Continuing with chapter 8

Super Wednesday bonus fun

How does the magnitude of the charge change, from Case a to Case b?

i) inserting dielectric causes induced polarization within
→ ability to attract more charge

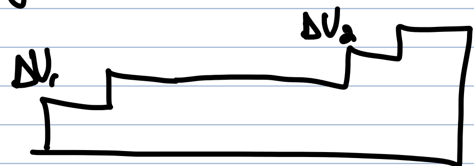
ii) compute $Q = C\Delta V$

Case a potential difference across each capacitor is $\Delta V/2$

$$Q = C_1 \Delta V_1 = C_2 \Delta V_2 = C_1 \frac{\Delta V}{2} = C_2 \frac{\Delta V}{2}$$

alternatively, $\Delta V = \Delta V_1 + \Delta V_2$

imagine 2 sets of stairs:



$\Delta V = \Delta V_1 + \Delta V_2$

$$\Delta V = \frac{Q}{C_1} + \frac{Q}{C_2} \Rightarrow \frac{\Delta V}{Q} = \boxed{\frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{C_{eq}}}$$

series

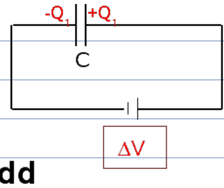
$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} \xrightarrow[C_1 = C_2 = C]{} \frac{C}{2}$$

Case b:

$$C_{eq} = \frac{kC^2}{kC + C} = \frac{kC}{k+1} = \frac{C}{\frac{1}{k}+1} > \frac{C}{2} \text{ since } k > 1$$

also: $Q_{case\ b} = \frac{kC}{k+1} \Delta V > Q_{case\ a} = \frac{C}{2}\Delta V$

One capacitor, one battery:



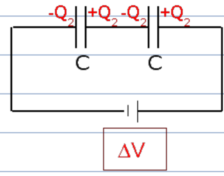
How are the various charges related if I add an exact copy of the capacitor in series?

a) $Q_1 = Q_2$

b) $Q_1 > Q_2$

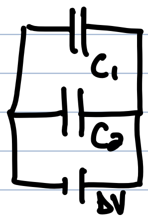
c) $Q_1 < Q_2$

d) $Q_1 = \{Q_2 + 42\}^{1/2}$



$C_{eq} = \frac{C}{2} \Rightarrow Q = \frac{C}{2}\Delta V$

Capacitors in parallel



They have the same potential "drop"

we know $\Delta V_1 = \Delta V_2 = \Delta V$

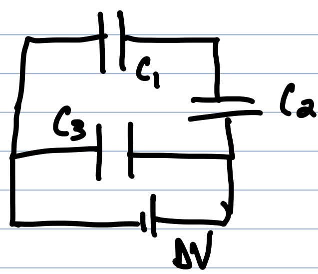
$\Delta V_1 = Q/C_1$, $\Delta V_2 = Q/C_2$, $\Delta V = Q_2/C_{eq}$

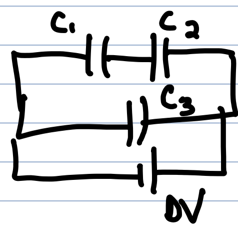
also know $Q_{tot} = Q_1 + Q_2 = C_1 \Delta V_1 + C_2 \Delta V_2 = C_1 \Delta V + C_2 \Delta V$

$\longrightarrow \boxed{C_1 + C_2 = Q/\Delta V = C_{eq}}$

parallel

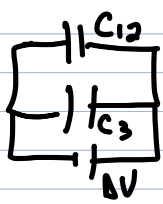
Different capacitor combinations



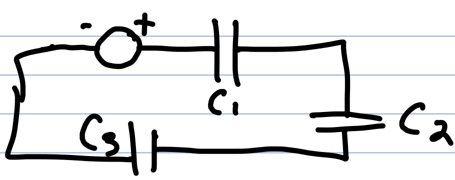


C_1 & C_2 in series

$\longrightarrow C_{12} = \frac{C_1 C_2}{C_1 + C_2}$

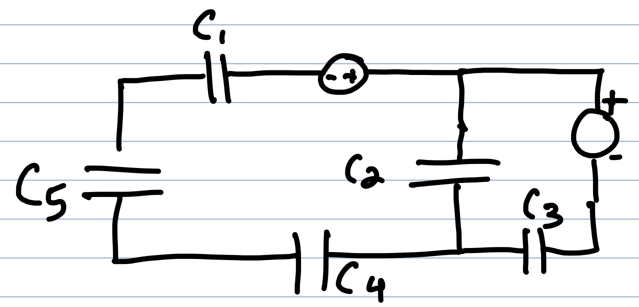


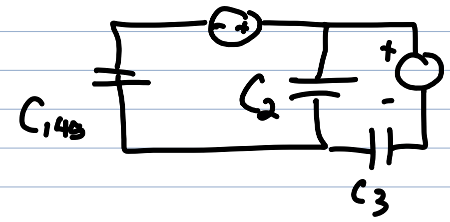
and C_{12} in parallel with $C_3 \Rightarrow C_{123} = C_{12} + C_3$



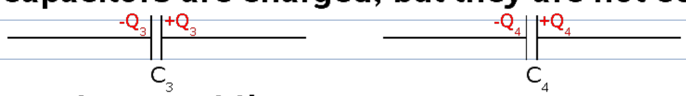
$C_{123}^{-1} = \cancel{C_1 + C_2 + C_3} = C_1^{-1} + C_2^{-1} + C_3^{-1}$

$= \cancel{\frac{C_1 C_2 C_3}{C_1 + C_2 + C_3}}$

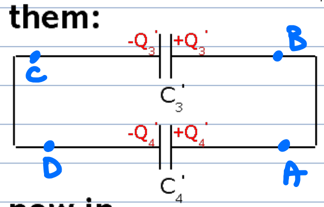




Two capacitors are charged, but they are not connected:



Suppose I connect them:



Concept Q #3

parallel b/c $V_A - V_D = V_B - V_C$

The capacitors are now in
a) series
b) parallel ✓ awesome effort!

Q: What is $V_B - V_C$?

$C_{eq} = C_3' + C_4' = C_3 + C_4$ (capacitances haven't changed)

$Q_{total} = Q_3' + Q_4' = Q_3 + Q_4$ (conservation of charge)

and since $\frac{Q_{tot}}{C_{eq}} = \Delta V$ and $\Delta V = V_B - V_C = V_A - V_D$

$$\Longrightarrow V_B - V_C = \frac{Q_3 + Q_4}{C_3 + C_4}$$

Q: what are Q_3' and Q_4' ?

$$Q_3' = C_3'(V_B - V_C) = C_3\left(\frac{Q_3 + Q_4}{C_3 + C_4}\right)$$

$$Q_4' = C_4'(V_A - V_D) = C_4\left(\frac{Q_3 + Q_4}{C_3 + C_4}\right)$$

Numbers: $C_3 = 2\mu F$ $\quad C_4 = 4\mu F$
$Q_3 = 24\mu C$ $\quad Q_4 = 12\mu C$
$V_3 = 12V$ $\quad V_4 = 3V$

$$Q_3' = 2\mu F \frac{36\mu C}{6\mu F} \qquad Q_4' = 4\mu F \frac{36\mu C}{6\mu F}$$

$$= 12\mu C \qquad\qquad = 24\mu C$$

($V_3' = 6V$ and $V_4' = 6V \Rightarrow$ parallel)

work on tutorial pp 94 (2^{nd} half), 95, 96