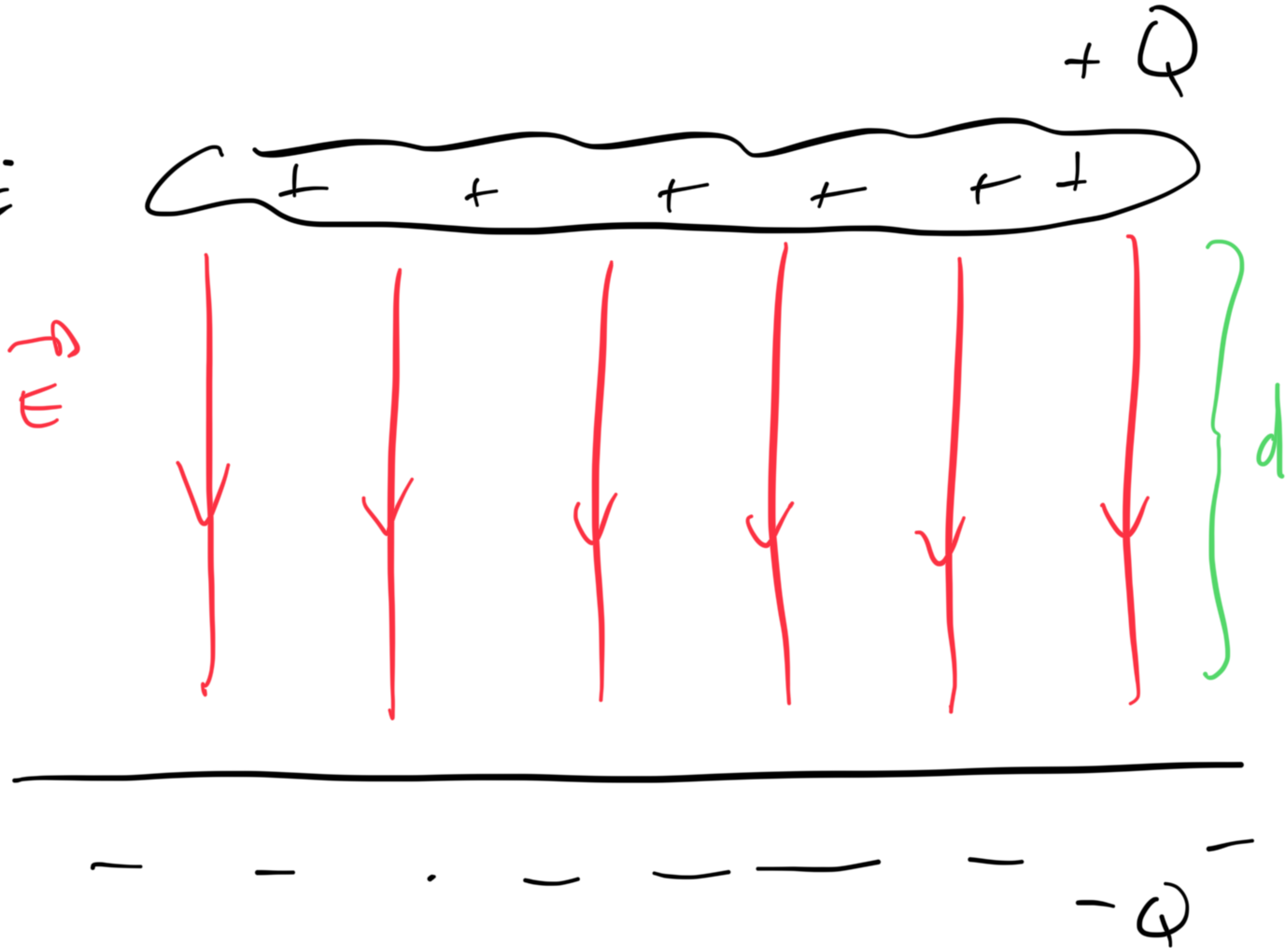
Assignment 4 Solutions

1.



$$C = \frac{\varepsilon_0 A}{d} \Rightarrow$$

$$A = 1\,km^2 = (1000\,m)\times(1000\,m) = 10^6\,m^2$$

$$d = 600\,m$$

$$C = \frac{(8.854\times10^{-12})(10^6)}{600} = 1.48\times10^{-8}\,F = 14.8\,nF$$

b) $|\vec{E}| = 3.00\times10^6\,N/C$

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

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

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

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

$$= 26.6 \text{ Coulombs}$$

2.

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

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

$$\Delta V = 150V$$

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

$$|\vec{E}|_{capacitor} = \frac{Q}{\varepsilon_0 A}$$ (from Gauss's Law)

3.5×10^{-4}

$$= \frac{\quad}{8.854\times10^{-12}}$$

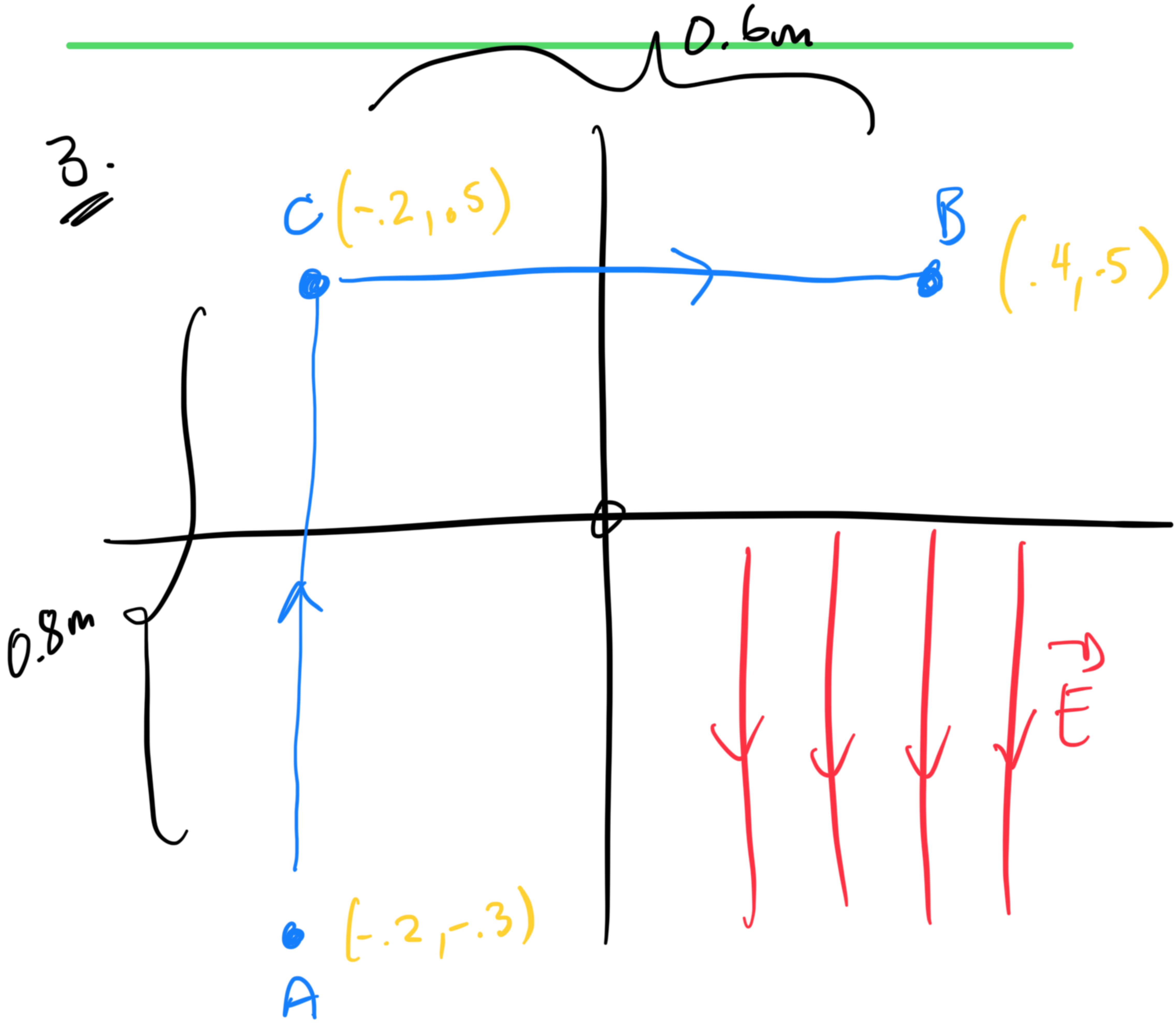
$$= 3.95\times10^{7}\ N/C$$

$$\therefore\quad d = \frac{\Delta V}{|\vec{E}|} = \frac{150\ V}{3.95\times10^{7}\ N/C}$$

$$= 3.79\times10^{-6}\ m$$

$$d = 3.79\ \mu m.$$

3.



$$W_{AC} = F \cdot \Delta x = q E \cdot \Delta x$$
$$= q(-E_0 \hat{j})(.8 \hat{j})$$

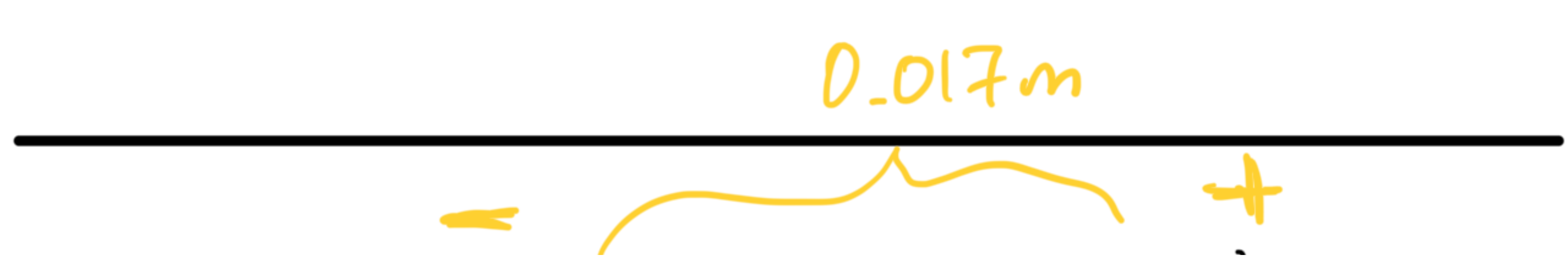
$$W_{AC} = -0.8\, q E_0$$

$$\Delta V_{AC} = -\frac{W_{AC}}{q} = 0.8 E_0$$
$$= (0.8)(255\, V/m)$$
$$= 204\, V$$

$$W_{CB} = \vec{F} \cdot \vec{\Delta x} = q \vec{E} \cdot \vec{\Delta x}$$
$$= q(-E_0 \hat{j}) \cdot (.6 \hat{i})$$
$$= 0!$$

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

$$\therefore \Delta V_{AC} = 204\, V + 0\, V$$
$$= 204\, V.$$



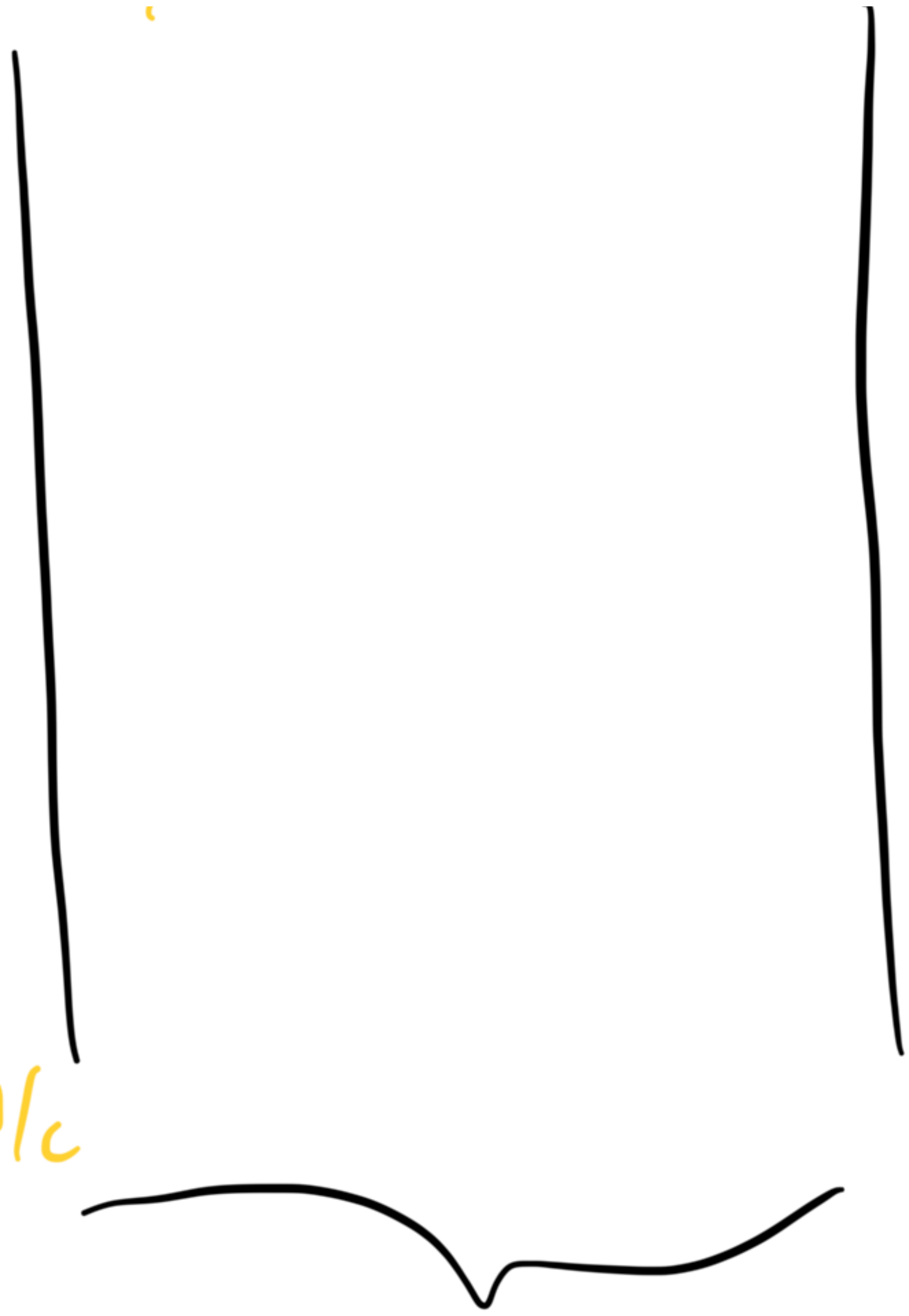
4.

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

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

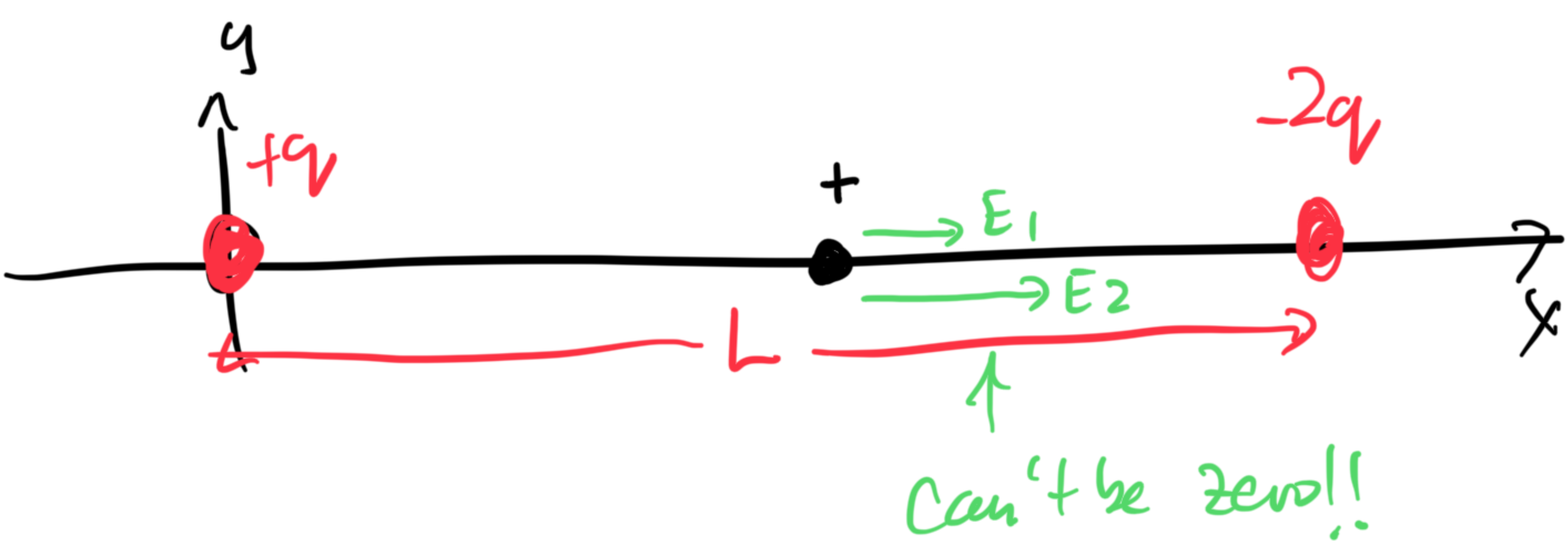
$$= 1.47 \times 10^{6}\ N/C$$

$$= 1.47\ MN/C$$



$\Delta V = 25040\,V$

5.



maybe!!

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

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

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

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

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

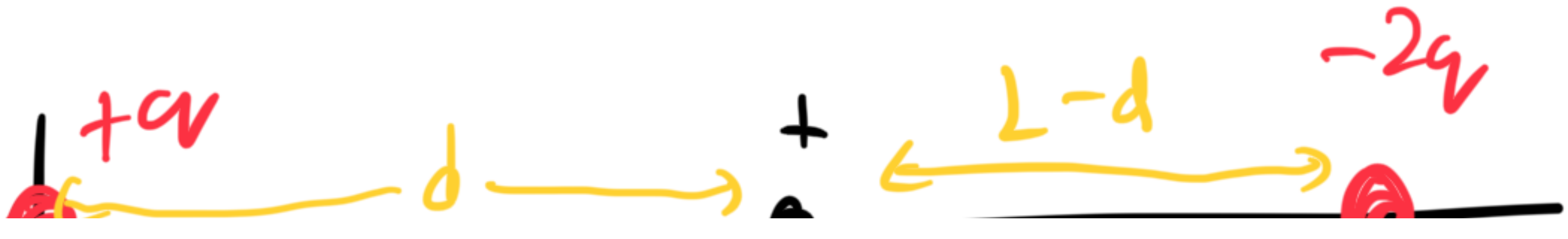
$$L = (\sqrt{2}-1)d$$

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

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

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

b)



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

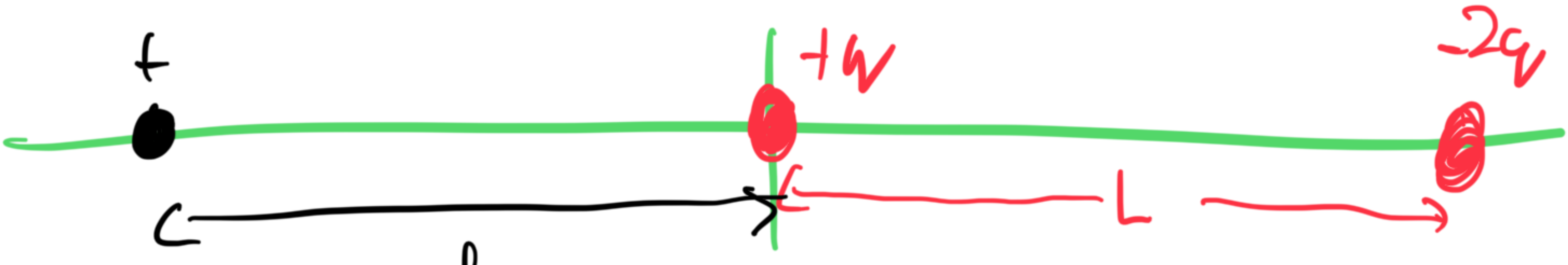
$$\frac{\cancel{q}}{d} = \frac{2\cancel{q}}{L-d}$$

$$L-d = 2d$$

$$L = 3d \qquad d = L/3 = \frac{7.9m}{3}$$

$$= 2.63m$$

$$\therefore \boxed{x = 2.63m}$$



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

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

$$L + d = 2d$$

$$L = d$$

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

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

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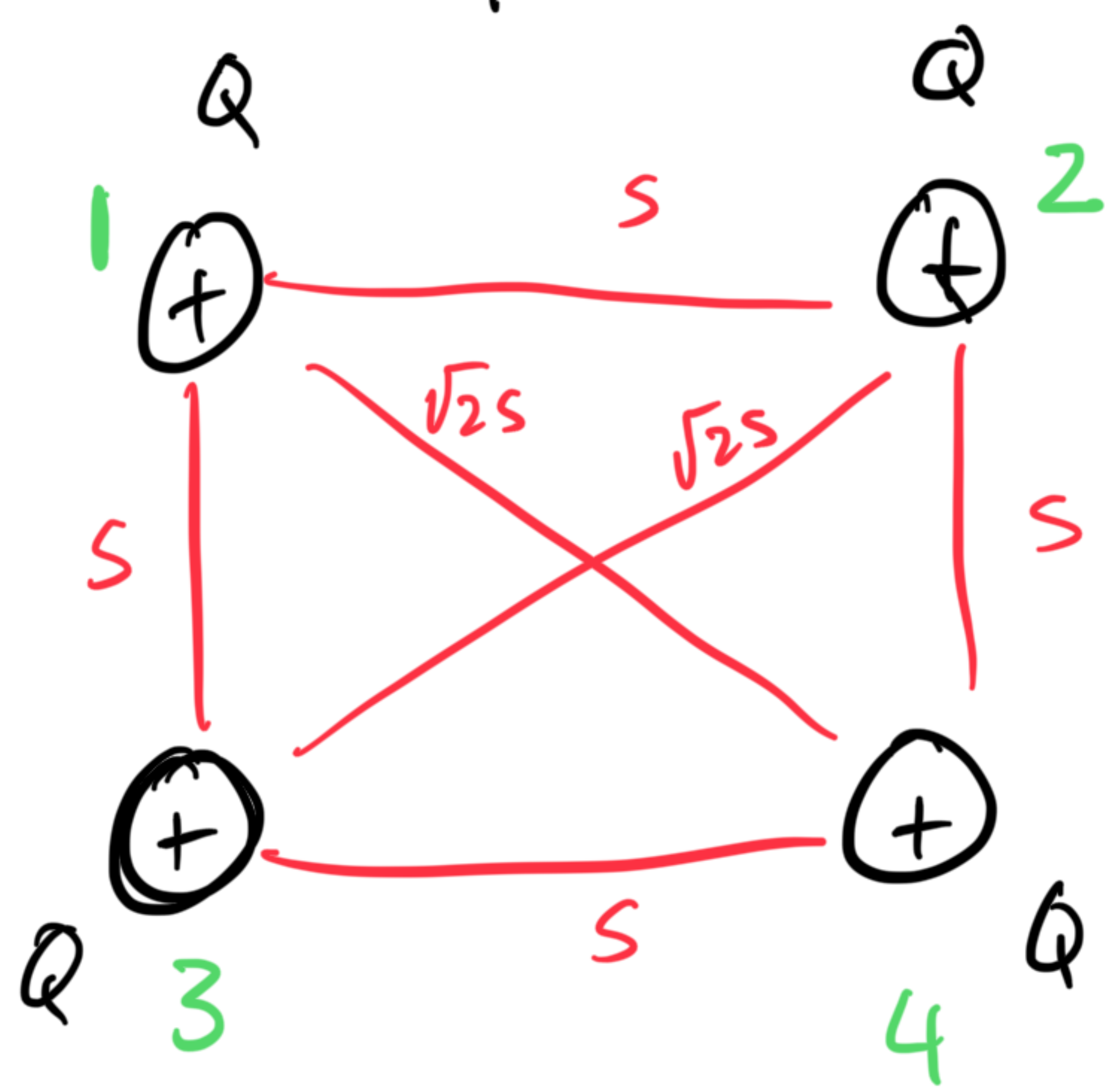
6. Calculate the potential energy between all pairs of charges.



$$U_{total} = U_{12} + U_{13} + U_{14}$$

$$+ U_{23} + U_{24} + U_{34}$$

$$= \frac{kQQ}{s} + \frac{kQQ}{s} + \frac{kQQ}{\sqrt{2}s}$$

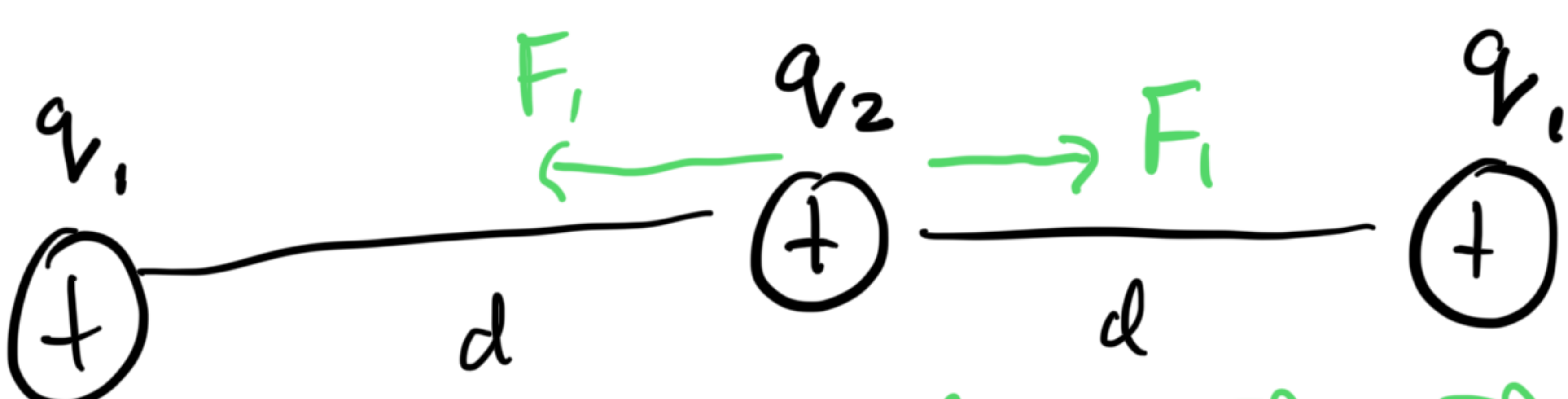
$$+ \frac{kQQ}{\sqrt{2}s} + \frac{kQQ}{s} + \frac{kQQ}{s}$$

$$= \frac{kQQ}{s}\left(1 + 1 + \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} + 1 + 1\right)$$

$$= 5.414\,\frac{kQ^2}{s}$$

7.

a)



$$|\vec{F_1}| = \frac{k q_1 q_2}{d^2}$$

$$\vec{F}_{net} = \vec{F_1} - \vec{F_1} = 0$$

b)

$$\vec{E} = \frac{\vec{F}}{\;} = 0$$

ii) q_2

c) $$V_0 = \frac{kq_1}{d^2} + \frac{kq_1}{d^2}$$

$$= \frac{2kq_1}{d^2} = 33700\,V$$

$$= \underline{\underline{33.7\,kV}}$$

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

$d = 0.8\,m$