Phy 4B 5/11

Thursday, May 11, 2017 5:22 PM

Goals for the Lecture:

1) Understand what a dielectric is and how it changes capacitance
2) Understand the difference of making changes to a capacitor while it is connected to a power source and when it is disconnected from its power source

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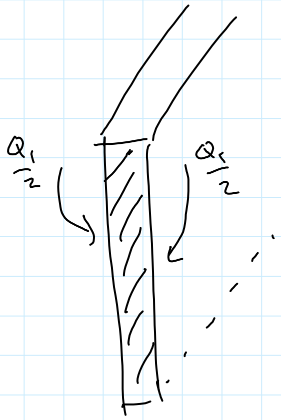
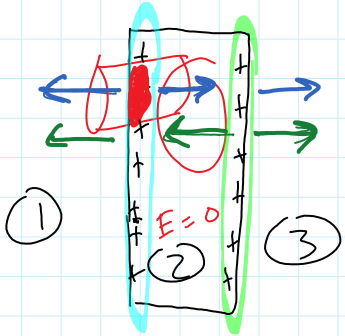
Worksheet
p. 79

1) A)

$\sigma = \frac{Q_1}{2A_1}$



B)



yes, E = 0 inside a conductor

c)

$E_{Lf} = \frac{\sigma_{Lf}}{2\epsilon_0}$ $E_{Rt} = \frac{\sigma_{Rt}}{2\epsilon_0}$

$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$

$EA + 0 + EA = \frac{q_{in}}{\epsilon_0}$

$E = \frac{q_{in}}{2\epsilon_0 A}$

$= \frac{\sigma_{Lf}}{2\epsilon_0}$

$\sigma_{Lf} = \frac{Q_1}{2A_1}$

Right side

Same

$$\frac{Q_1}{2A_1}$$

$$E_{Lf} = \frac{Q_1}{4\epsilon_0 A_1} = \frac{\sigma_{Lf}}{2\epsilon_0} \quad \Big| \quad E_{Rt} = \frac{Q_1}{4\epsilon_0 A_1} = \frac{\sigma_{Rt}}{2\epsilon_0}$$

In region ① : (to the left of the plate):

$$E_{total} = \vec{E}_{Lf} + \vec{E}_{Rt} \qquad \rightarrow +$$

$$= -\left(\frac{Q_1}{4\epsilon_0 A_1}\right) - \left(\frac{Q_1}{4\epsilon_0 A_1}\right)$$

$$= -2\left(\frac{Q_1}{4\epsilon_0 A_1}\right) = -2\frac{\sigma}{2\epsilon_0}$$

In Region ② : (Inside the conductive plate)!

$$E_{total} = \vec{E}_{Lf} + \vec{E}_{Rt} \qquad \rightarrow +$$

$$= +\frac{Q_1}{4\epsilon_0 A_1} - \frac{Q_1}{4\epsilon_0 A_1}$$

$$= 0$$

In Region ③ : (Rt side of plate)

$$E_{total} = +2\frac{Q_1}{4\epsilon_0 A_1} = 2\frac{\sigma}{2\epsilon_0}$$

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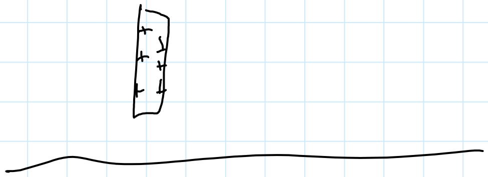
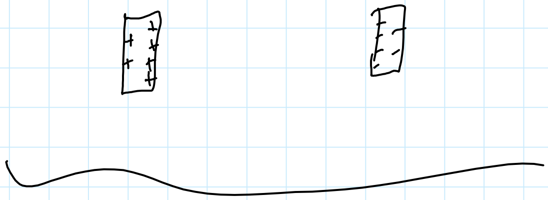
p. 80 D) $\sigma' = \frac{Q_1}{A_1}$

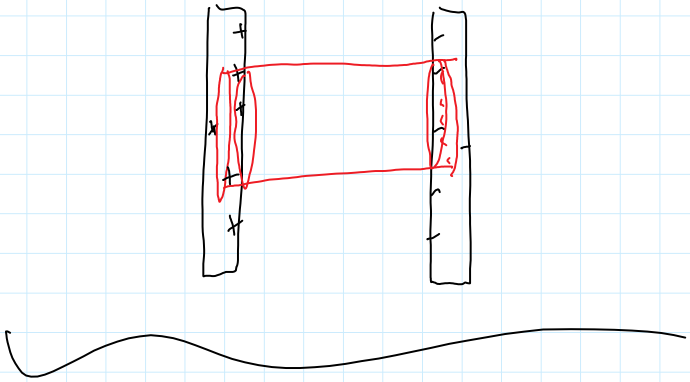
$$\sigma' = 2\sigma$$

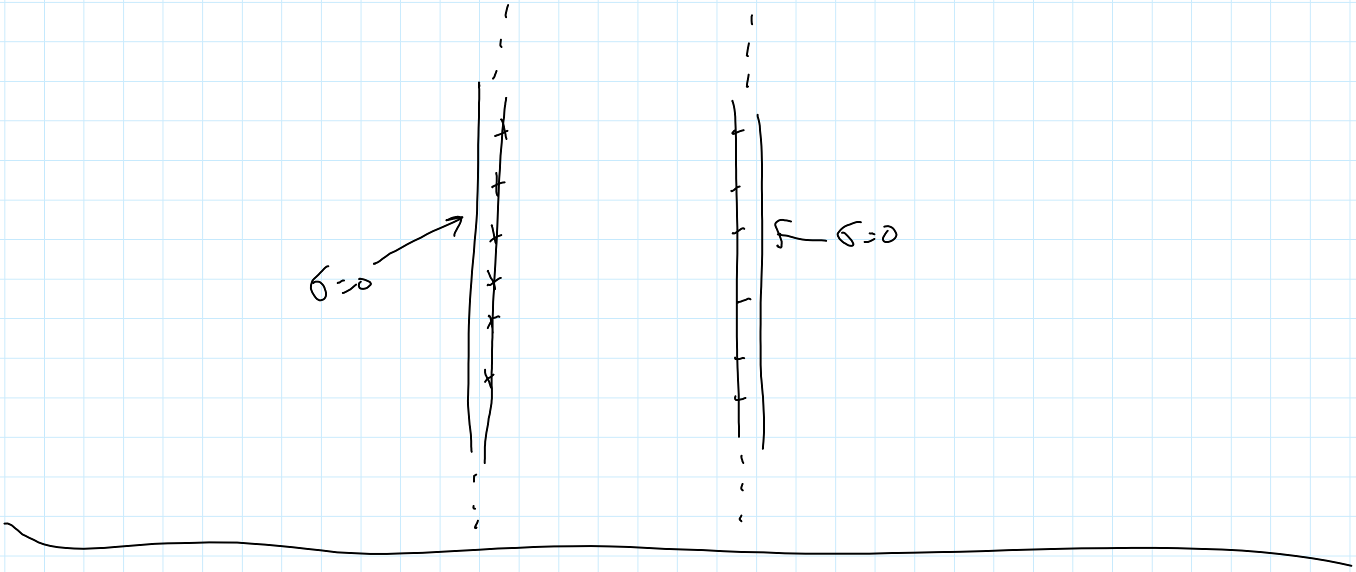
$$E_{insulator} = E_{conductor}$$

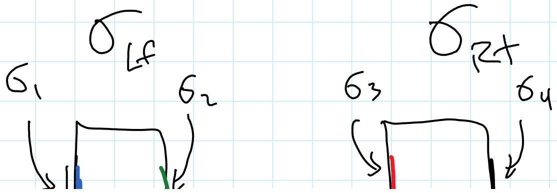
E)

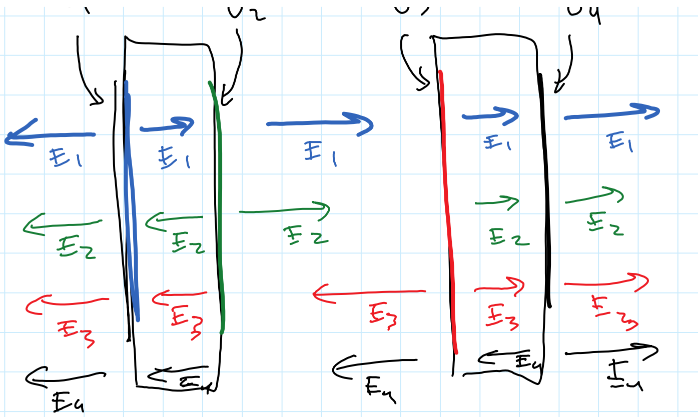












1) $\boxed{\sigma_1+\sigma_2=\sigma_{Lf}}$ ← given value

2) $\boxed{\sigma_3+\sigma_4=\sigma_{Rt}}$

3) $\boxed{\sigma_2=-\sigma_3}$

4) E = 0 inside conductor

$$E_1-E_2-E_3-E_4=0$$

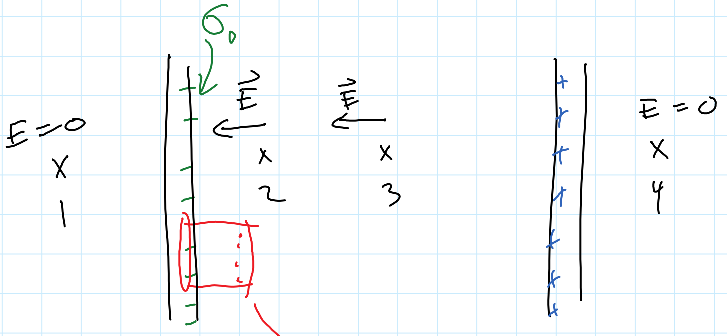
$$\frac{\sigma_1}{\cancel{2\epsilon_0}}-\frac{\sigma_2}{\cancel{2\epsilon_0}}-\frac{\sigma_3}{\cancel{2\epsilon_0}}-\frac{\sigma_4}{\cancel{2\epsilon_0}}=0$$

$$\boxed{\sigma_1-\sigma_2-\sigma_3-\sigma_4=0}$$

4 equations

p. 81 A)

1)



2) $E_1=0$

$E_4=0$

$E_2=E_3=\frac{\sigma_0}{\epsilon_0}$ ←

$$\oint\vec{E}\cdot d\vec{A}=\frac{q_{in}}{\epsilon_0}$$

$$\int\vec{E}\cdot d\vec{A}+\int\vec{E}\cdot d\vec{A}+\int\vec{E}\cdot d\vec{A}=\frac{q_{in}}{\epsilon_0}$$

$$\underbrace{\int_{Lf} \vec{E}\cdot d\vec{A}}_{0} + \underbrace{\int_{side} \vec{E}\cdot d\vec{A}}_{0} + \underbrace{\int_{Rt} \vec{E}\cdot d\vec{A}}_{EA} = \frac{q_{in}}{\epsilon_0}$$

$$EA = \frac{q_{in}}{\epsilon_0}$$

$$E = \frac{q_{in}}{A}\frac{1}{\epsilon_0}$$

$$= \frac{\sigma_0}{\epsilon_0}$$

$$\Delta V = -E\,d$$

$$|\Delta V| = E\,D = \frac{\sigma_0 D}{\epsilon_0}$$

3) σ → same

E → same

ΔV → smaller

p. 82 4) $E = \frac{\sigma_0}{\epsilon_0}$ ← $\sigma_0 = \epsilon_0 E$

$$V = \frac{\sigma_0 D}{\epsilon_0}$$

5) $$\frac{Q}{\Delta V} = \frac{Q}{\frac{\sigma_0 D}{\epsilon_0}} = \frac{\cancel{\sigma_0} A}{\frac{\cancel{\sigma_0} D}{\epsilon_0}} = \frac{\epsilon_0 A}{D}$$

it would Not change

B) 1) $\Delta V = V_0$

$E_2 = E_3 = \frac{V_0}{D}$ $E_1 = E_4 = 0$

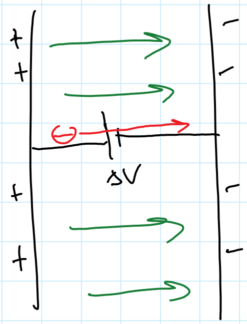
$\sigma = \frac{V_0 \epsilon_0}{D}$

p. 83

2) $\Delta V \to$ same

$E \to$ increases

$\sigma \to$ increases



$Q = CV$

3) $E = \frac{V_0}{d}$

$\sigma = \frac{V_0 \epsilon_0}{d}$

4) $\frac{Q}{\Delta V} = \frac{\sigma A}{\frac{\sigma d}{\epsilon_0}} = \boxed{\frac{\epsilon_0 A}{d}} = C_{\text{parallel plate}}$

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p. 84

1) No

2) yes

D) 1) $Q \to$ same

$\sigma \to$ same

$E \to$ same $\quad E = \frac{\sigma}{\epsilon_0}$

$\Delta V \to$ increases

$C \to$ decreases

2) $Q \to$ decreases $\quad Q = \underset{\uparrow}{C}\,\underset{\uparrow\ \text{same}}{V}$

2)

$Q \rightarrow$ decreases

$\sigma \rightarrow$ decrease

$E \rightarrow$ decreases

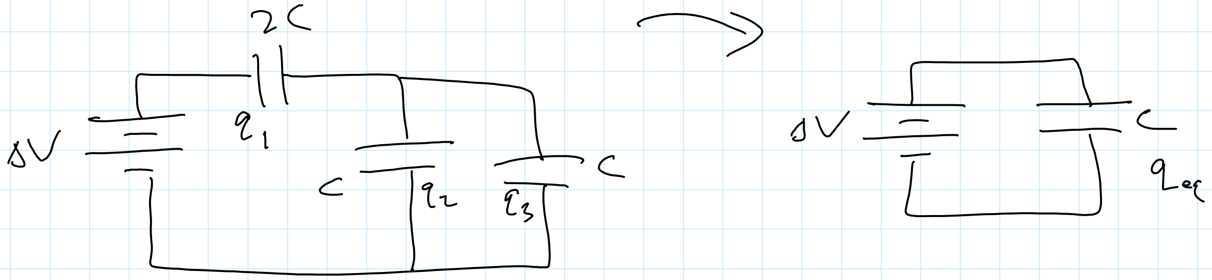
$\Delta V \rightarrow$ same

$C \rightarrow$ decreases

$$Q = \underset{\text{decreases}}{\underset{\uparrow}{C}}\ \underset{\text{same}}{\underset{\uparrow}{V}}$$

From last time:

Find q and ΔV for every capacitor:



Let $C = 1\text{ F}$

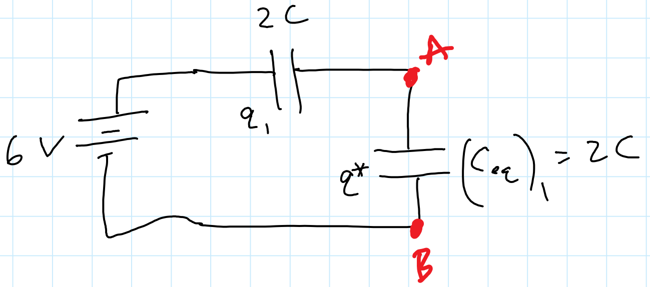
$\Delta V = 6\text{ V}$

$$q_{eq} = C_{eq} V$$
$$= (1\text{ F})(6\text{ V})$$
$$= 6\text{ C}$$

2 in Series

$q_1 = q^* = q_{total}$

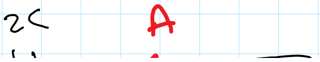
$q_1 = q^* = 6\text{ C}$

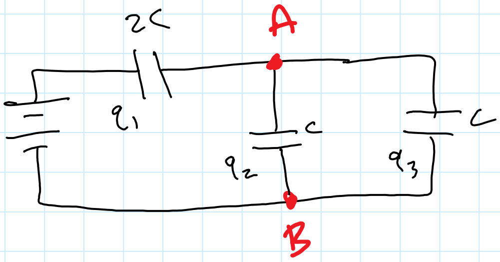


Since $q_1 = C_1 V_1$

$(6\text{ C}) = (2\text{ F})\ V$

$\underline{V_1 = 3\text{ Volts} = V^*}$



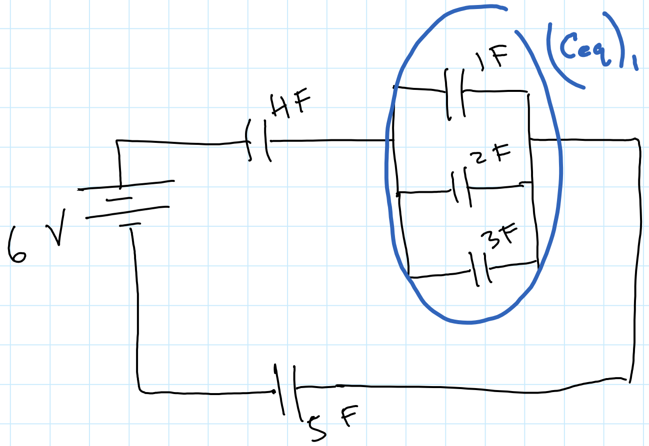


$$V_2 = V_3 = V^* = 3\ V$$

$$q_2 = C_2 V_2 = (1\ F)(3\ V) = 3\ C$$

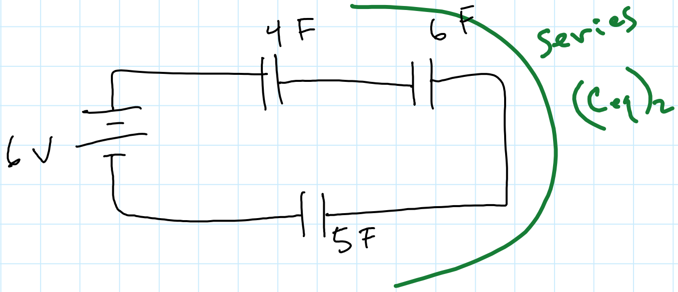
$$q_3 = C_3 V_3 = (1\ F)(3\ V) = 3\ C$$

Find Q and ΔV for every capacitor:



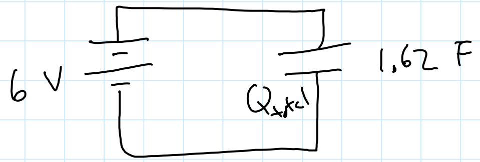
$$(C_{eq})_1 = (1\ F) + (2) + (3) = 6\ F$$

$$\Downarrow$$



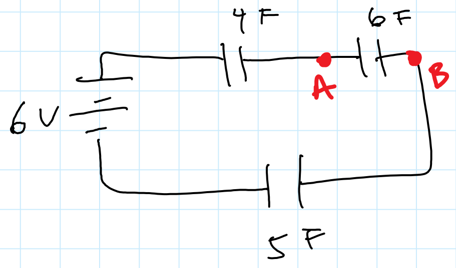
$$\frac{1}{(C_{eq})_2} = \frac{1}{4} + \frac{1}{5} + \frac{1}{6}$$

$$(C_{eq})_2 = 1.62\ F$$



$$Q = C V$$

$$Q_{total} = (1.62)(6) = 9.73 \text{ C}$$



$$Q_4 = Q_6 = Q_5 = Q_{total} = 9.73 \text{ C}$$

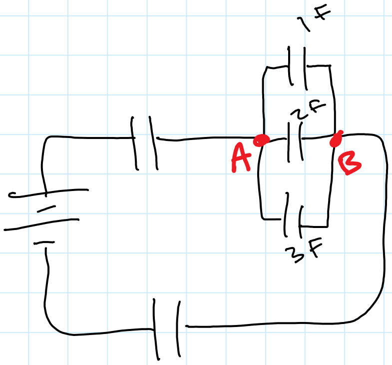
$$V_4 = \frac{Q_4}{C_4} = \frac{9.73}{4} = 2.43 \text{ V}$$

$$V_5 = \frac{Q_5}{C_5} = \frac{9.73}{5} = 1.95 \text{ V}$$

$$V_{AB} = V_6 = \frac{Q_6}{C_6} = \frac{9.73}{6} = 1.62 \text{ V}$$

$$\overline{\quad 6.0 \text{ V} \quad}$$

good ✓



$$V_1 = V_2 = V_3 = V_6 = 1.62 \text{ V}$$

$$Q_1 = C_1 V_1 = (1)(1.62) = 1.62 \text{ C}$$

$$Q_2 = C_2 V_2 = 2(1.62) = 3.24 \text{ C}$$

$$Q_3 = C_3 V_3 = 3(1.62) = 4.86 \text{ C}$$

$$\overline{\quad 9.72 = Q_6 \quad}$$

good ✓