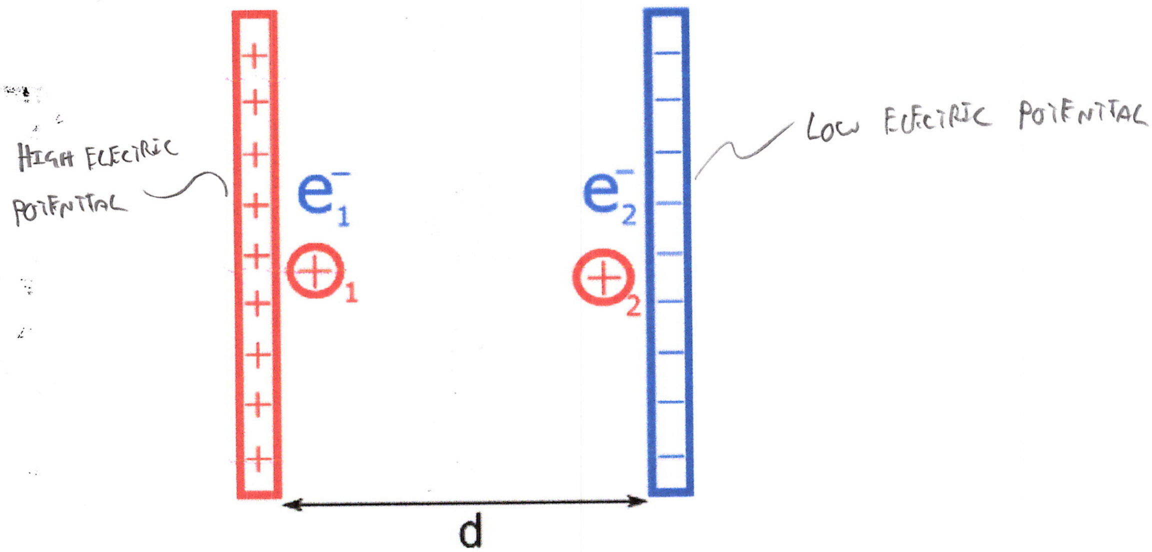
ELECTRIC FIELDS & POTENTIALS: ELECTRIC POTENTIAL - FUNDAMENTAL EXAMPLE SOLUTIONS

(1)

a)



$$\sum E_i + \cancel{W^{NC}}^{\,0} = \sum E_f$$

$$KE_i + U_i^E = KE_f + U_f^E$$

$$-\Delta KE = \Delta U^E$$

* $\oplus$ IS REPELLED BY POSITIVE SIDE, SO ITS SPEED INCREASES, THUS KE INCREASES AS IT MOVES FROM POSITIVE SIDE TO NEGATIVE SIDE. IF KE $\uparrow$ THEN $U^E \downarrow$

* e^- IS REPELLED BY NEGATIVE SIDE, SO ITS SPEED INCREASES, THUS KE INCREASES AS IT MOVES FROM NEGATIVE SIDE TO POSITIVE SIDE. IF KE $\uparrow$ THEN $U^E \downarrow$

b) LOW ELECTRIC POTENTIAL ENERGE

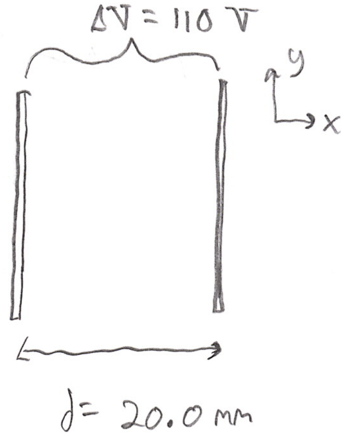
c) HIGH ELECTRIC POTENTIAL ENERGY

d) HIGH ELECTRIC POTENTIAL ENERGY

e) LOW ELECTRIC POTENTIAL ENERGY

(2)

a)



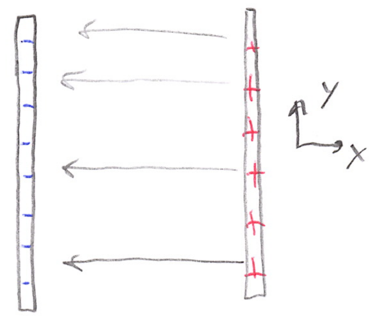
$$|E_x| = \left|\frac{-\Delta V}{\Delta x}\right|$$

$$|E_x| = \left|-\frac{110\ V}{20\times10^{-3}\ m}\right|$$

$$|E_x| = 5500\ \frac{V}{m}$$

b)

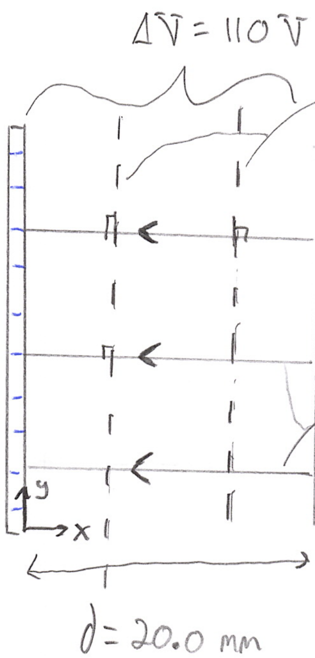
IF...



THEN $\vec{E}$ ⟵

$$\vec{E} = \langle -5500, 0\rangle\ \frac{V}{m}$$

c)



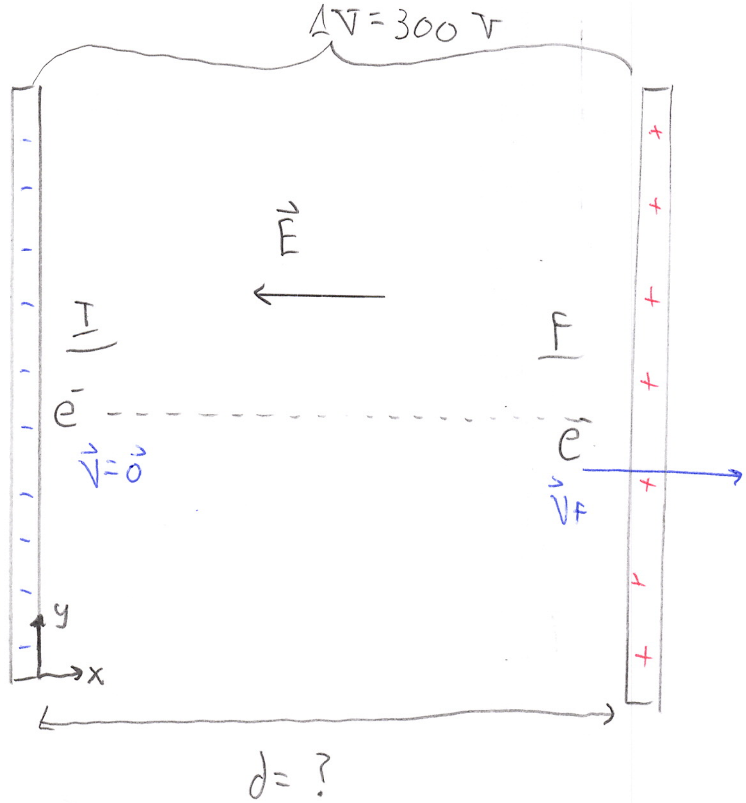
DASHED LINES... EQUIPOTENTIAL LINES

⊥ TO E-FIELD LINES

ELECTRIC FIELD LINES

$$\vec{E} = \langle -5500, 0\rangle\ \frac{V}{m}$$

(3)



SYSTEM: e^- + CHARGE DISTRIBUTION

$$\Sigma E_i + \cancel{W^{NC}}^{\,0} = \Sigma E_f$$

$$\cancel{KE_i}^{\,0} + U_i^E = KE_f + U_f^E$$

$$-KE_f = \Delta U^E \qquad V \equiv \frac{U^E}{q}$$

$$-KE_f = q\Delta V$$

$$-KE_f = -e\Delta V$$

$$\frac{1}{2} m_{e^-} v^2 = e\Delta V$$

$$v = \sqrt{\frac{2e\Delta V}{m_{e^-}}} = \sqrt{\frac{2(1.602\times10^{-19}\,C)(300\ V)}{9.11\times10^{-31}\,kg}} \approx 10271826.91\ m/s$$

$$v \approx 1.03\times10^{7}\ m/s$$

FAST!

$\frac{v}{c} \times 100 = 3.4\%$ SPEED OF LIGHT

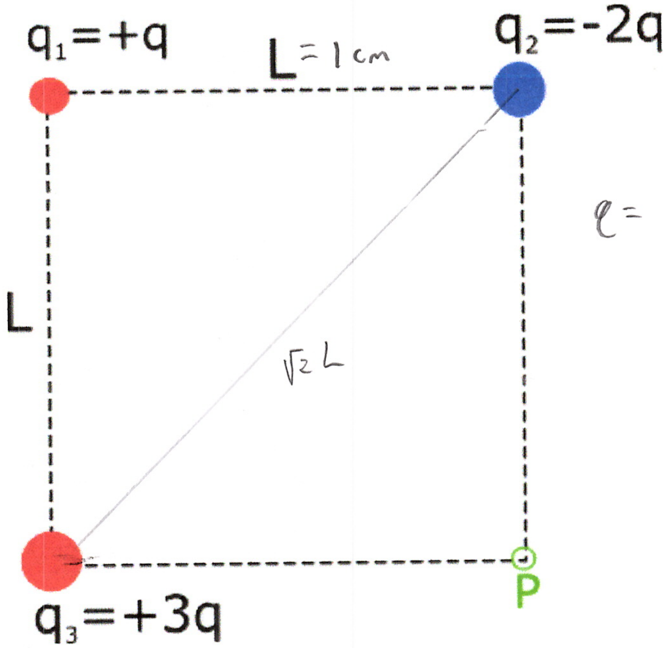
(4)

a) * NOTE:

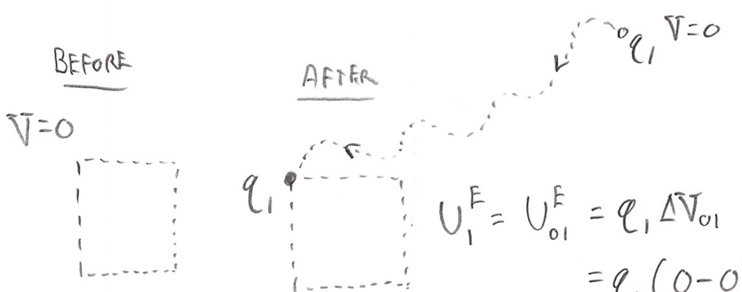
$$W^E = -\Delta U^E$$

... SO IN A SENSE WE ARE FINDING THE WORK REQUIRED TO "BUILD" THE DISTRIBUTION OF CHARGES.

$$U^E_{system} = ?$$



STEP 1: BRING q_1 IN FROM VERY FAR AWAY



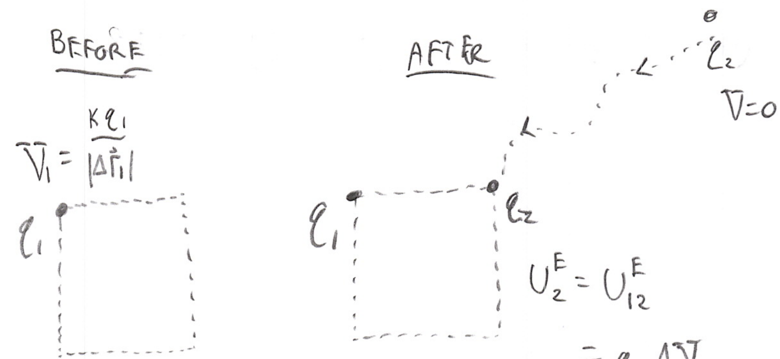
$$U^E_1 = U^E_{01} = q_1 \Delta V_{01}$$

$$= q_1(0-0)$$

$$U^E_1 = 0$$

WORK REQUIRED TO BRING 1^{st} CHARGE INTO A REGION OF NO CHARGES.

STEP 2: BRING q_2 IN FROM VERY FAR AWAY



$$U^E_2 = U^E_{12}$$

$$= q_2 \Delta V_{12}$$

$$= q_2\left(\frac{kq_1}{|\Delta \vec{r}_{12}|}\right)$$

$$U^E_2 = \frac{kq_1q_2}{|\Delta \vec{r}_{12}|}$$

WORK REQUIRED TO BRING 2^{ND} CHARGE INTO LOCATION IN THE PRESENCE OF THE 1^{ST} CHARGE

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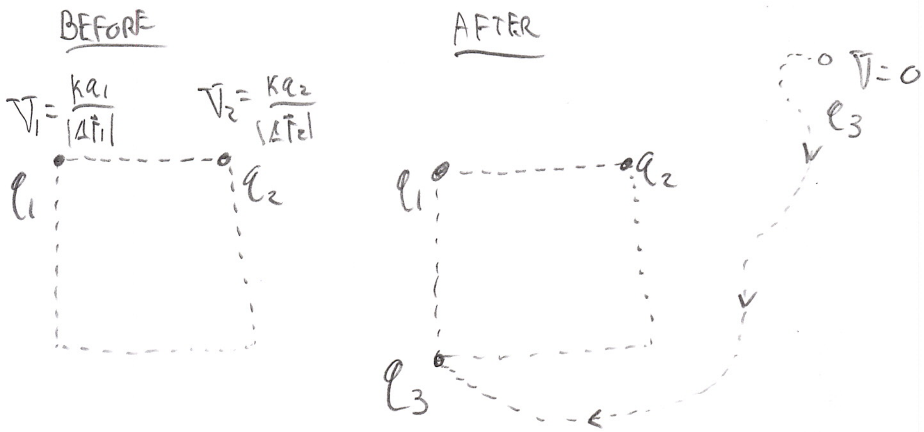
STEP 3: BRING IN q_3 FROM VERY FAR AWAY



$$U^E_3 = U^E_{13} + U^E_{23}$$

$$= q_3 \Delta V_{13} + q_3 \Delta V_{23}$$

$$U^E_3 = \frac{kq_1q_3}{|\Delta \vec{r}_{13}|} + \frac{kq_2q_3}{|\Delta \vec{r}_{23}|}$$

WORK REQUIRED TO BRING 3RD CHARGE INTO LOCATION IN THE PRESENCE OF BOTH THE 1ST AND 2ND CHARGE.

...SO... $U^E_{SYSTEM} = U^E_1 + U^E_2 + U^E_3$

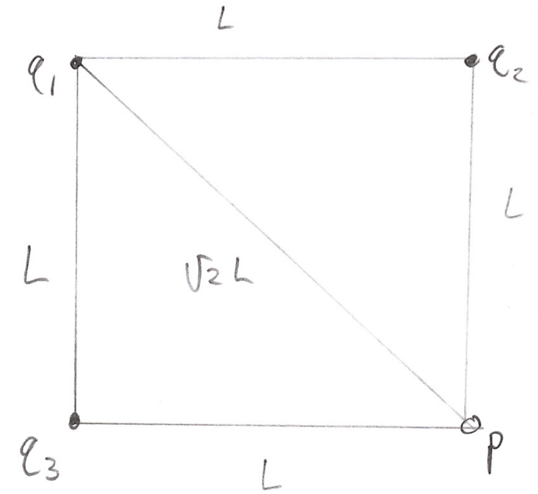
$$= 0 + \frac{kq_1q_2}{|\Delta \vec{r}_{12}|} + \frac{kq_1q_3}{|\Delta \vec{r}_{13}|} + \frac{kq_2q_3}{|\Delta \vec{r}_{23}|}$$

$$= \frac{k(q)(-2q)}{L} + \frac{k(q)(3q)}{L} + \frac{k(-2q)(3q)}{\sqrt{2}L}$$

$$= -\frac{2kq^2}{L} + \frac{3kq^2}{L} - \frac{6kq^2}{\sqrt{2}L}$$

$$U^E_{SYSTEM} = \frac{kq^2}{L}\left(1 - \frac{6}{\sqrt{2}}\right) \approx -2.92 \text{ J}$$

b)



$$V(P) = V_1(P) + V_2(P) + V_3(P)$$

$$V(P) = \frac{kq_1}{|\Delta\vec{r}_{1P}|} + \frac{kq_2}{|\Delta\vec{r}_{2P}|} + \frac{kq_3}{|\Delta\vec{r}_{3P}|}$$

$$= \frac{kq}{\sqrt{2}L} - \frac{2kq}{L} + \frac{3kq}{L}$$

$$V(P) = \frac{kq}{L}\left(\frac{1}{\sqrt{2}} + 1\right) \simeq 1.54 \times 10^6 \text{ V}$$