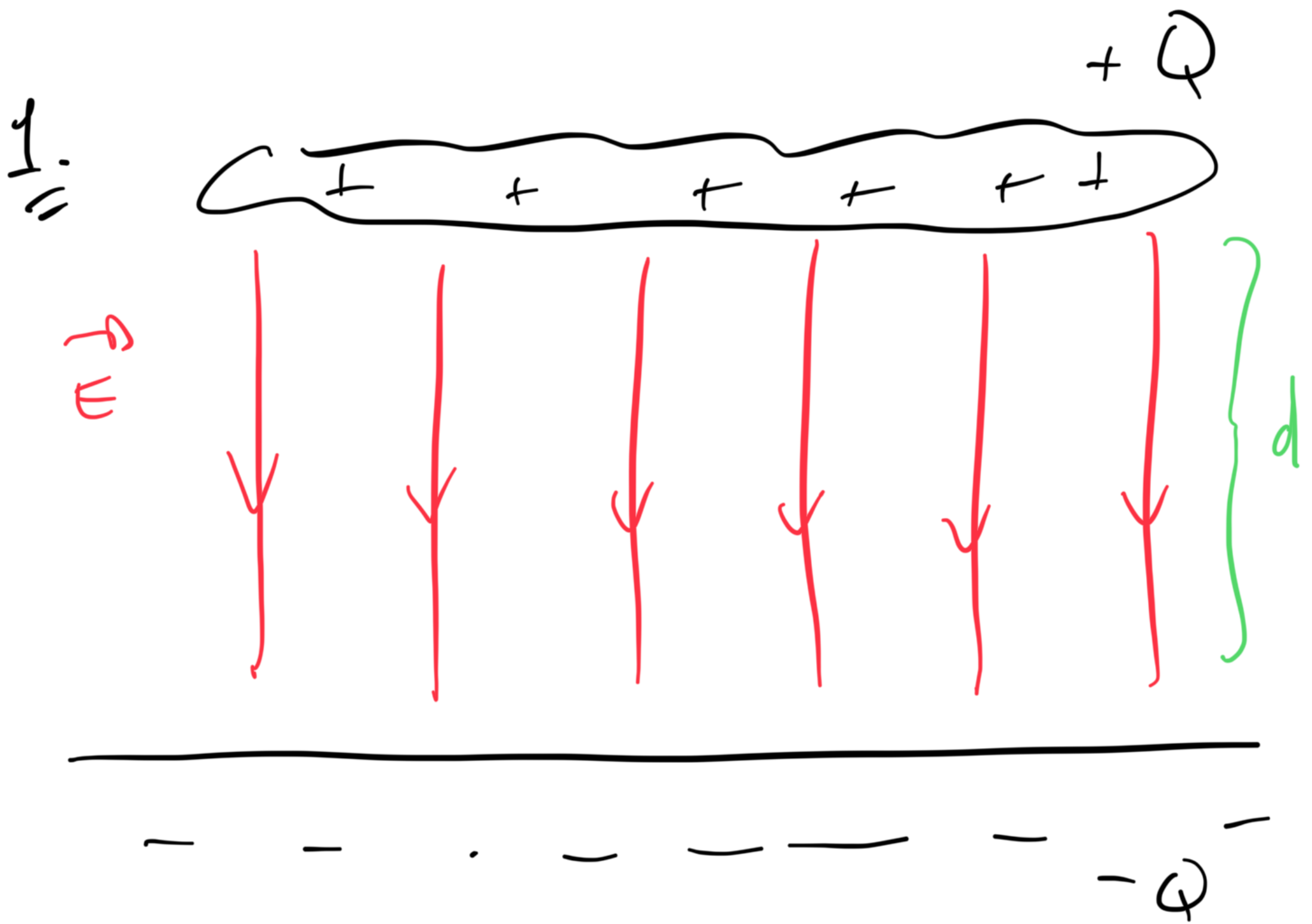


Assignment 4 Solutions



$$C = \frac{\epsilon_0 A}{d} \Rightarrow$$

$$\begin{aligned} A &= 1 \text{ km}^2 \\ &= (1000 \text{ m}) \times (1000 \text{ m}) \\ &= 10^6 \text{ m}^2 \\ d &= 600 \text{ m} \end{aligned}$$

$$C = \frac{(8.854 \times 10^{-12})(10^6)}{600} = 1.48 \times 10^{-8} \text{ F} = 14.8 \text{ nF}$$

$$b) |\vec{E}| = 3.00 \times 10^6 \text{ N/C}$$

$$Q = C \cdot \Delta V$$

$$\text{also } \vec{\tau} = |\vec{E}| \cdot d$$

$$= C \cdot |\vec{E}| \cdot d$$

$$= (1.48 \times 10^{-8}) (3.00 \times 10^6) (600)$$

$$= 26.6 \text{ Coulombs}$$

2.

Surface charge density : $35 \frac{nC}{cm^2}$

$$\frac{35 \times 10^{-9} C}{(.01m)(.01m)} = 3.5 \times 10^{-4} \frac{C}{m^2} \equiv \frac{Q}{A}$$

$$\Delta V = 150V$$

$$|\vec{E}| = \Delta V / d \quad \therefore \quad d = \frac{\Delta V}{|\vec{E}|}$$

$$|\vec{E}|_{\text{capacitor}} = \frac{Q}{\epsilon_0 A} \quad \left(\text{from Gauss's Law} \right)$$

7.5×10^{-4}

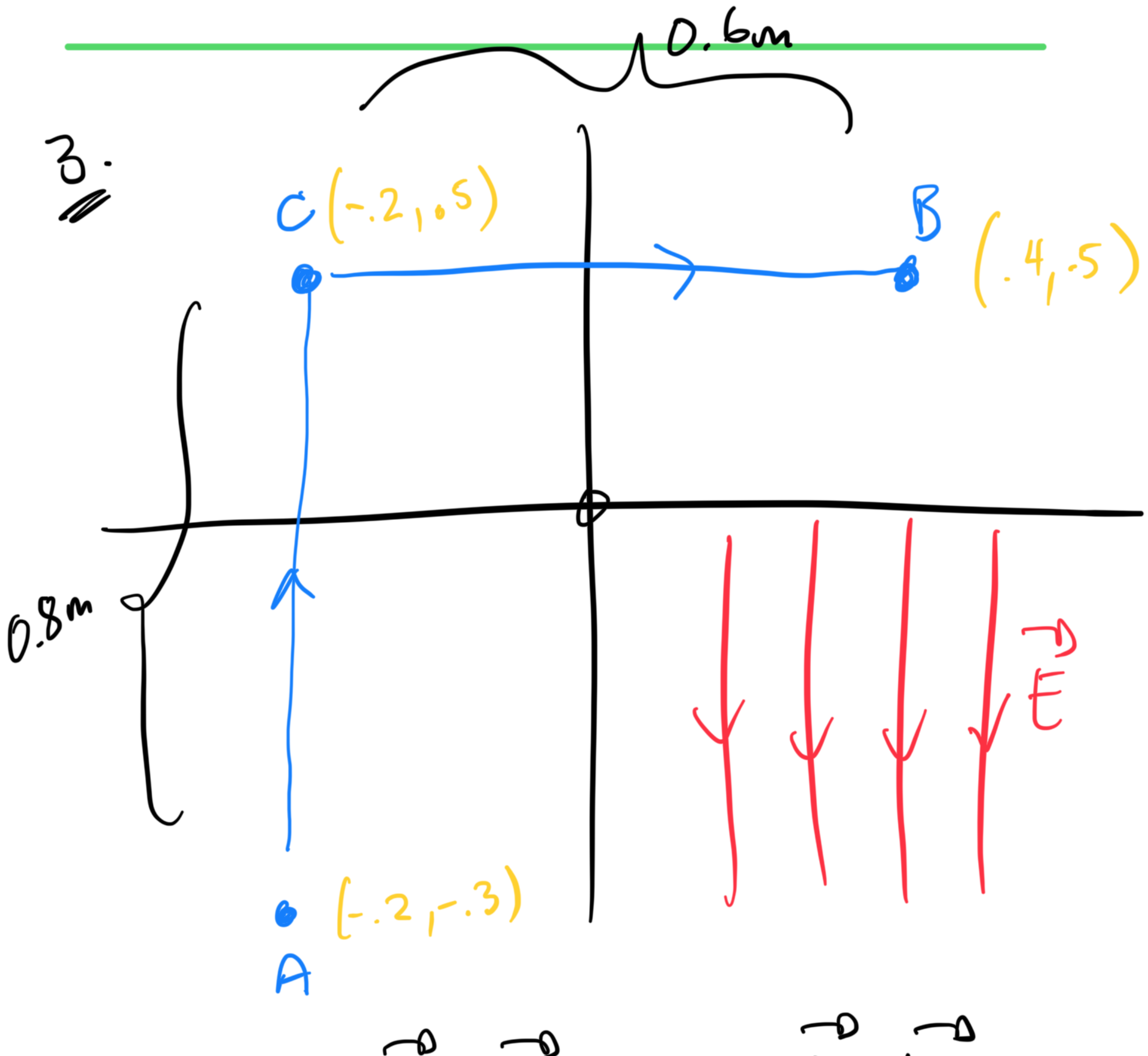
$$= \frac{3.95 \times 10^7}{8.854 \times 10^{-12}}$$

$$= 3.95 \times 10^7 \text{ N/C}$$

$$d = \frac{\Delta V}{|E|} = \frac{150 \text{ V}}{3.95 \times 10^7 \text{ N/C}}$$

$$= 3.79 \times 10^{-6} \text{ m}$$

$$d = 3.79 \mu\text{m}.$$



$$W_{AC} = F \cdot \Delta x = q E \cdot \Delta x$$

$$= q (-E_0 \hat{j}) (\cdot 8 \hat{j})$$

$$W_{AC} = -0.8 q E_0$$

$$\Delta V_{AC} = - \frac{W_{AC}}{q} = 0.8 E_0$$

$$= (0.8)(255 \text{ V/m})$$

$$= 204 \text{ V}$$

$$W_{CB} = \vec{F} \cdot \vec{\Delta x} = q \vec{E} \cdot \vec{\Delta x}$$

$$= q (-E_0 \hat{j}) \cdot (.6 \hat{i})$$

$$= 0$$

$$\therefore \Delta V_{CB} = 0 \text{ V}$$

$$\Delta V_{AC} = 204 \text{ V} + 0 \text{ V}$$

$$= 204 \text{ V}.$$

0.017m

4.

$$|\vec{E}| = \frac{\Delta V}{d}$$

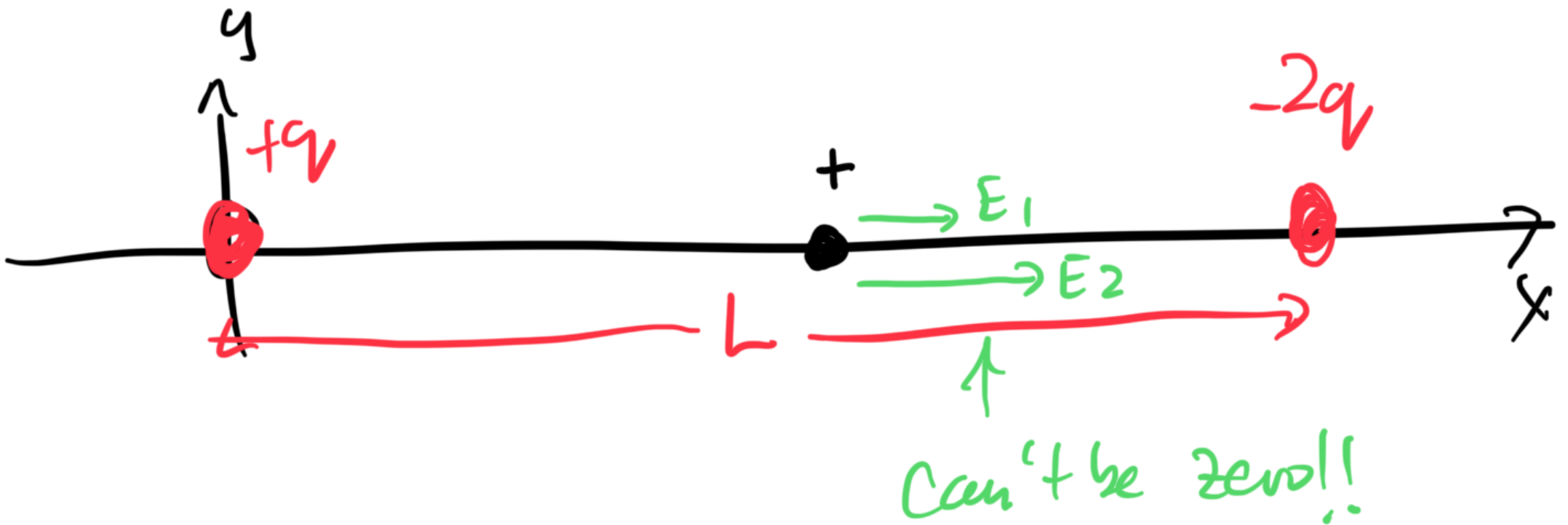
$$= \frac{25040 \text{ V}}{.017 \text{ m}}$$

$$= 1.47 \times 10^6 \text{ N/C}$$

$$= 1.47 \text{ MN/C}$$

$$\Delta V = 25040 \text{ V}$$

5.



$\leftarrow E_1 \quad E_2 \rightarrow$

maybe!!

$$|\vec{E}| = E_2 - E_1$$

$$0 = \frac{k_e (2q)}{(L+x)^2} - \frac{k_e (q)}{x^2}$$

$$\frac{2}{(L+d)^2} = \frac{1}{d^2}$$

$$\frac{(L+d)^2}{2} = d^2$$

$$\frac{L+d}{\sqrt{2}} = d$$

$$L+d = \sqrt{2}d$$

$$L = (\sqrt{2}-1)d$$

$$d = \frac{L}{(\sqrt{2}-1)} = \frac{7.9}{(\sqrt{2}-1)}$$

$$d = 19.1 \text{ m}$$

so

$$\boxed{x = -19.1 \text{ m}}$$

b)



$$V = \frac{q}{d} - \frac{2q}{L-d} = 0$$

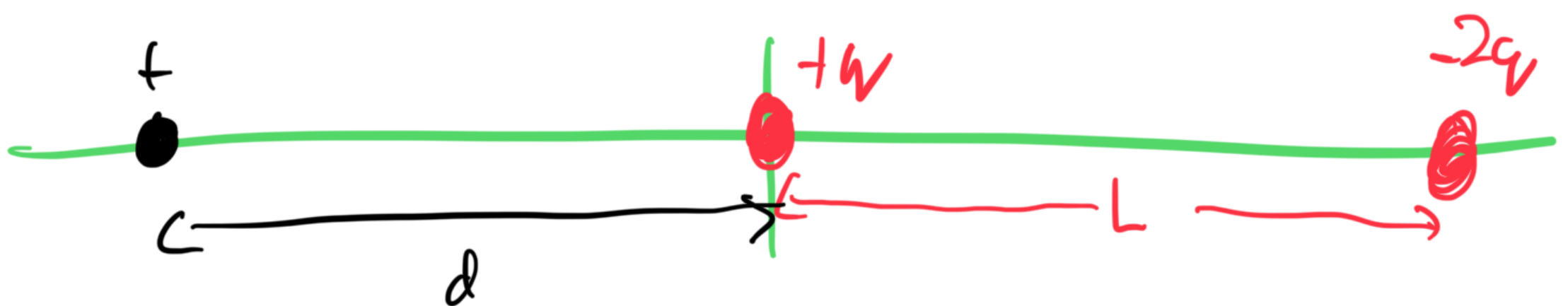
$$\frac{q}{d} = \frac{2q}{L-d}$$

$$L-d = 2d$$

$$L = 3d$$

$$d = \frac{L}{3} = \frac{7.9\text{m}}{3} = 2.63\text{m}$$

$$\therefore \boxed{d = 2.63\text{m}}$$



$$V = \frac{q}{d} - \frac{2q}{L+d} = 0$$

$$\therefore \frac{q}{d} = \frac{2q}{L+d}$$

$$L + d = 2d$$

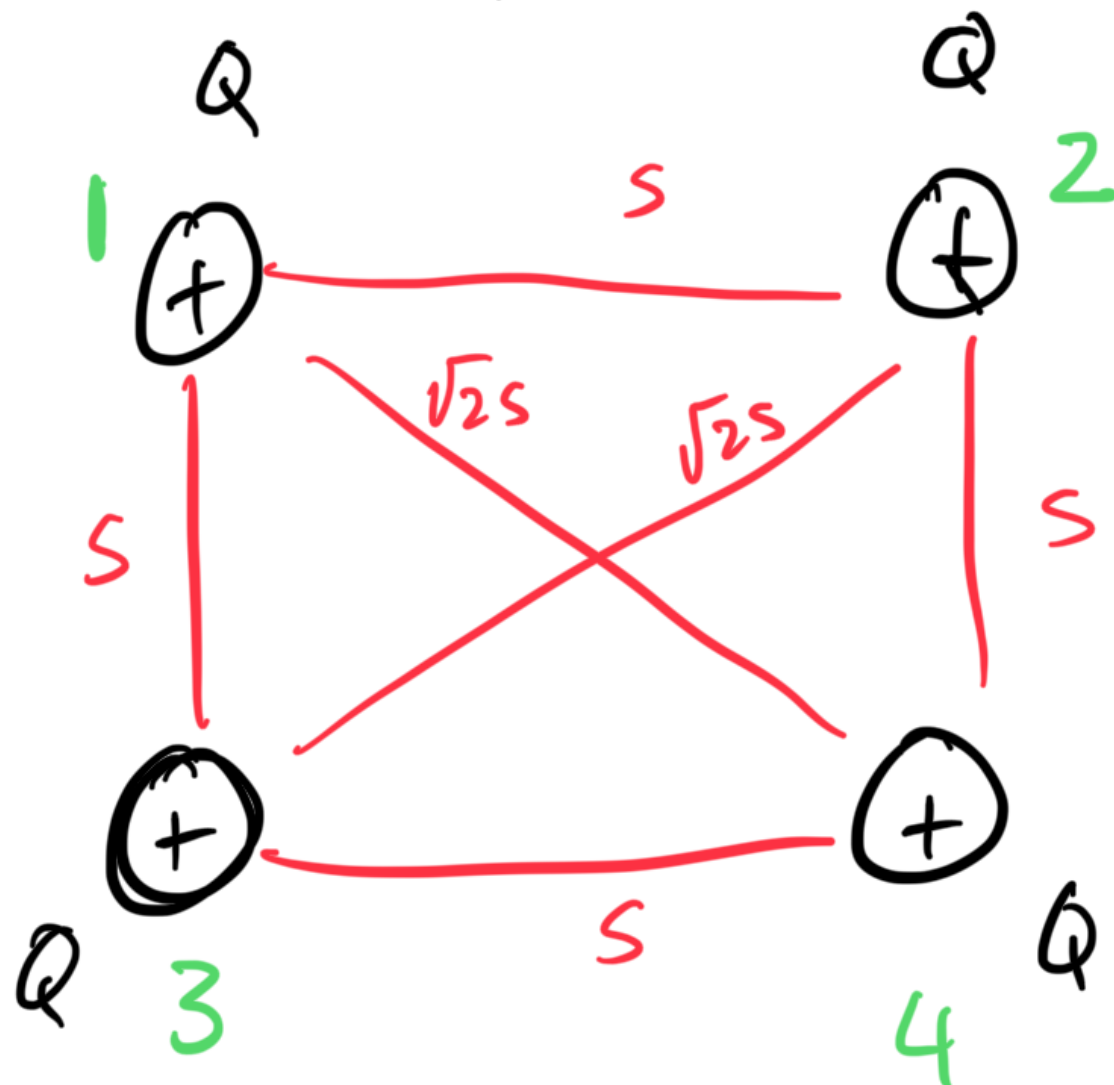
$$L = d$$

$$\therefore d = 7.9 \text{ m}$$

$$\therefore \boxed{x = -7.9 \text{ m}}$$

6.

Calculate the potential energy between all pairs of charges.



$$U_{\text{total}} = U_{12} + U_{13} + U_{14} + U_{23} + U_{24} + U_{34}$$

$$\begin{aligned}
 &= \frac{kQQ}{s} + \frac{kQQ}{s} + \frac{kQQ}{\sqrt{2}s} \\
 &\quad + \frac{kQQ}{\sqrt{2}s} + \frac{kQQ}{s} + \frac{kQQ}{s} \\
 &= \frac{kQQ}{s} \left(1 + 1 + \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} + 1 + 1 \right) \\
 &= 5.414 \frac{kQ^2}{s}
 \end{aligned}$$

7.

a)

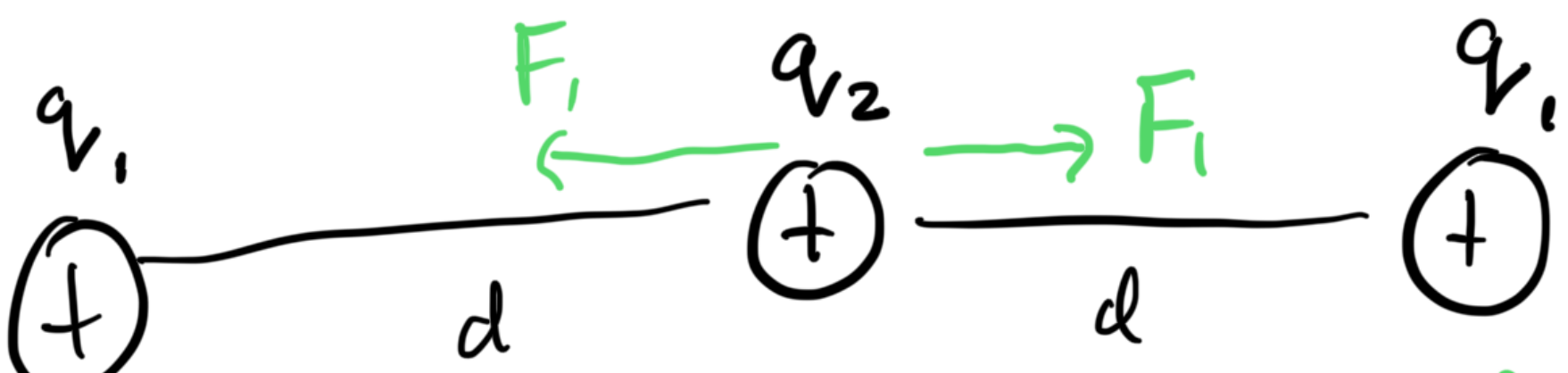


Diagram showing three positive charges q_1 , q_2 , and q_3 arranged in a horizontal line. The distance between q_1 and q_2 is d , and the distance between q_2 and q_3 is d . Force vectors F_1 and F_2 are shown acting on q_2 , both pointing to the left.

$$|\vec{F}_1| = \frac{kq_1q_2}{d^2}$$

$$\vec{F}_{\text{net}} = \vec{F}_1 - \vec{F}_1 = 0$$

b)

$$\vec{F} = \vec{F} = 0$$

b)

q_2

$$c) \quad V_0 = \frac{k q_1}{d^2} + \frac{k q_1}{d^2}$$

$$= \frac{2k q_1}{d^2} = 33700 \text{ V}$$

$$= \underline{\underline{3.3.7 \text{ kV}}}$$

$$q_1 = 1.5 \mu\text{C} = 1.5 \times 10^{-6} \text{ C}$$

$$d = 0.8 \text{ m}$$