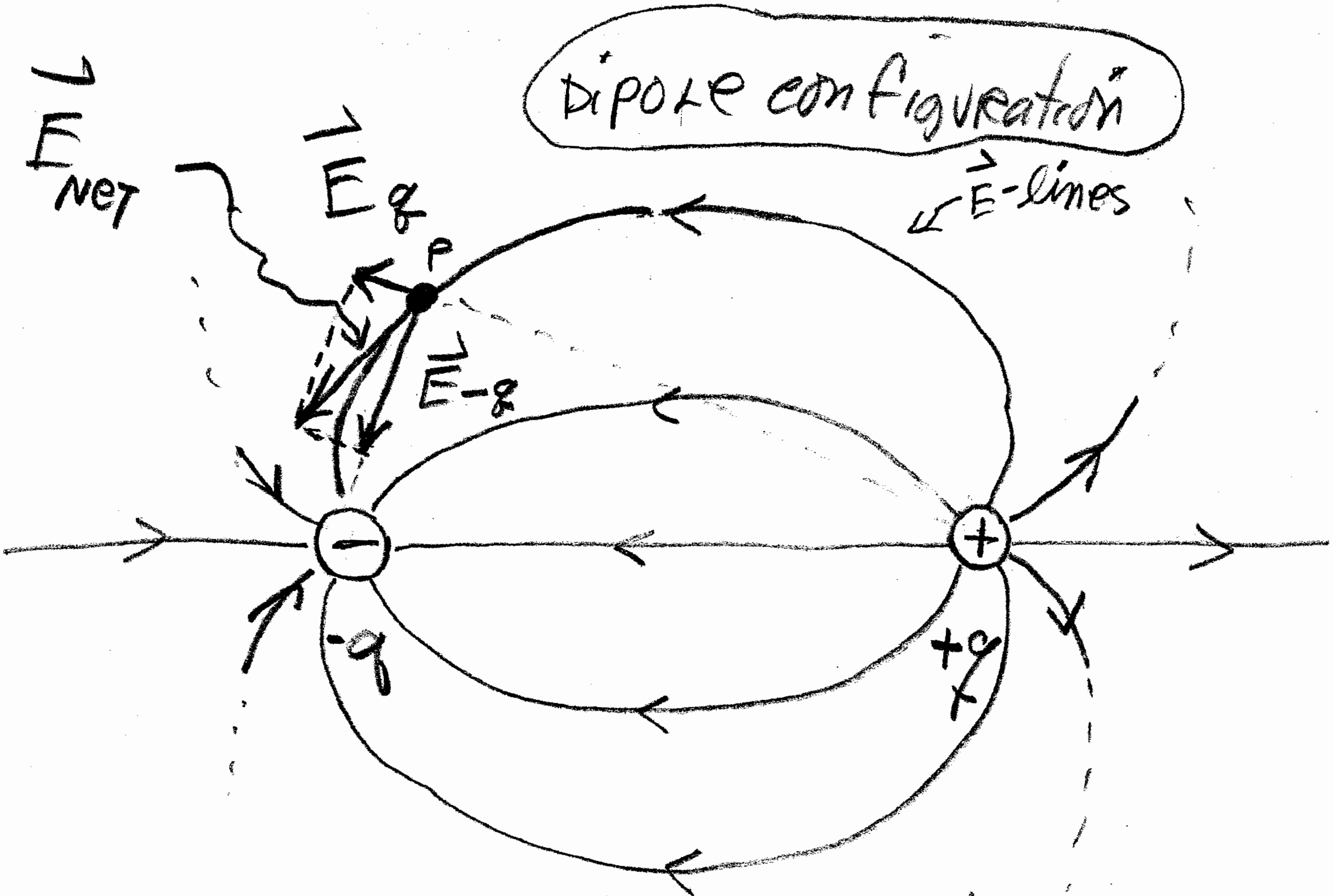


fig 21-28 (b)



<u>NOTE</u>: ⓐ $\vec{E}_{net} = \vec{E}_q + \vec{E}_{-q}$

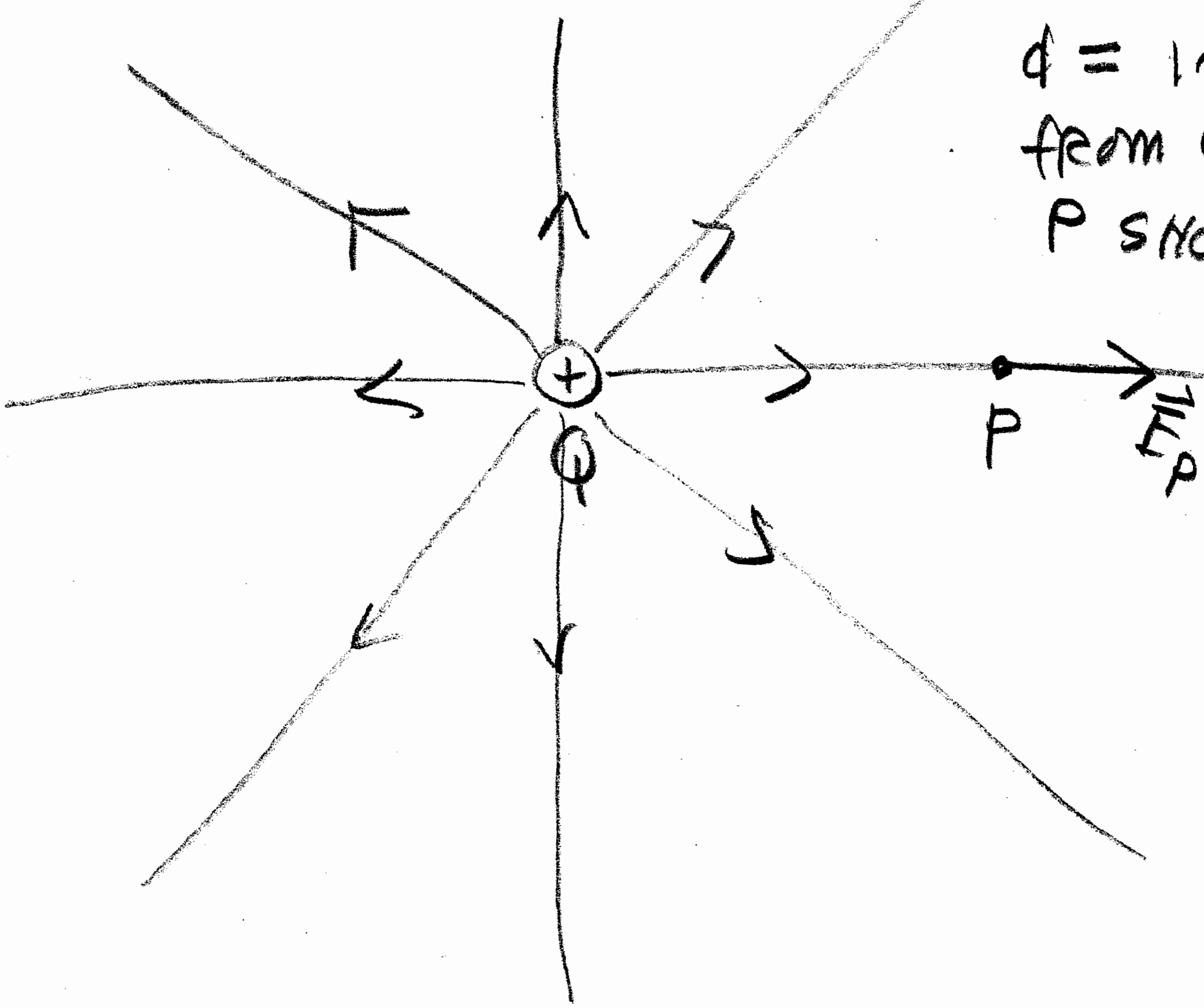
ⓑ $\vec{E}_{net}$ is tangent TO $\vec{E}$-line at point P.

3 examples:

(A.) FIND field FROM Q using charge q.

$Q = 1 \times 10^{-6}\,C = 1\,\mu C$.

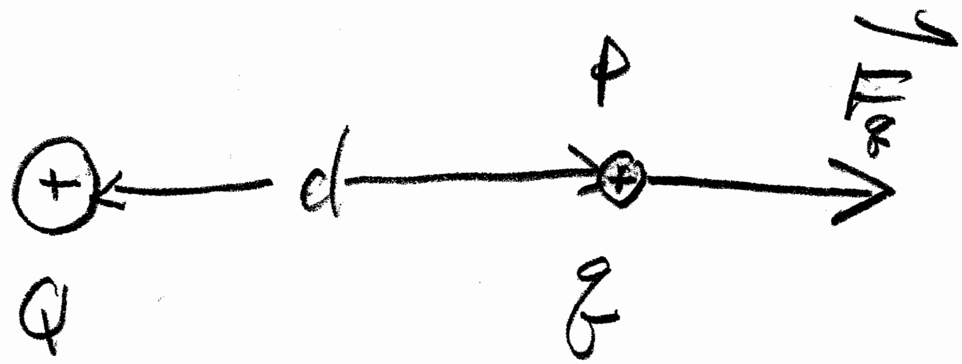
FIND $\vec{E}$ at $d = 1m$ AWAY from Q at P SHOWN.



SOLUTION: Let our test charge q measure $\vec{E}$. Let $q = 0.5\,\mu C$

$0.5 \times 10^{-6}\,C$

Place q at point P.



$$|\vec{F}| = \frac{k \cdot |Q \cdot q|}{d^2}$$

$$|\vec{F}| = \frac{(9\times10^{9})(1\times10^{-6})\cdot(0.5\times10^{-6})}{(1)^2}\ (N)$$

$$|\vec{F}| = F = 4.5\times10^{-3}\ (N)$$

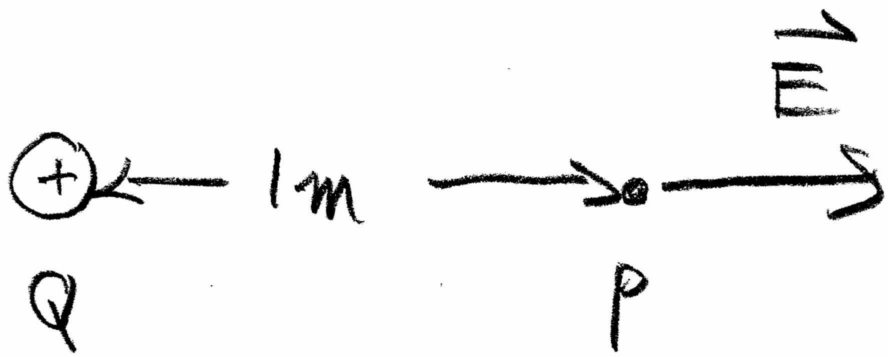
$$\vec{F} = 4.5\times10^{-3}\ (N),\ \text{Right.}$$

Now divide force by q:

$$|\vec{E}| = \frac{|\vec{F}|}{q} = \frac{4.5\times10^{-3}\,(N)}{0.5\times10^{-6}\,(C)}$$

$$= 9\times10^{3}\,\frac{N}{C}$$

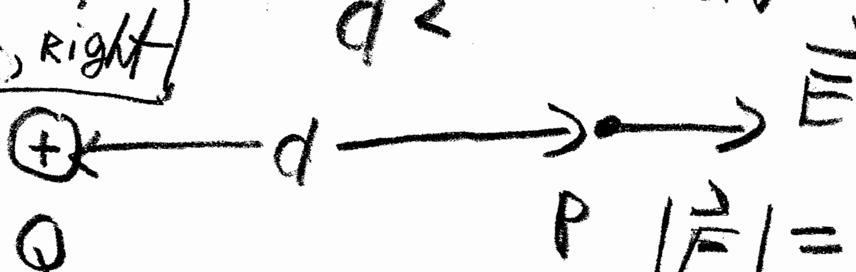
$$\vec{E} = 9\times10^{3}\,\frac{N}{C}\text{), right.}$$



(B.) Short cut: Use formula to find $\vec{E}$.

$$|\vec{E}| = \frac{K\cdot|Q|}{d^2} = \frac{(9\times10^{9})(1\times10^{-6})}{(1)^2}\left(\frac{N}{C}\right)$$

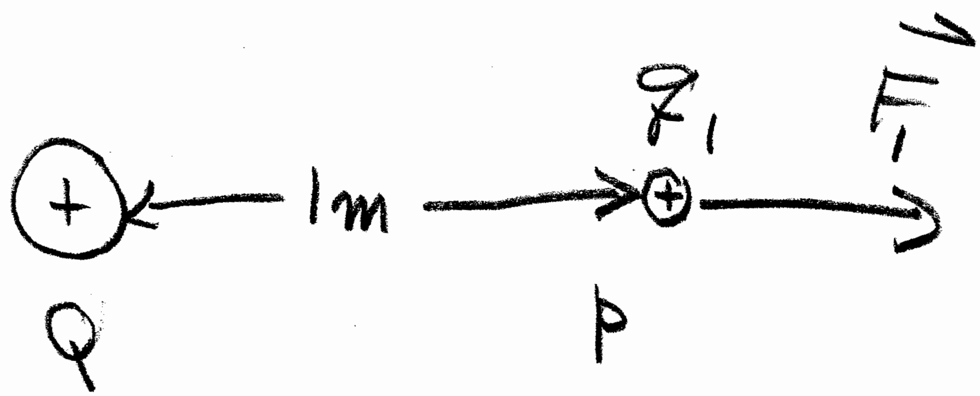
$$\boxed{\vec{E} = 9\times10^{3}\,\frac{N}{C}\text{), right}}$$



$$|\vec{E}| = 9\times10^{3}\,\frac{N}{C}$$

(C) FOLLOW UP QUESTION:

What is the force on a charge $q_1 = 15\mu C$ at point P.?



SOLUTION:

$$\boxed{\vec{F}_1 = q_1 \cdot \vec{E}}$$

$$|\vec{F}_1| = q_1 \cdot |\vec{E}|$$

$$= (15 \times 10^{-6} C) \cdot (9 \times 10^{3} \frac{N}{C})$$

$$= 135 \times 10^{-3} (N) = 1.35 \times 10^{-1} (N)$$

$\vec{F}_1 = 1.35 \times 10^{-1}$ (N), Right

AFTER BREAK:

Review problem similiar to EXAMPLE 21.8

FIELD from a dipole:

Two opposite charges separated by 0.12 m.

$\oplus \longleftarrow 0.12\,m \longrightarrow \ominus$

$+q \qquad\qquad -q$

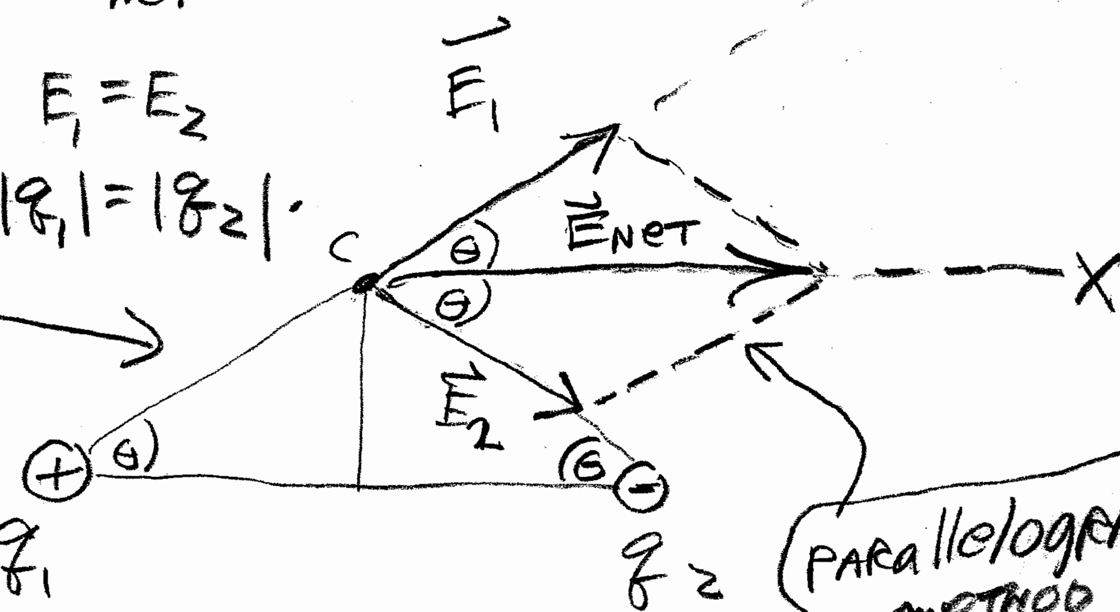
<u>NOTE</u>: DIPOLES are important in BIOLOGY. <u>YOU</u> ARE MADE UP of 70% WATER (H_2O - LIQUID).

H_2O is a POLAR MOLECULE CRITICAL TO cell BIOLOGY and functioning.

SIMILAR TO Example 21.8 (pp. 704-5)

Find $\vec{E}_{net}$ at POINT C:

NOTE: $E_1 = E_2$
since $|q_1| = |q_2|$.



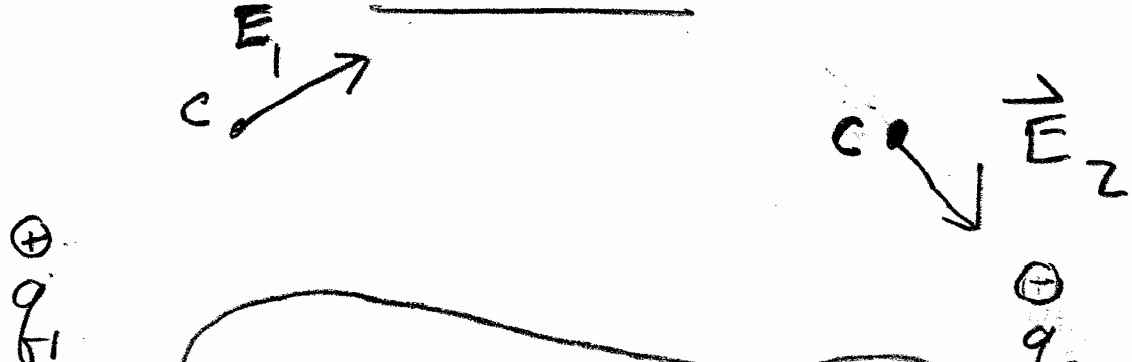
isosceles TRIANGLE.

c is the Apex.

PARAllelogRAM METHOD TO PREDICT ANSWER.

$$\vec{E}_{net} = \vec{E}_1 + \vec{E}_2$$

review:

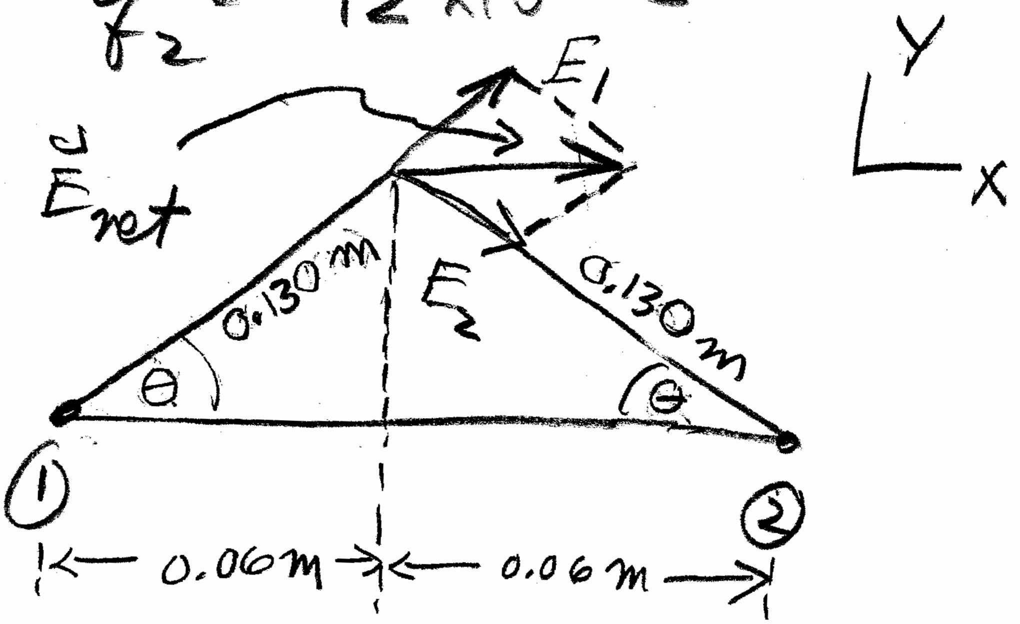


Isolate EACH CHARGE and FIND $\vec{E}_1$ and $\vec{E}_2$ as if the other CHARGE WAS absent.

LET $|q_1| = |q_2|$.

let $q_1 = 12 nC = 12 \times 10^{-9} C$

$q_2 = -12 \times 10^{-9} C$



$$E_{net_X} = E_{1X} + E_{2X}$$

$$E_{net_Y} = E_{1Y} + E_{2Y} = 0$$

PREDICTION (PARALLELOGRAM)

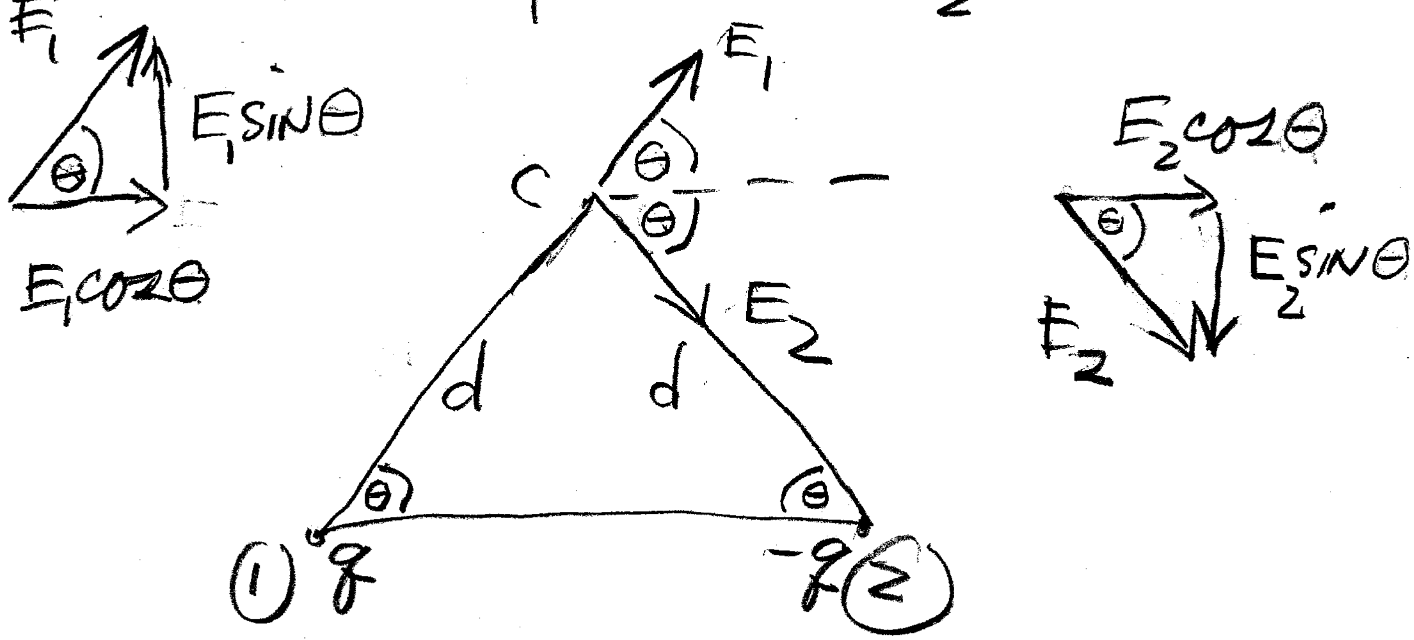
$\cos\theta = \frac{0.06}{0.130}$

$\theta = \cos^{-1}\left(\frac{6}{13}\right) = 62.51°$

(PICTURE NOT TO SCALE)

$$E_{net_x} = E_{1x} + E_{2x}$$

$$E_{net_x} = E_1 \cdot \cos\theta + E_2 \cdot \cos\theta$$



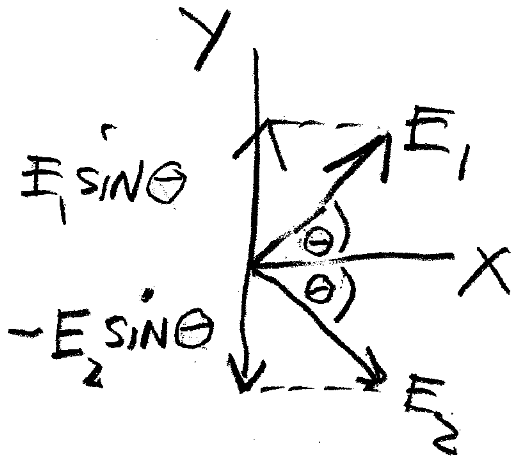
$$E_1 = E_2 = \frac{k \cdot q}{d^2} = E$$

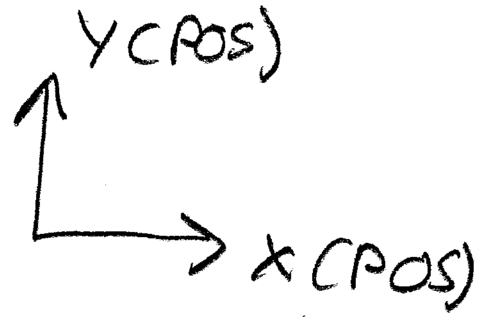
$$|q_1| = |q_2| = q$$

$$E_{net_x} = 2E \cdot \cos 62.51^\circ$$

$$E_{net_x} = \frac{2 \cdot kq}{d^2} \cdot \cos 62.51^\circ$$

$$E_{net_y} = E_1 \sin\theta - E_2 \sin\theta$$

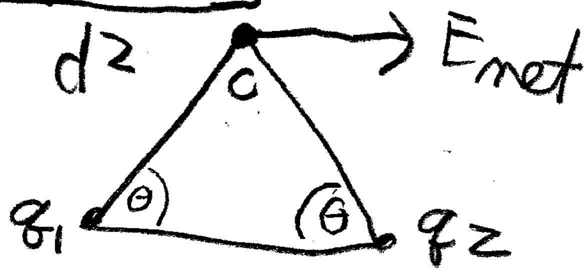




Since $E_1 = E_2 = E$

$$E_{net_y} = E\sin\theta - E\sin\theta = 0$$

$$|\vec{E}_{net}| = \frac{2kq\cos 62.51^\circ}{d^2}$$



$$\vec{E}_{net} = \frac{2kq\cos 62.51^\circ}{d^2}, \text{ right}$$

$\vec{E}_{net}$ = net electric FIELD at point C due to source charges q_1 and q_2.

note: $q_1 > 0$

$q_2 < 0$

and $|q_1| = |q_2| = 12 \times 10^{-9}$ (C).

note: $\vec{E}_{net}$ units $= \frac{N}{C}$.

$$E_{net} = \frac{(2)(9 \times 10^{9})(12 \times 10^{-9}) \cos 62.51}{(0.130)^2} \left(\frac{N}{C}\right)$$

$$= 5.9 \times 10^{3} \frac{N}{C}$$

$$\boxed{\vec{E}_{NET} = 5.9 \times 10^{3} \frac{N}{C}, \text{ right}}$$