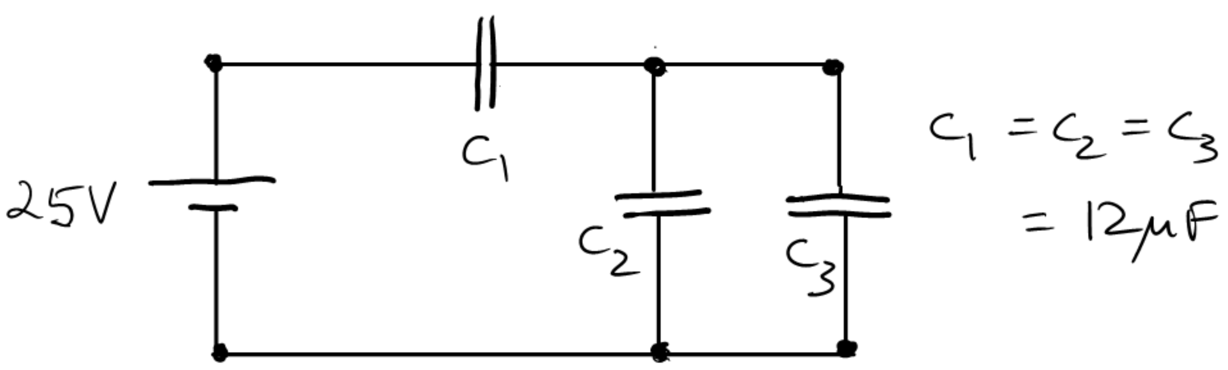
PhysicsTutor

Capacitor network

Problem:

- What is the potential drop across the first capacitor C_1?



Relevant ideas:

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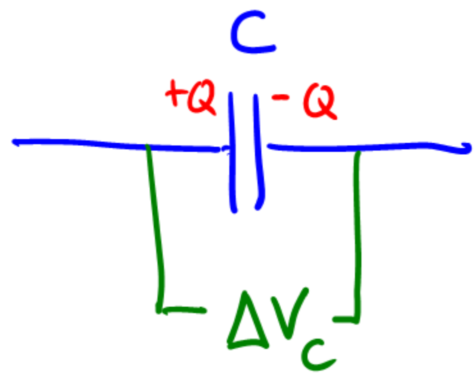
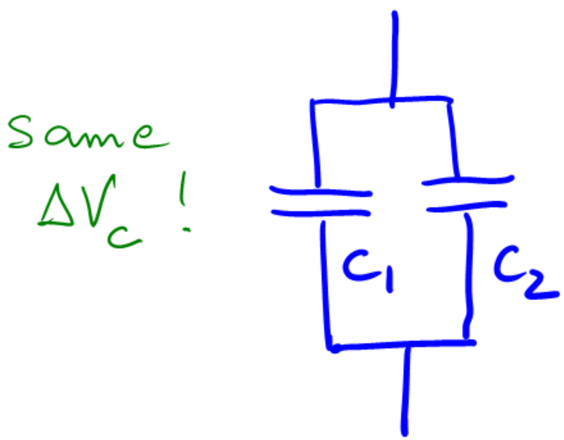
- Voltage-charge relationship: $\Delta V_C = Q/C$.

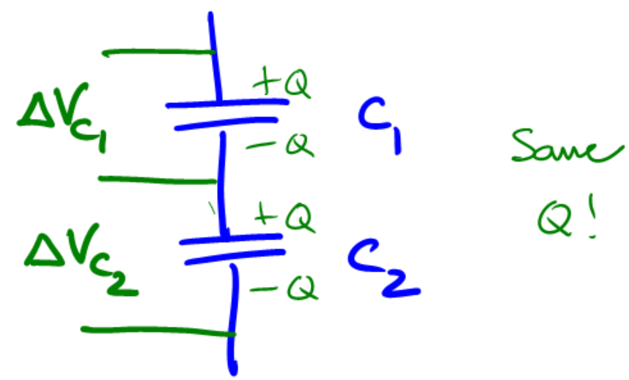


Relevant ideas:

- Voltage-charge relationship: $\Delta V_C = Q/C$.
- Equivalent capacitance for series and parallel capacitor combinations.



$$C_{eq} = C_1 + C_2$$



$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

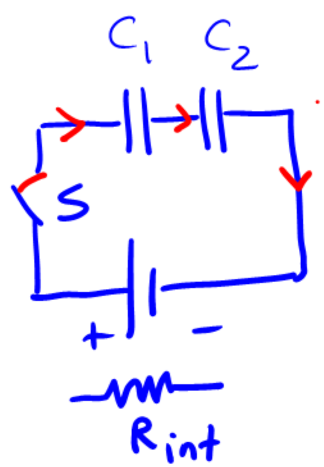
$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

Relevant ideas:

- Voltage-charge relationship: $\Delta V_C = Q/C$.
- Equivalent capacitance for series and parallel capacitor combinations.
- Series capacitors are charged to the same Q, since the same current passes through them.

time scale for charge current::

$\tau = R_{int} \cdot C_{eq}$.



switch closes:

current flows for a short time to displace charge Q

→ charge displacement is the same for C_1, C_2

Equations associated with ideas:

$$C_{23}^{eq} = C_2 + C_3$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_{23}^{eq}}$$

$$\Delta V_C = \frac{Q}{C}$$

$$\Delta V_B + \Delta V_1 + \Delta V_{23^{eq}} = 0$$

Strategy

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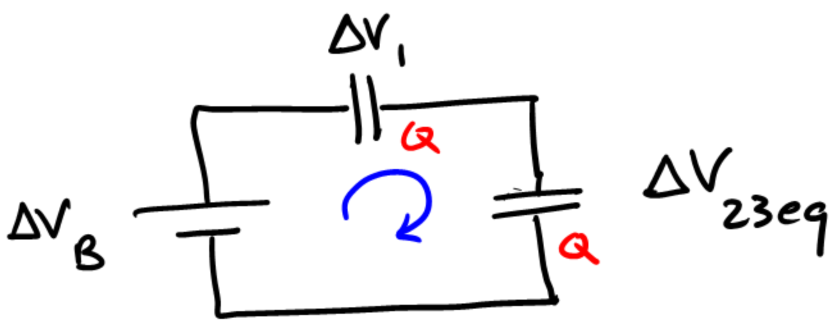
- The series capacitor circuit splits the battery to different voltage drops.



$$\Delta V_B + \Delta V_1 + \Delta V_{23eq} = 0$$

Strategy

- Replace the parallel pair by a single capacitor with the capacitances added.
- The series capacitor circuit splits the battery to different voltage drops.
- The charge is the same in both series-connected capacitors, this allows to determine the voltage split.

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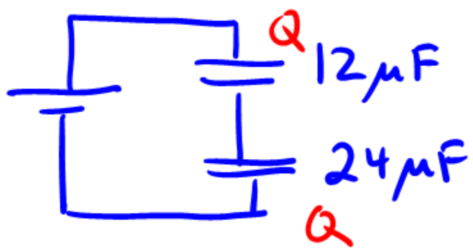
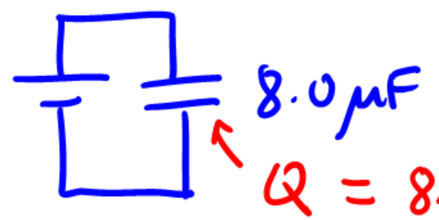
- $C_{23}^{eq} = (12 + 12)\,\mu F = 24\,\mu F$
- $C_{eq} = \dfrac{C_{23}^{eq} \cdot C_1}{C_{23}^{eq} + C_1} = \dfrac{24 \cdot 12}{24 + 12}\,\mu F = 8.0\,\mu F$





$Q = 8.0\,\mu F \cdot \Delta V_B$

Solution

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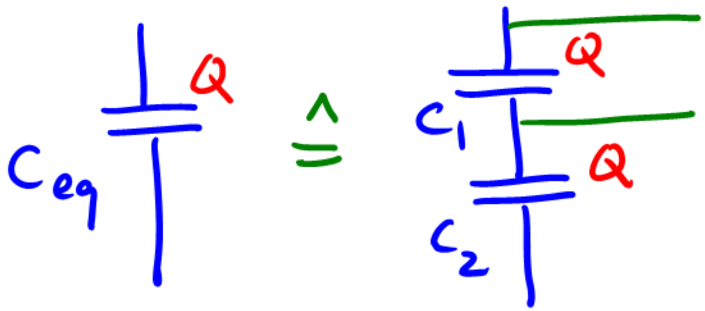
- $C_{eq} = \dfrac{C_{23}^{eq} \cdot C_1}{C_{23}^{eq} + C_1} = \dfrac{24 \cdot 12}{24 + 12}\,\mu F = 8.0\,\mu F$
- $Q = C_{eq}\,\Delta V_B = 8.0 \times 10^{-6} \cdot 25\ FV = 2.0 \times 10^{-4}\,C$



$\Delta V_1 = \dfrac{Q}{C_1}$

Solution

- $C_{23}^{eq} = (12 + 12)\,\mu F = 24\,\mu F$
- $C_{eq} = \dfrac{C_{23}^{eq} \cdot C_1}{C_{23}^{eq} + C_1} = \dfrac{24 \cdot 12}{24 + 12}\,\mu F = 8.0\,\mu F$
- $Q = C_{eq}\,\Delta V_B = 8.0 \times 10^{-6} \cdot 25\ FV = 2.0 \times 10^{-4}\,C$
- $\Delta V_1 = \dfrac{Q}{C_1} = \dfrac{2.0 \times 10^{-4}\,C}{12 \times 10^{-6}\,F} = 16.7\,V = 17.0\,V$

cross check: $\Delta V_2 = \dfrac{Q}{C_2} = \dfrac{2 \times 10^{-4}\,C}{24\,\mu F} = 8.33\,V$

$= (25 - 16.67)\,V$ ✓