# PHYS102 - Capacitors

Dr. Suess

February 16, 2007

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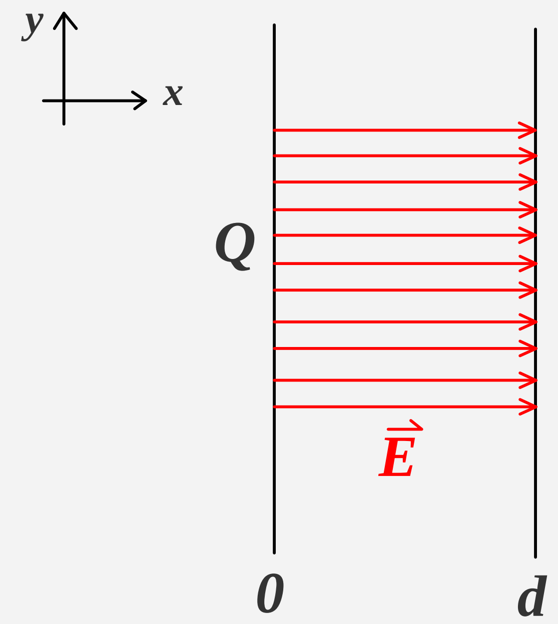

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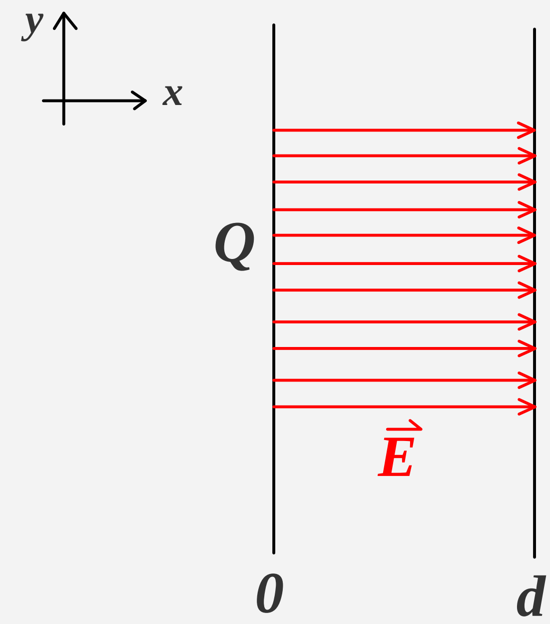

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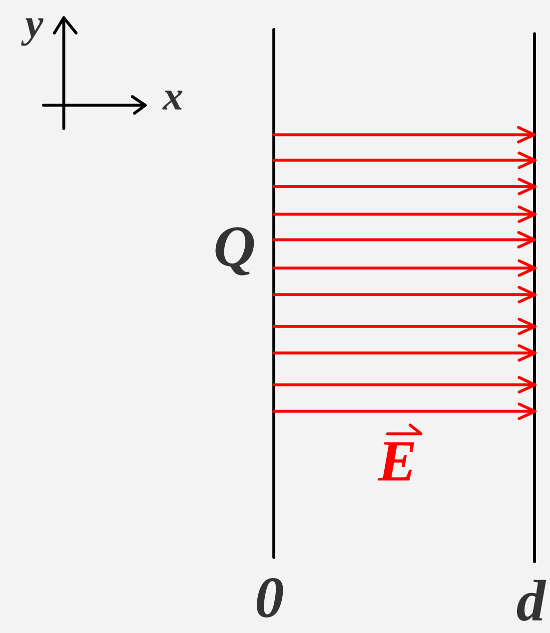

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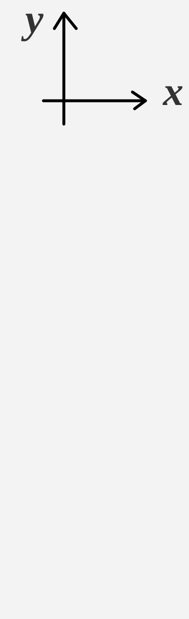

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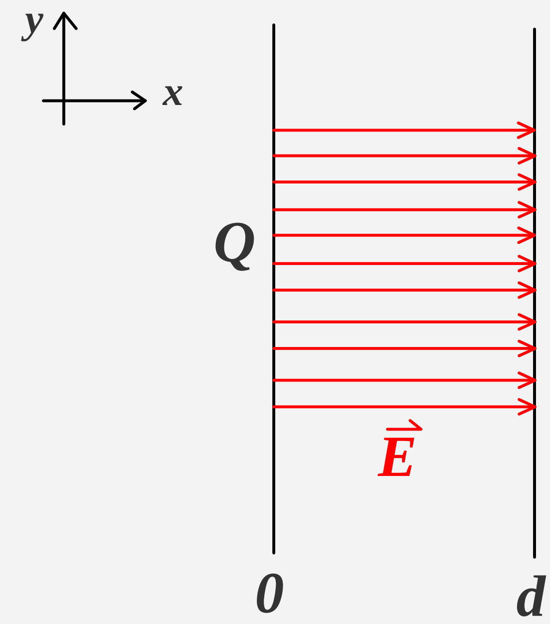

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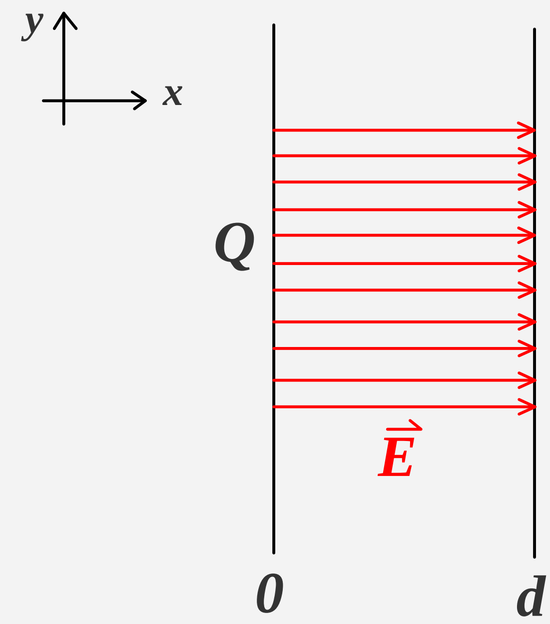

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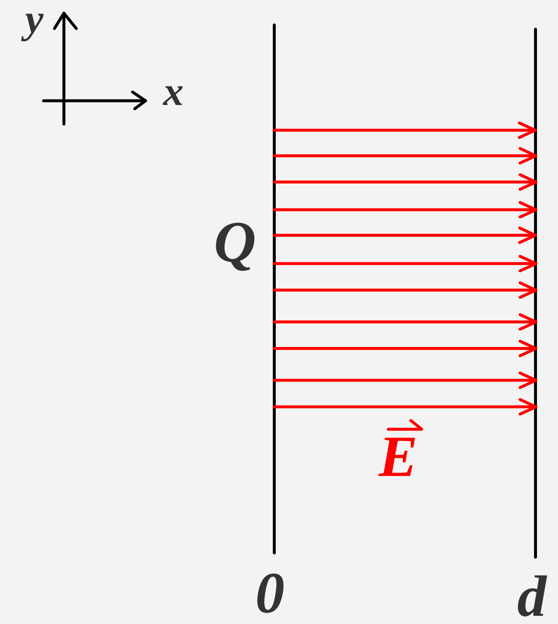

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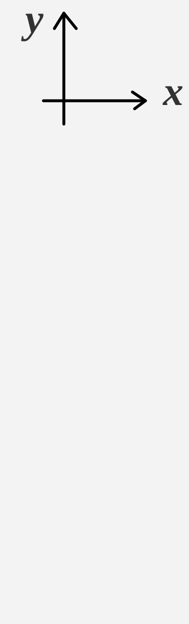

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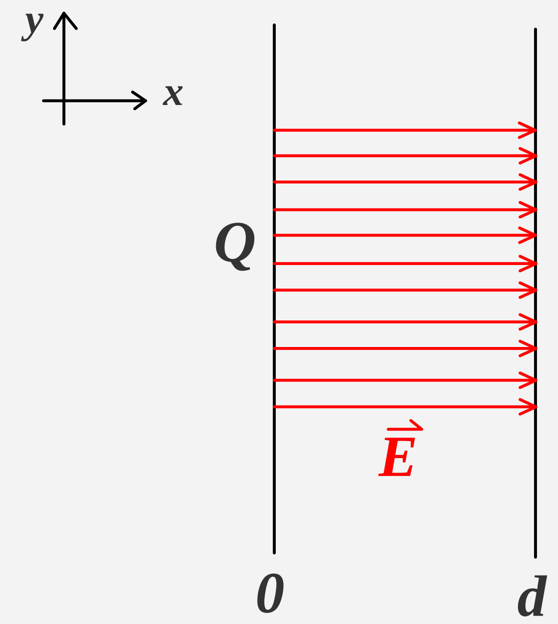

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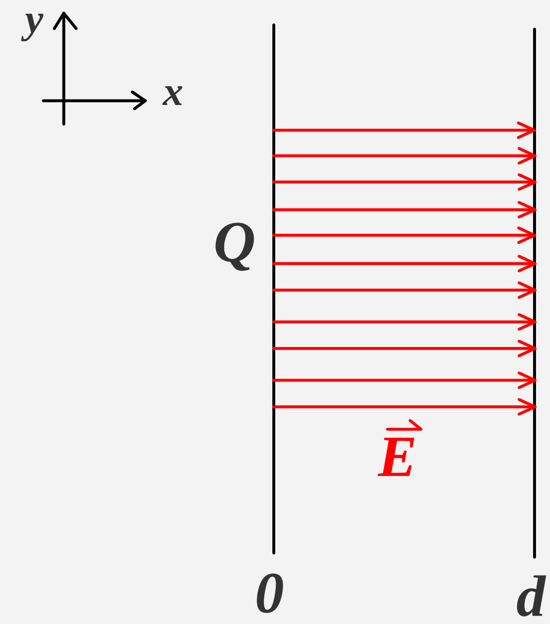

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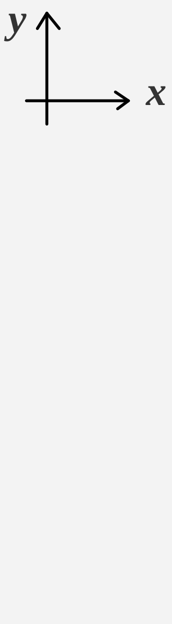

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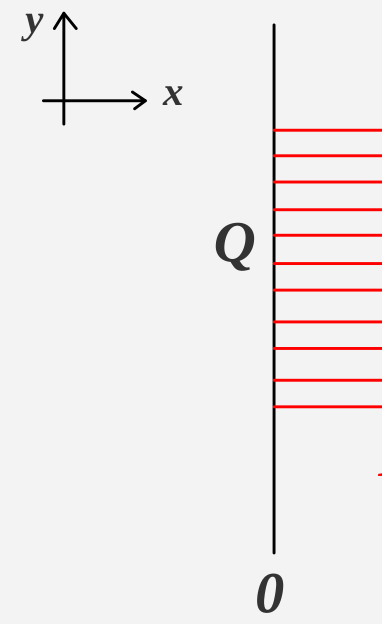

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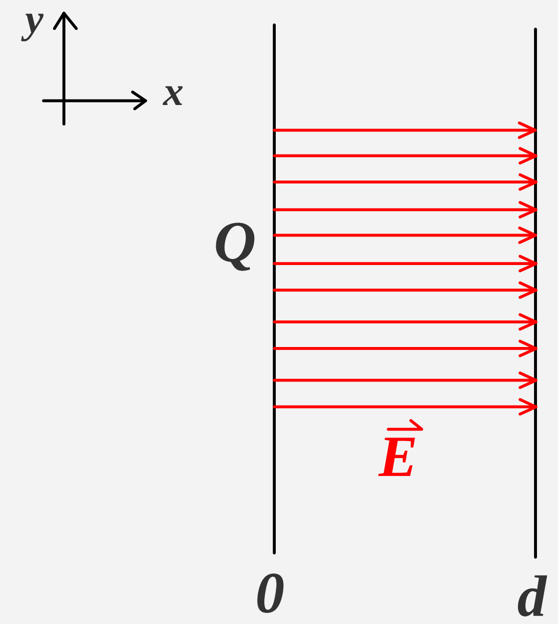


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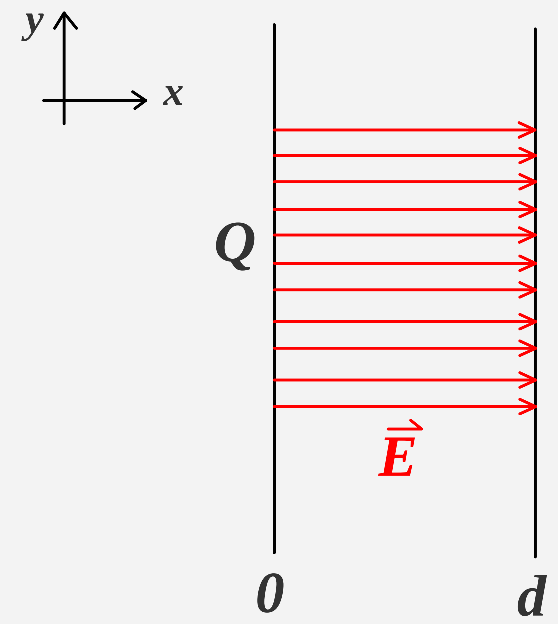
- The ratio $C \equiv Q/V$ is termed the capacitance.



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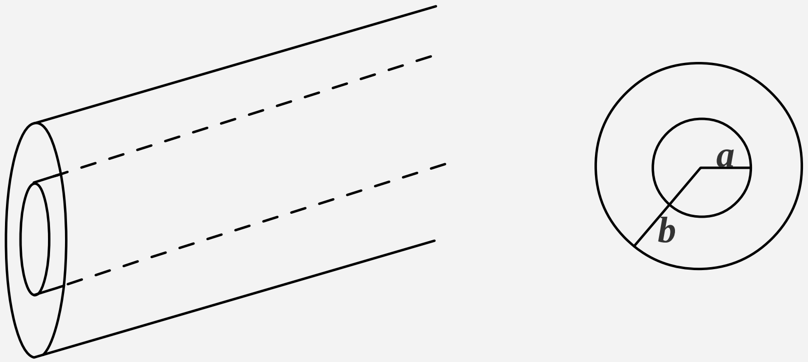

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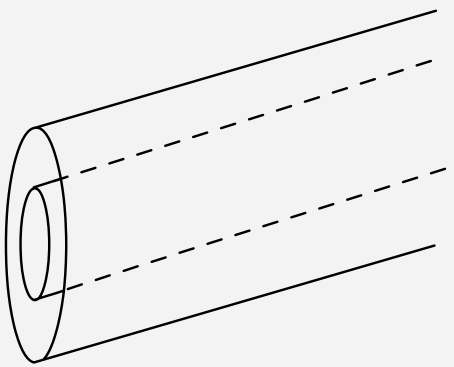

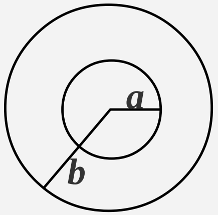

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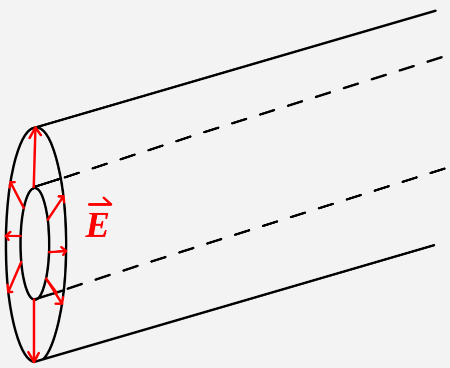


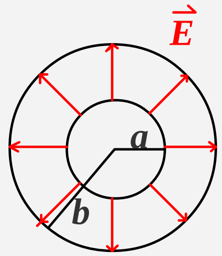

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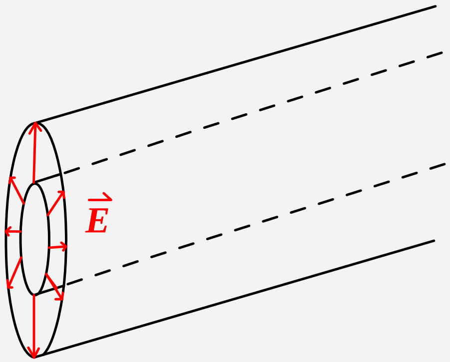


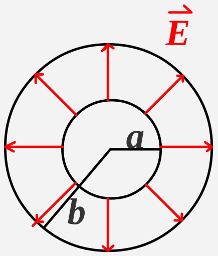

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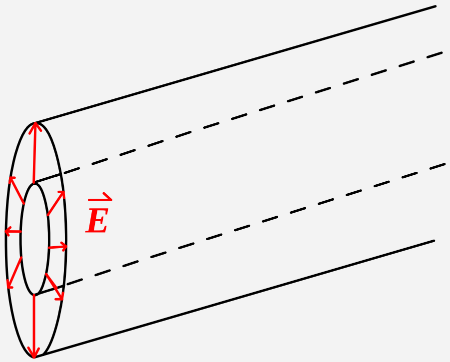


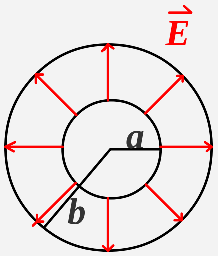

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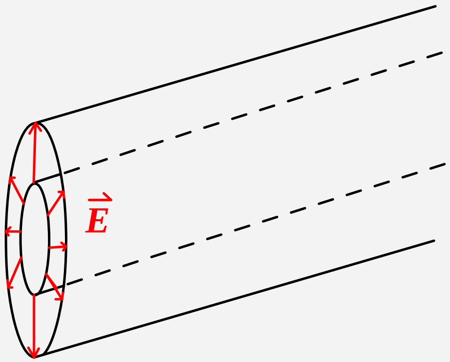


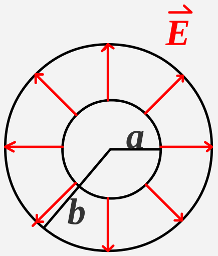

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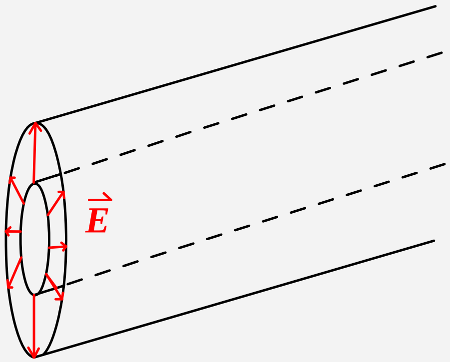


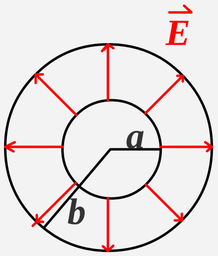

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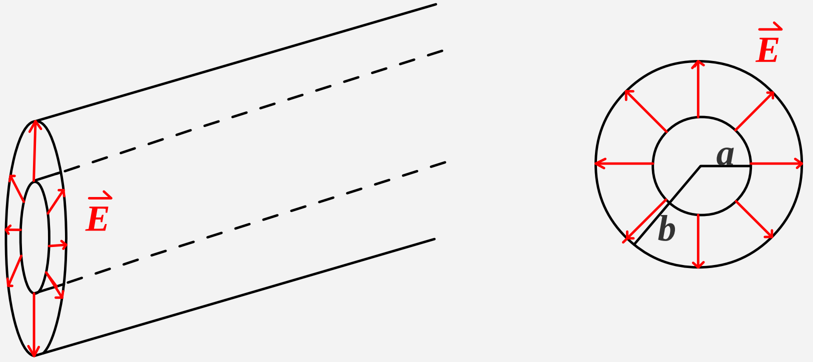

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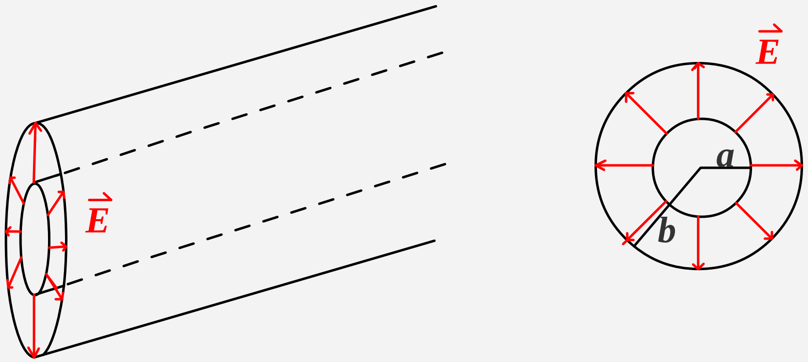

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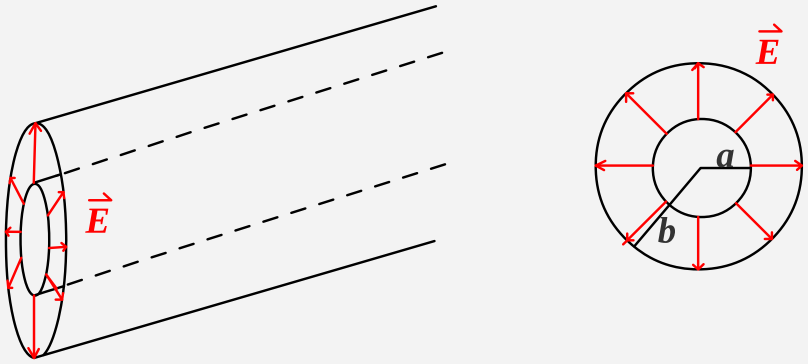

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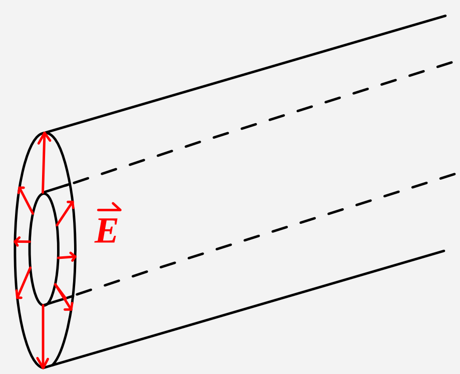


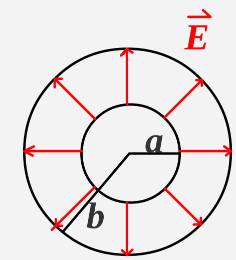

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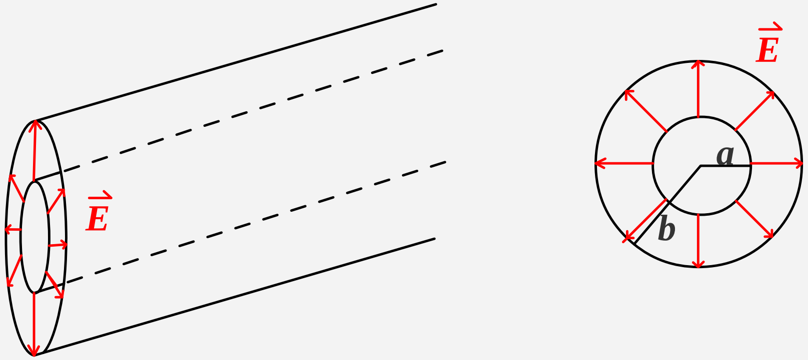

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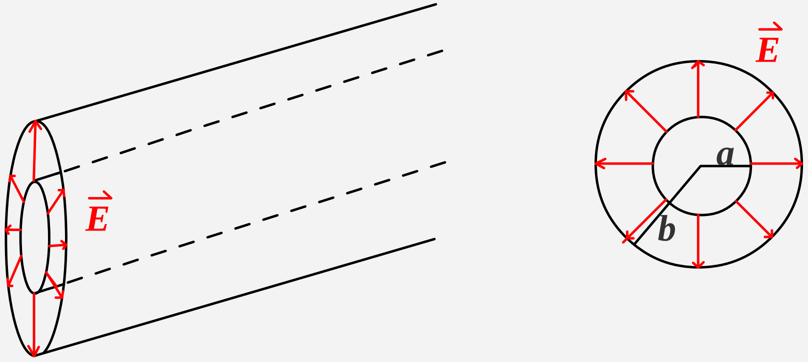

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- The three equations above are equivalent since $C \equiv Q/V$.

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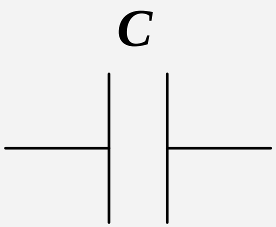

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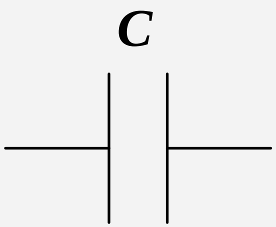


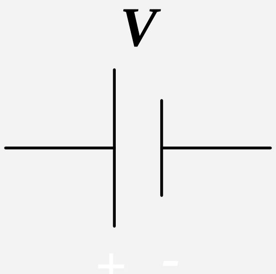

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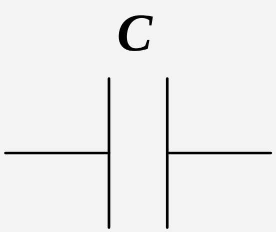
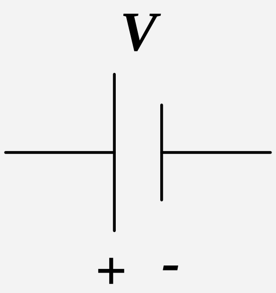
  - The long side of the battery represents the side of a battery which is at a higher potential (i.e., $+$).



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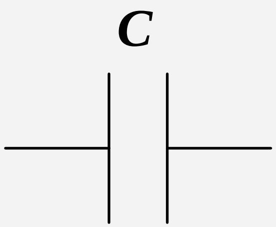
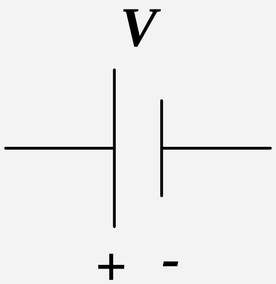
- The figure on the right (two parallel lines of equal length) will be used to represent a capacitor.
- The next figure on the right will be used to represent a battery (Notice the long and short sides).
  - The long side of the battery represents the side of a battery which is at a higher potential (i.e., $+$).
  - The short side of the battery represents the end of the batter which is lower in potential (i.e., -).



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- Let's begin.

# Capacitors in Parallel

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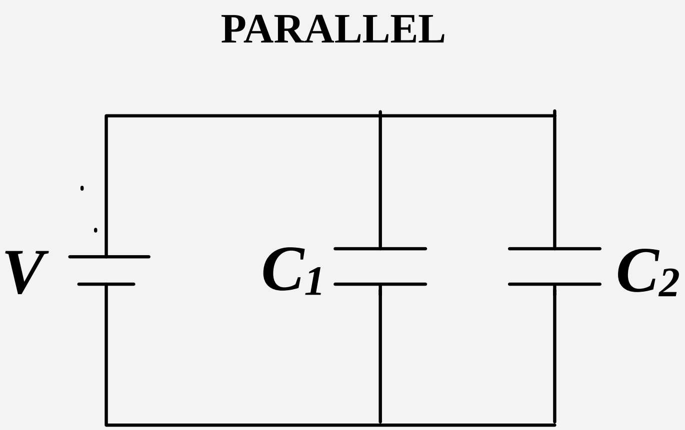

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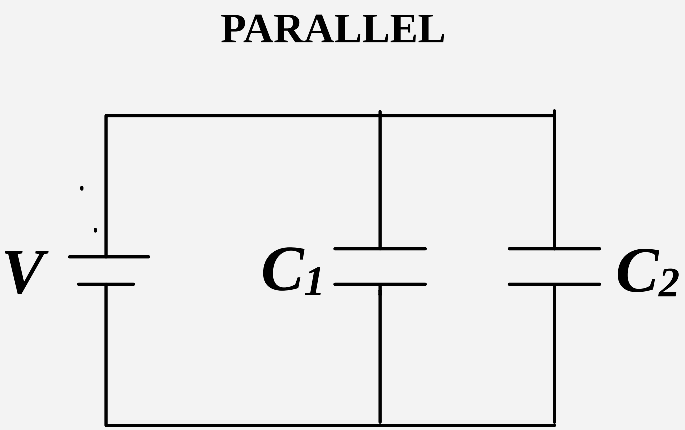

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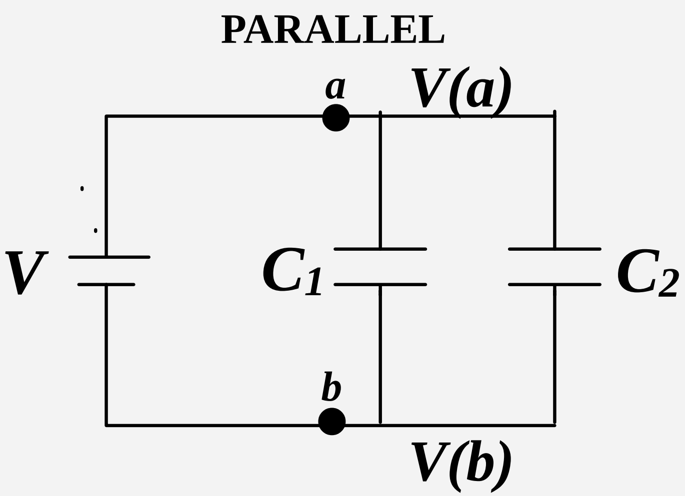

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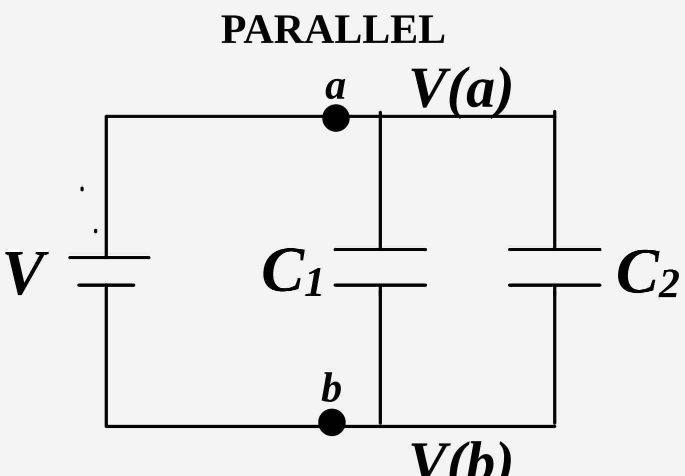

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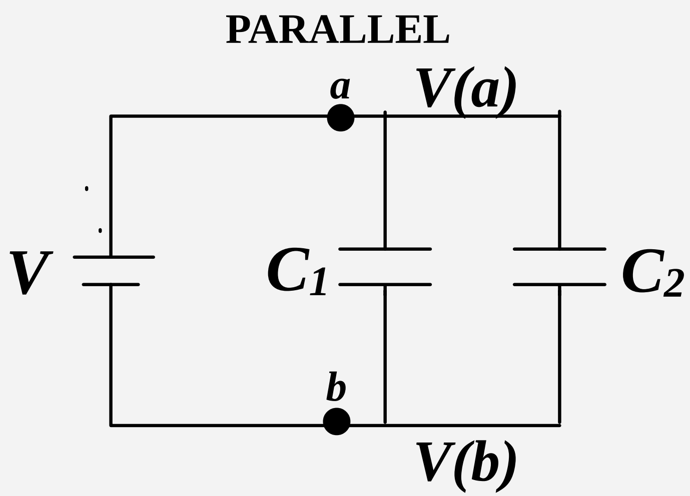

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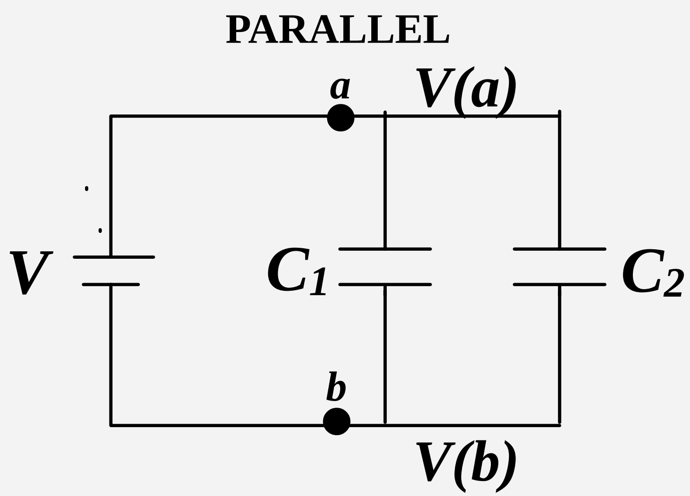

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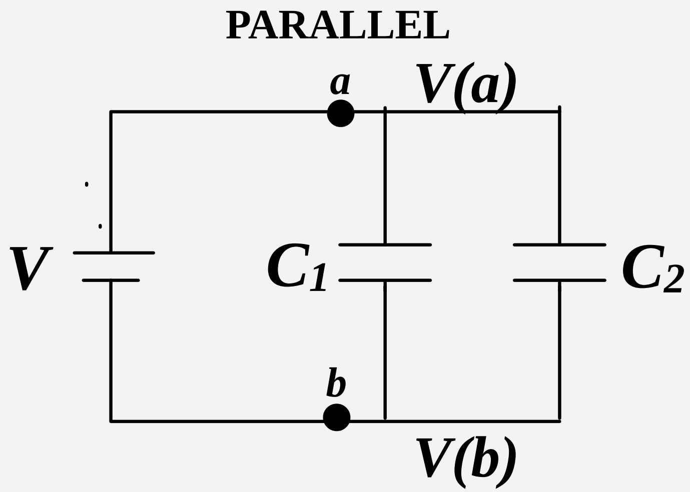

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- This means that the potential difference across $C_1$ and $C_2$ is the same and is given by the $V$.

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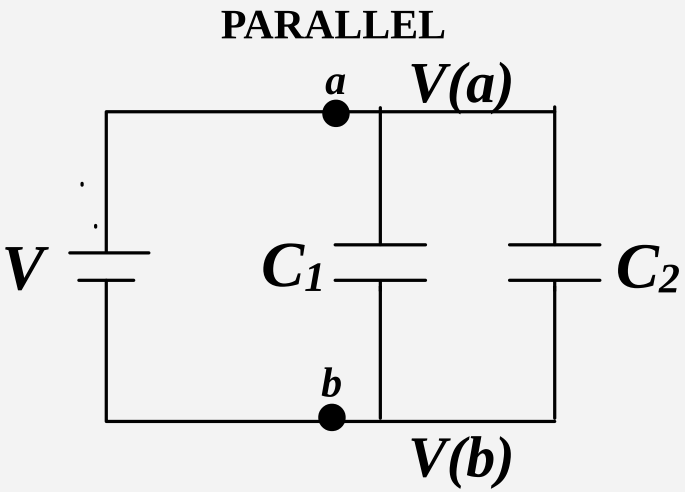

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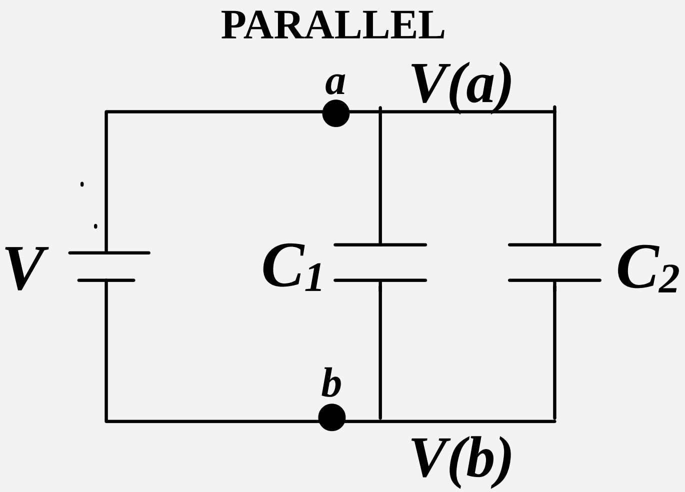

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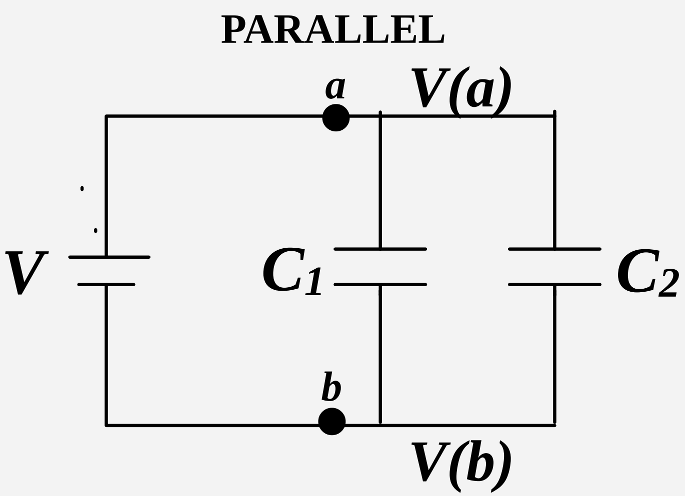

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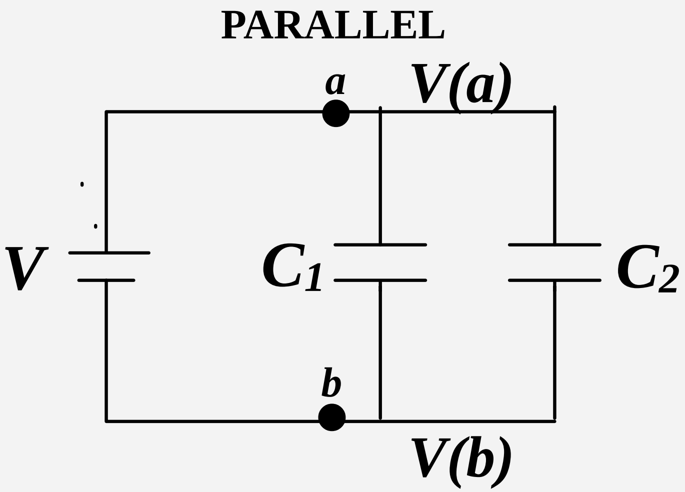


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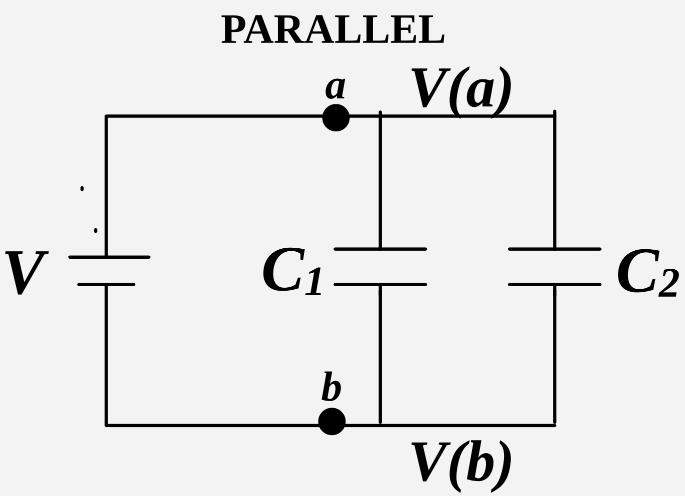


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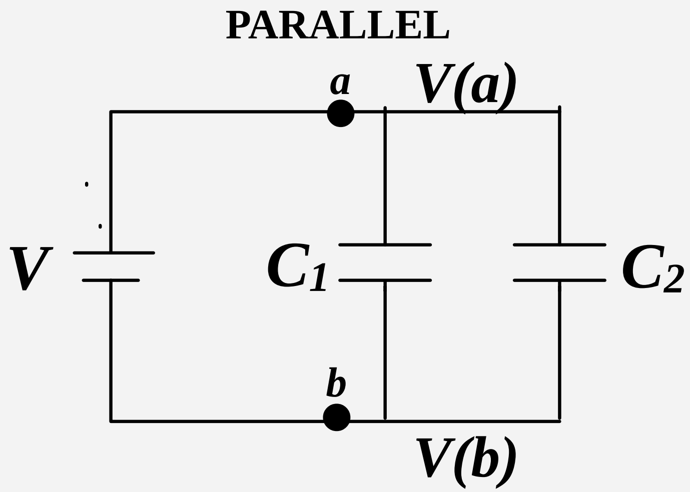


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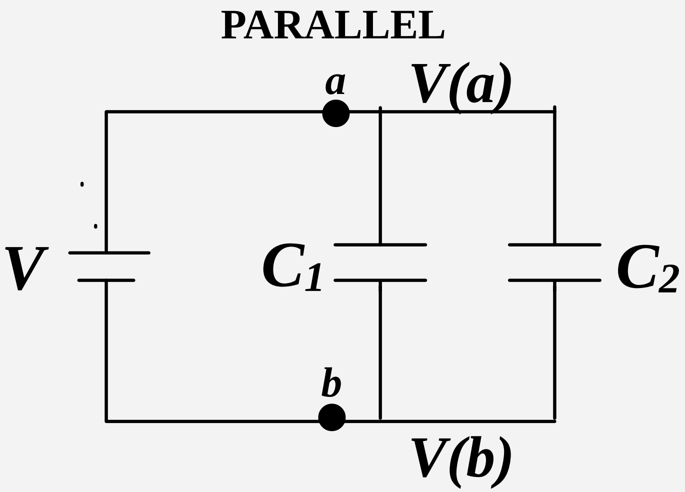


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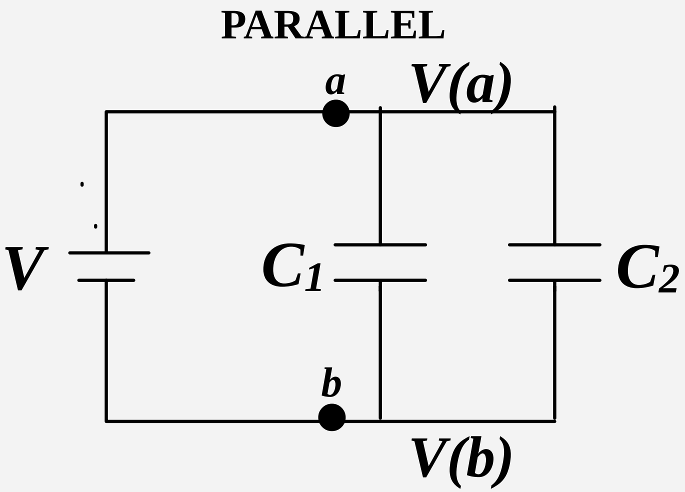
# Capacitors in Parallel III

$$C_T\, V_T = V\,(C_1 + C_2)$$



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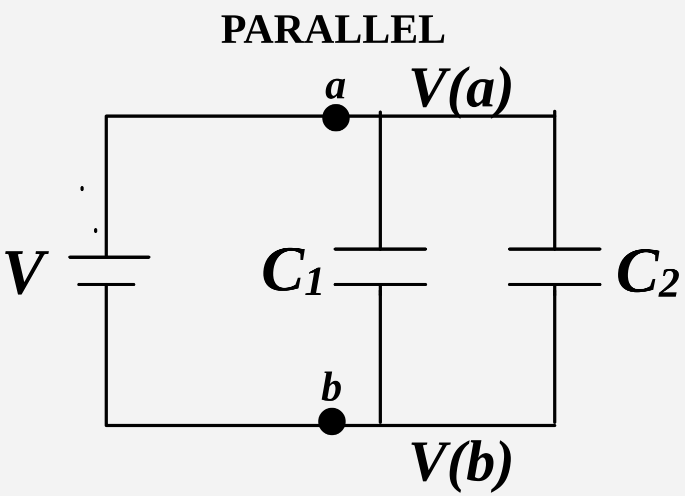

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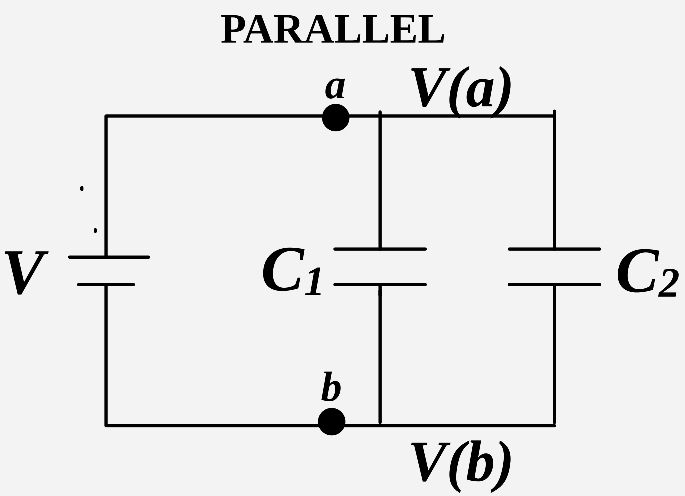

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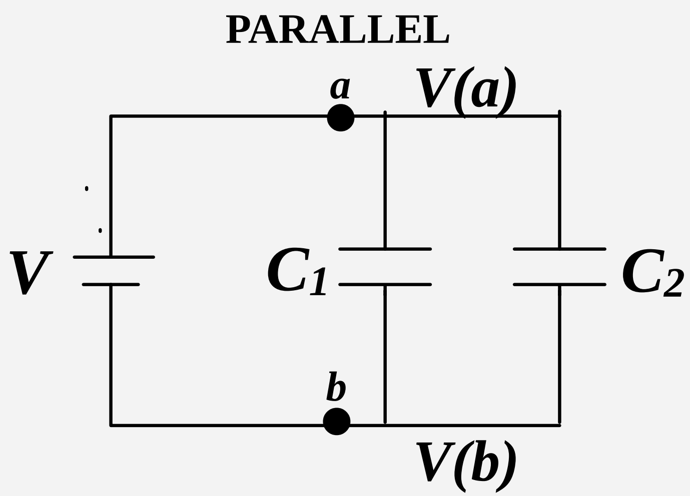

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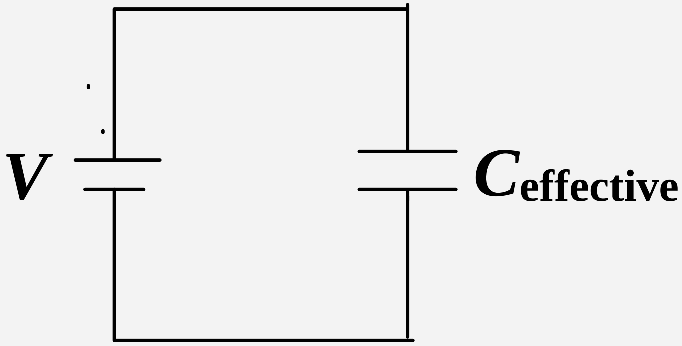

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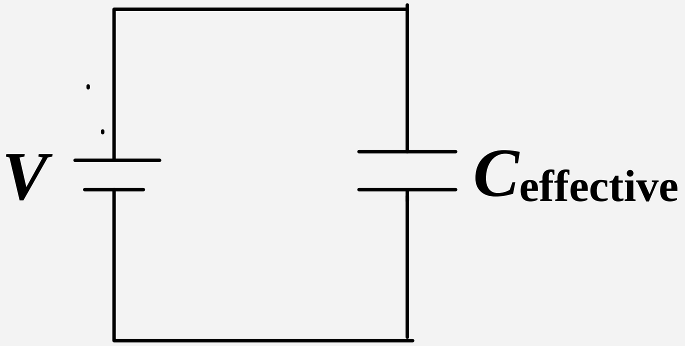

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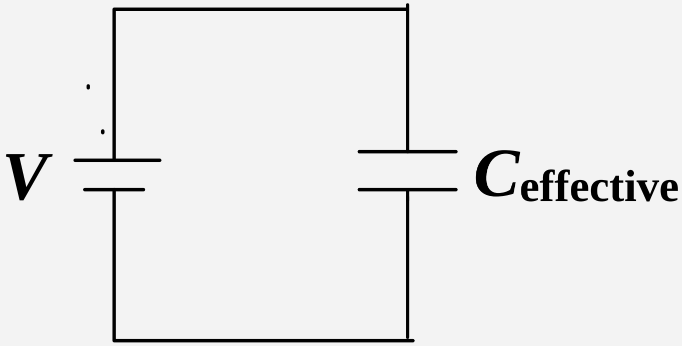

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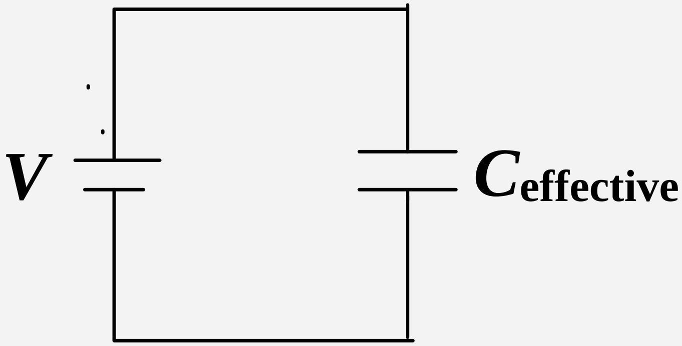
$$C_{\text{effective}} = C_1 + C_2 + C_3 + \cdots$$



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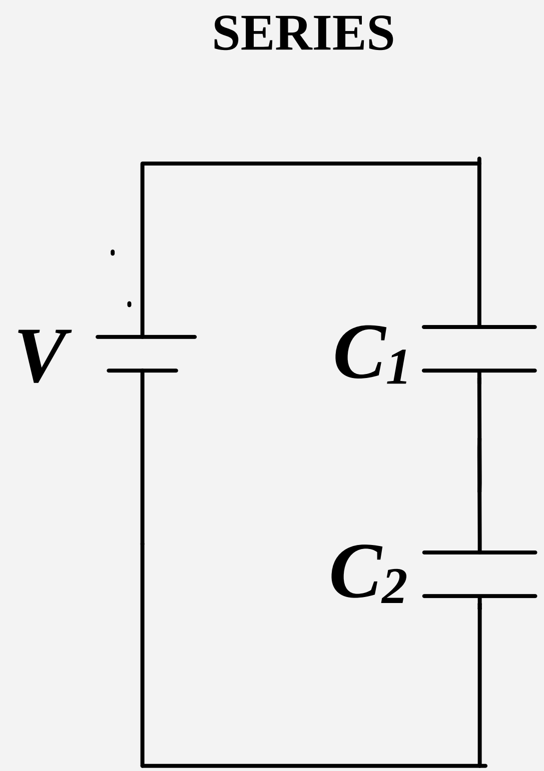

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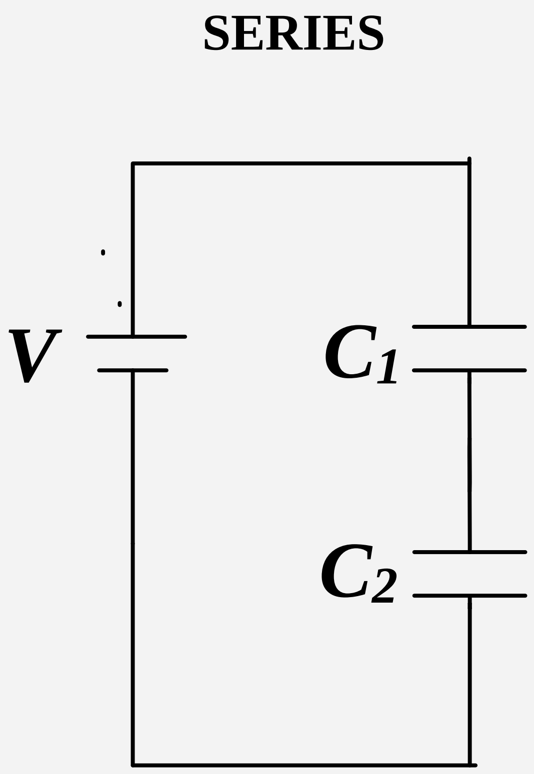

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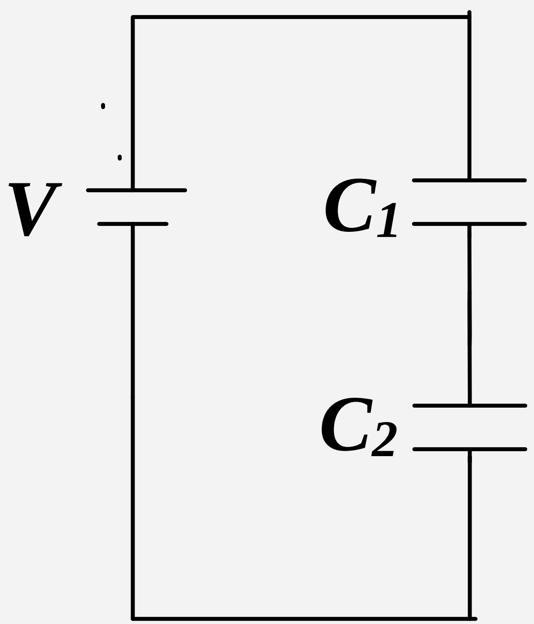
**SERIES**



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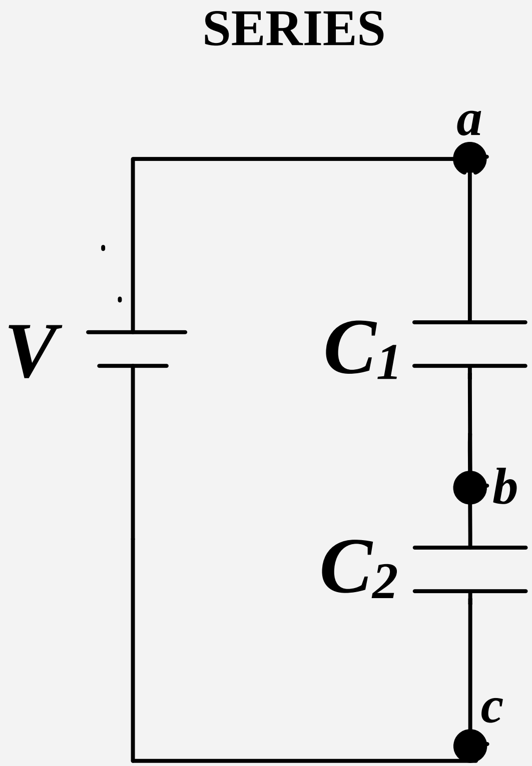

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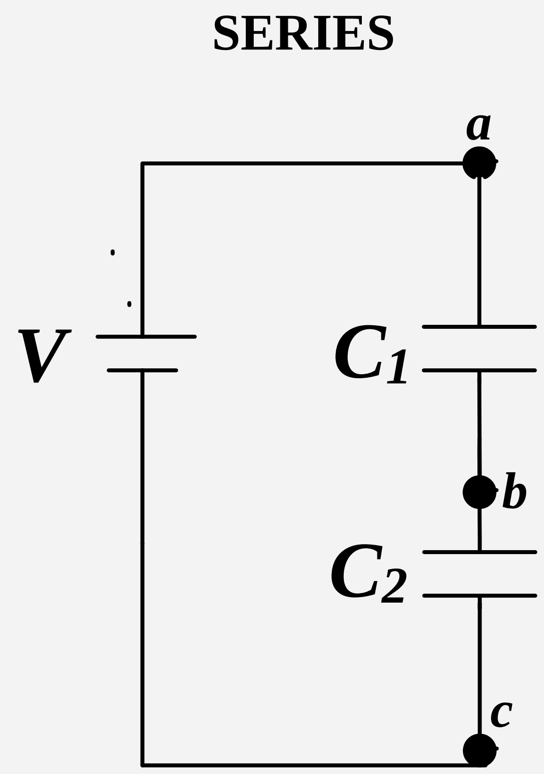
  - The difference in potential between points $c$ and $a$ is the potential difference, $V$, of the battery.



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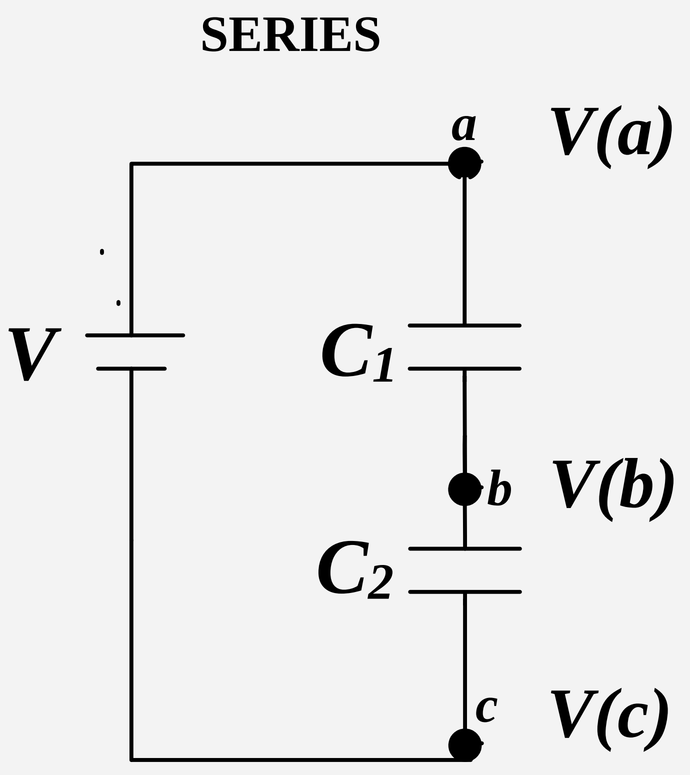

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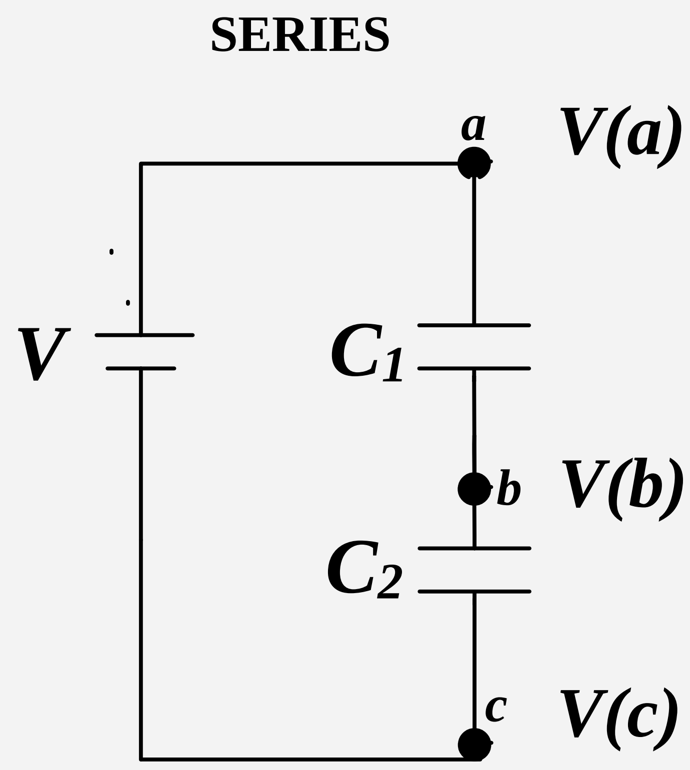

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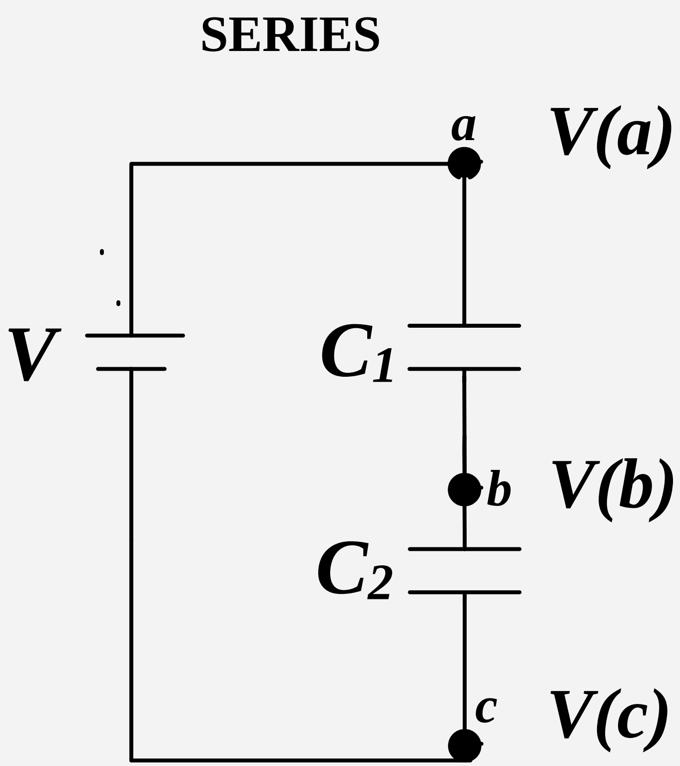
$$\Delta V_{ca}$$



# Capacitors in Series II

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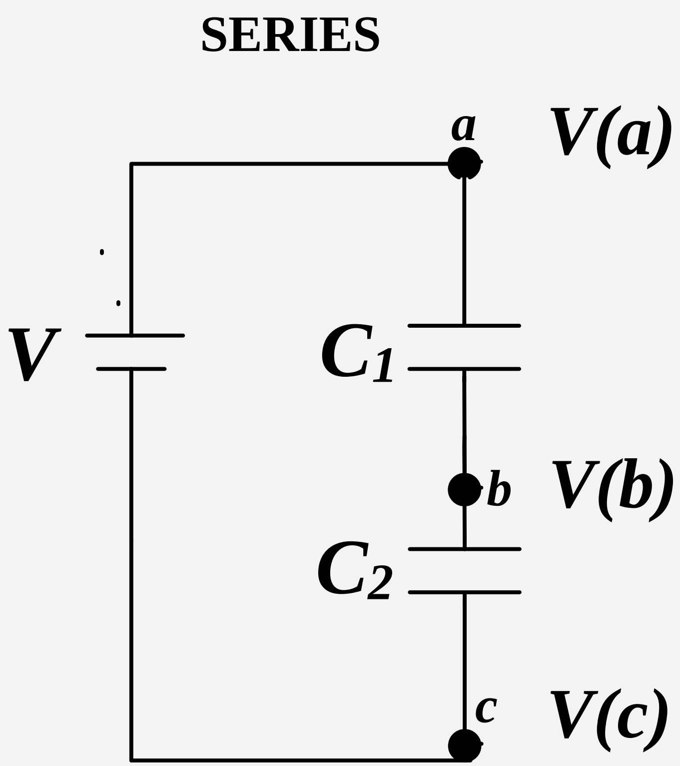
$$\Delta V_{ca} = V(a) - V(c) = V$$



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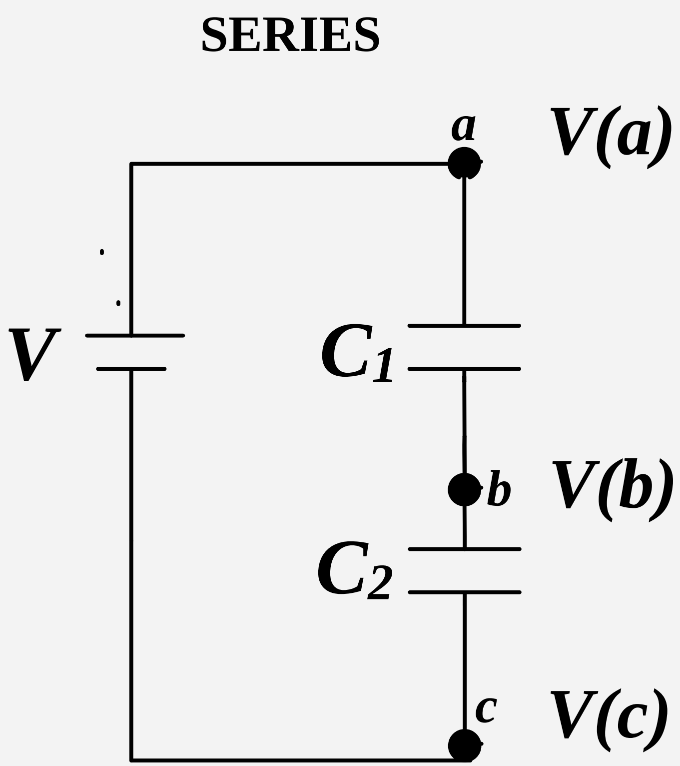
$$\Delta V_{ba}$$



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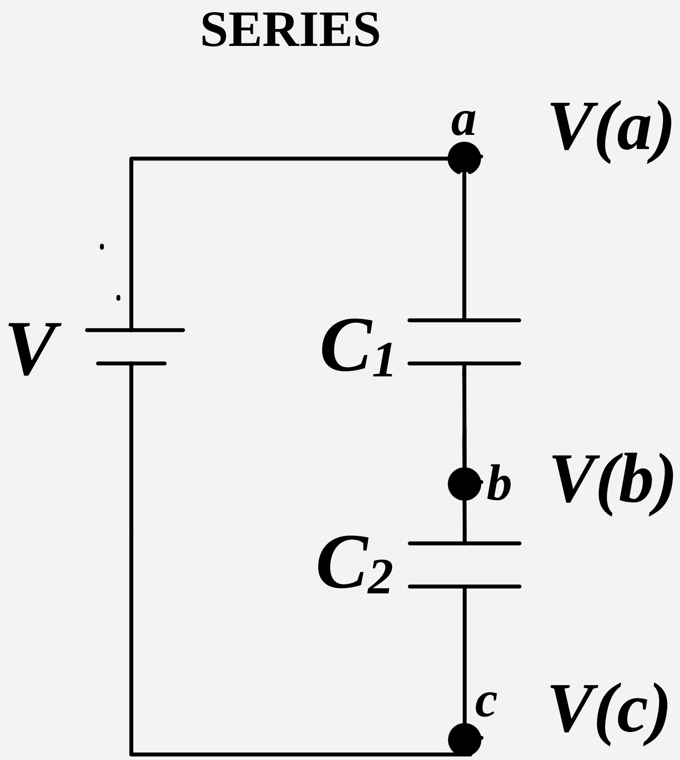

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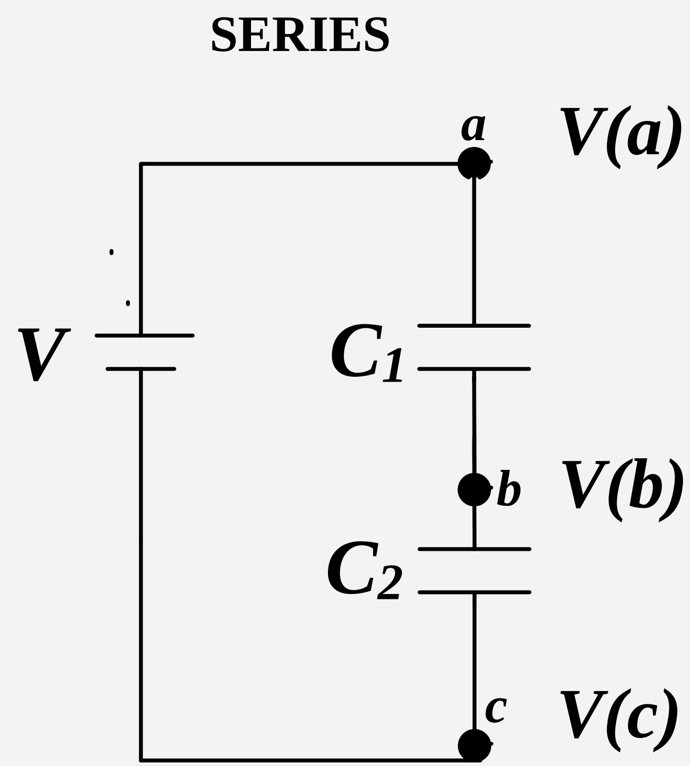

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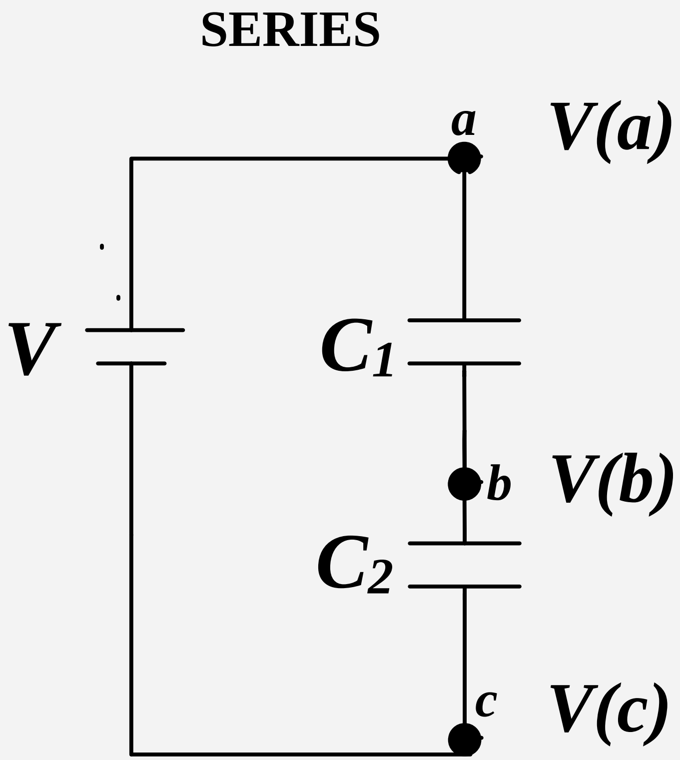

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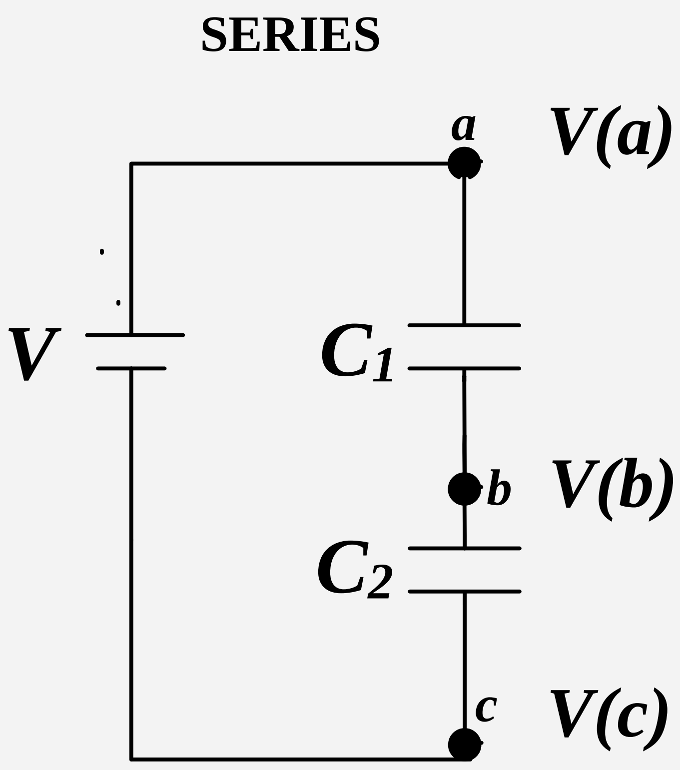

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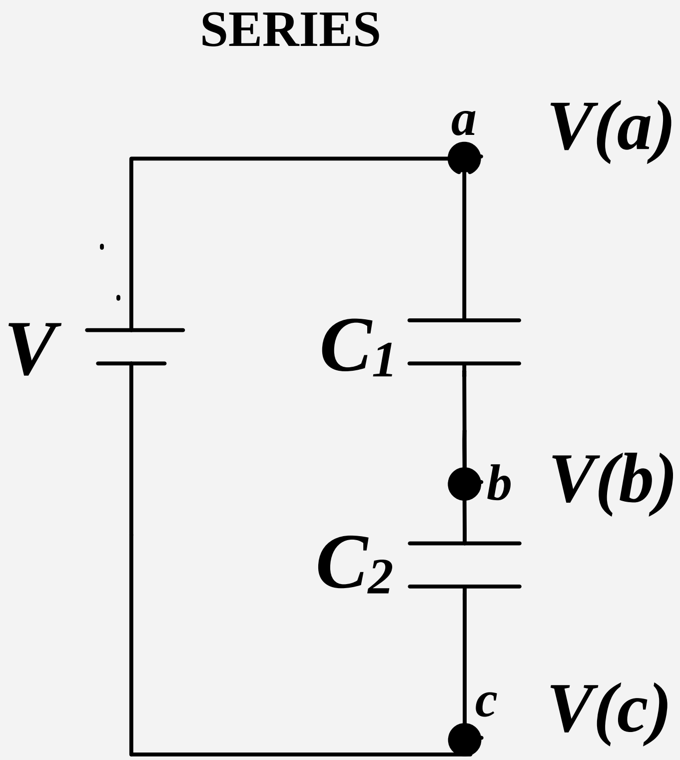

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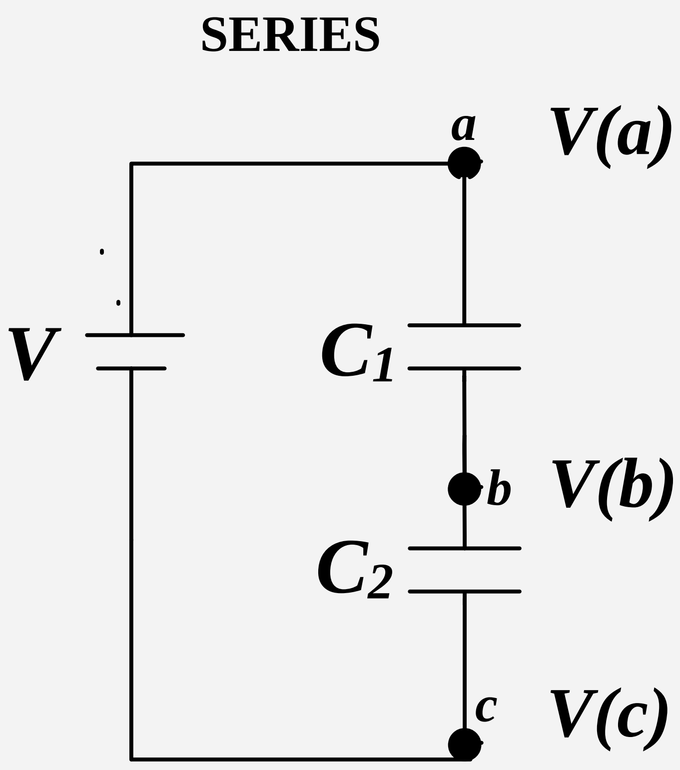
$$\Delta V_{ca} = \Delta V_{ba} + \Delta V_{cb}$$

- $\Delta V_{ba}$ is the potential difference across capacitor $C_1$



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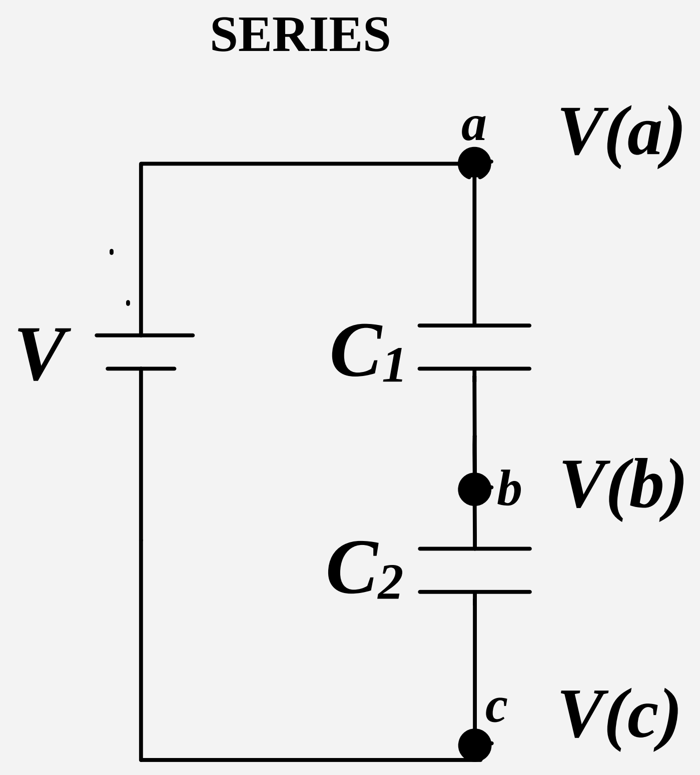
$$\Delta V_{ca} = \Delta V_{ba} + \Delta V_{cb}$$

- $\Delta V_{ba}$ is the potential difference across capacitor $C_1$, and $\Delta V_{cb}$ is the potential difference across capacitor $C_2$.



# Capacitors in Series II

- The difference in potential between points $c$ and $a$ is the potential difference, $V$, of the battery.

$$\Delta V_{ca} = V(a) - V(c) = V$$
$$\Delta V_{ba} = V(a) - V(b)$$
$$\Delta V_{cb} = V(b) - V(c)$$
$$\Delta V_{ca} = \Delta V_{ba} + \Delta V_{cb}$$

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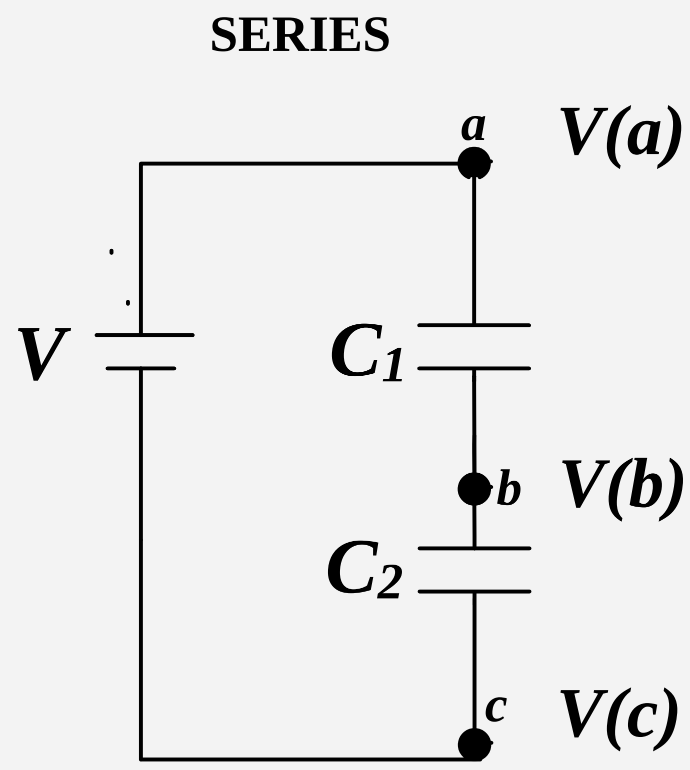
$$V = V_1 + V_2$$



# Capacitors in Series III

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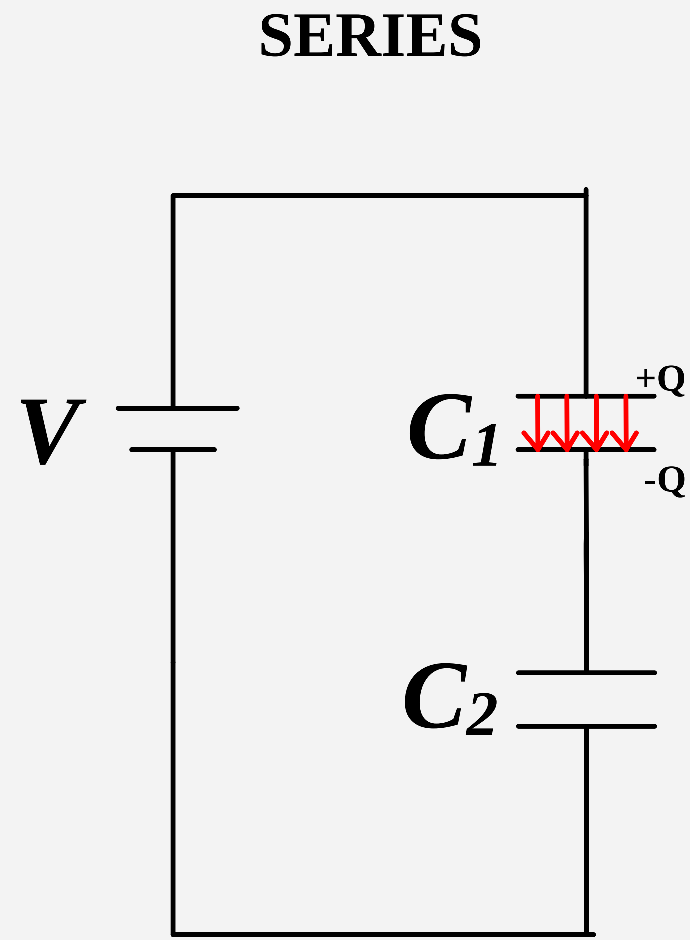

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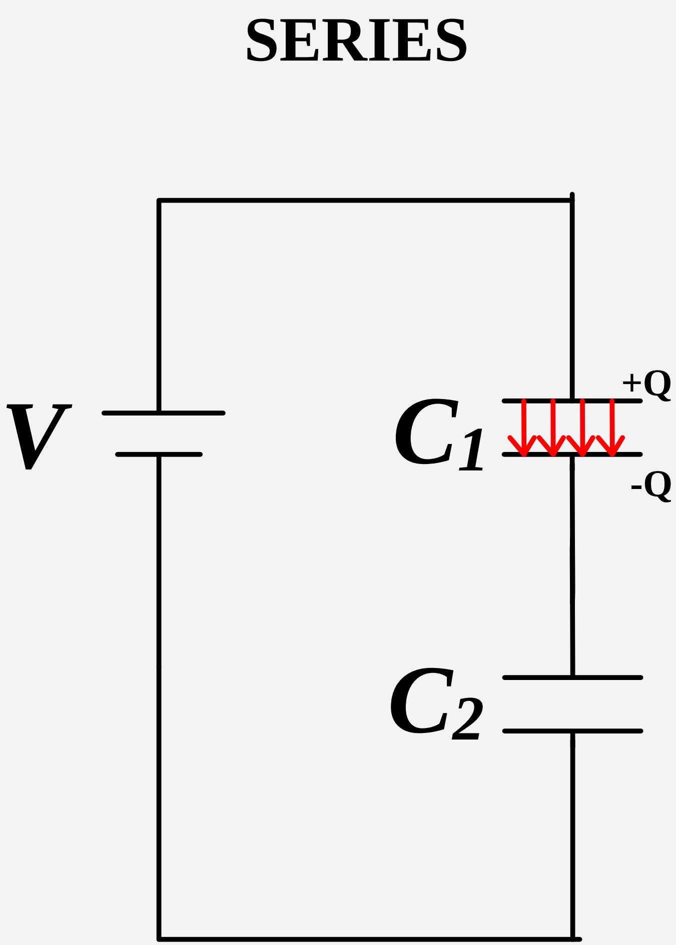
- There is a potential difference across $C_1$.
- The electric field in $C_1$ does something to the wire connecting $C_1$ with $C_2$ (What is it?).



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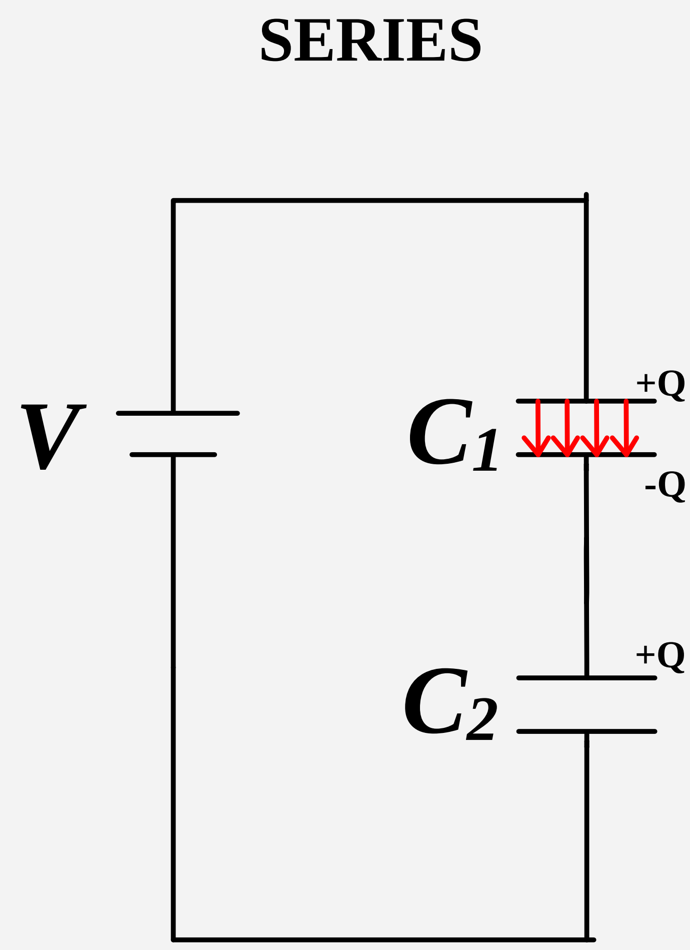

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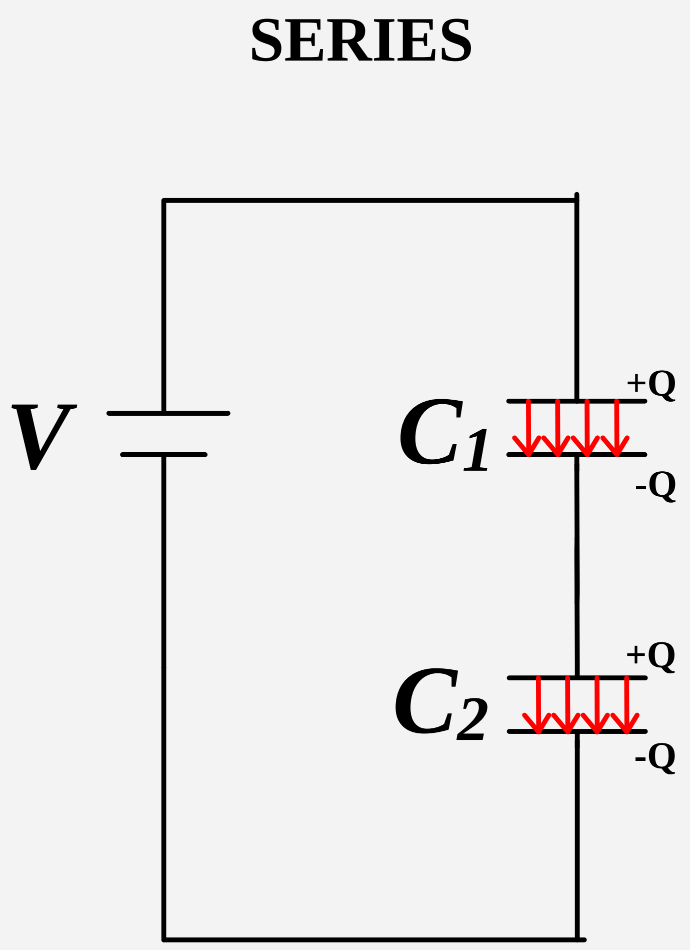

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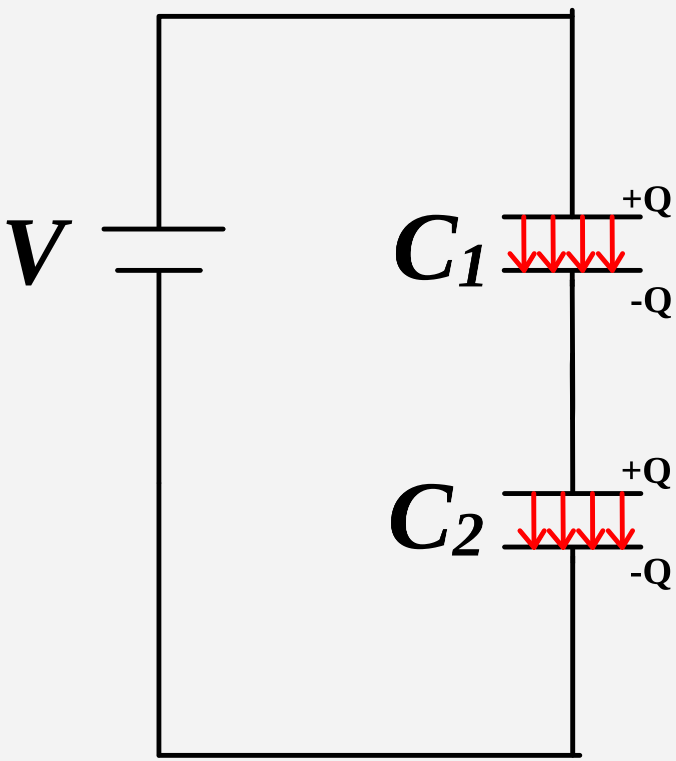
- MORAL OF THE STORY: Capacitors in series have the same amount of charge!!

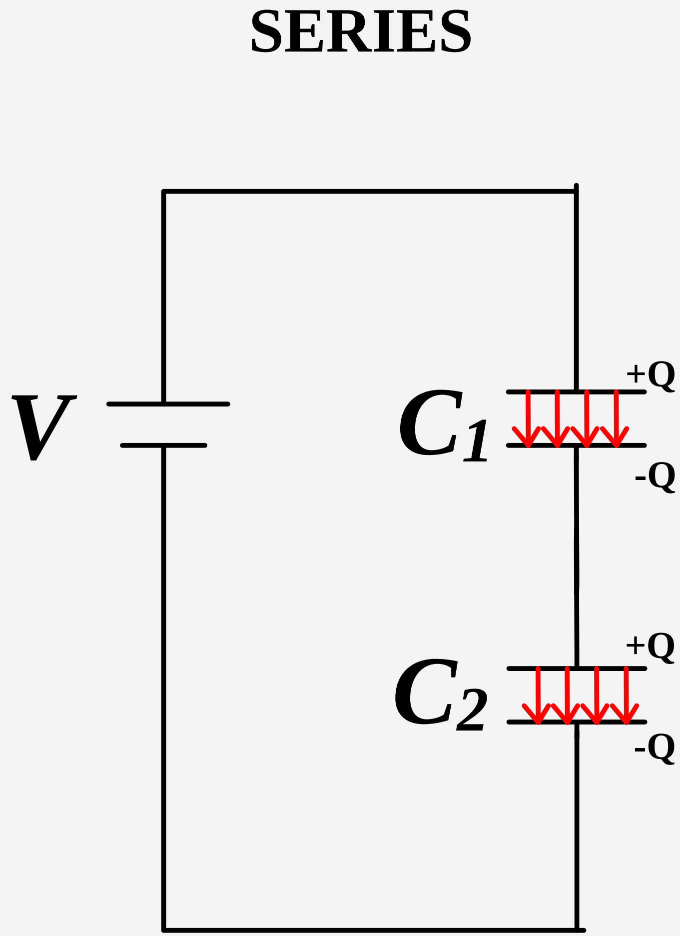
**SERIES**



# Capacitors in Series IV

- Starting with:

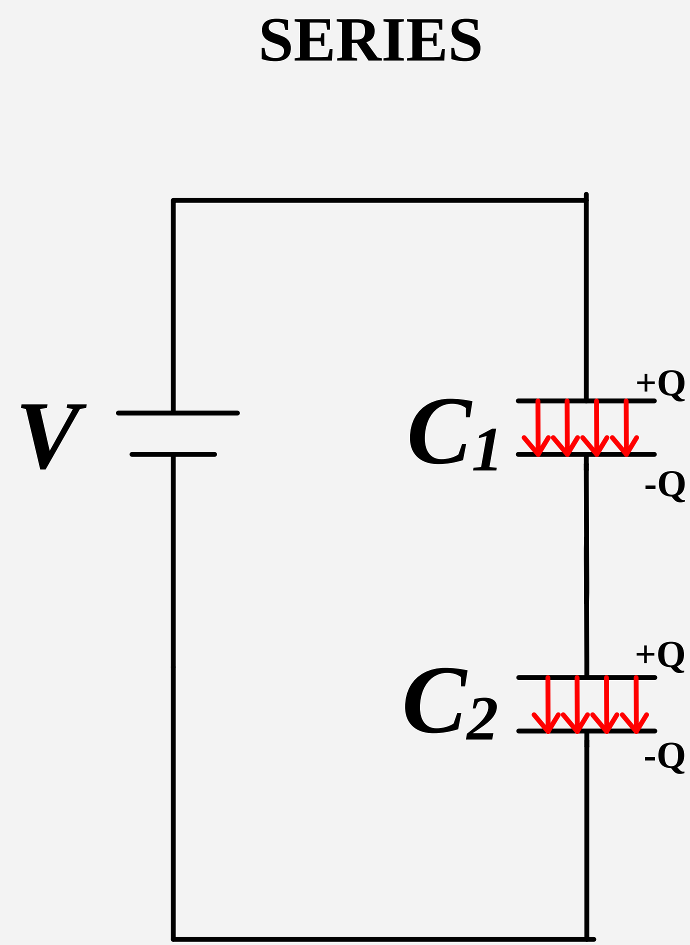
$$V = V_1 + V_2$$



# Capacitors in Series IV

- Starting with:

$$V = V_1 + V_2 = \frac{Q_1}{C_1} + \frac{Q_2}{C_2}$$



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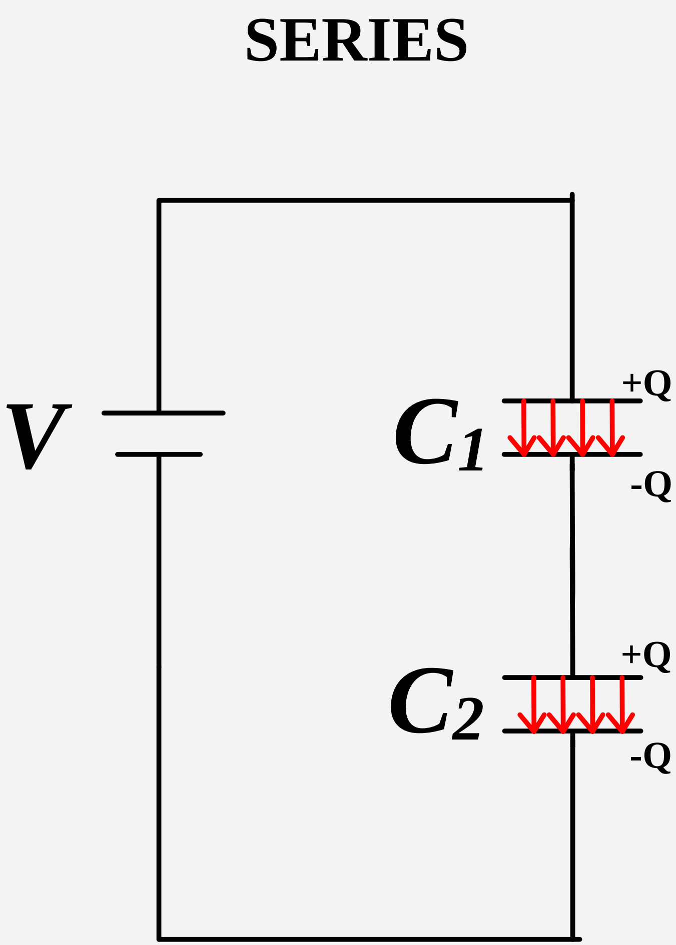

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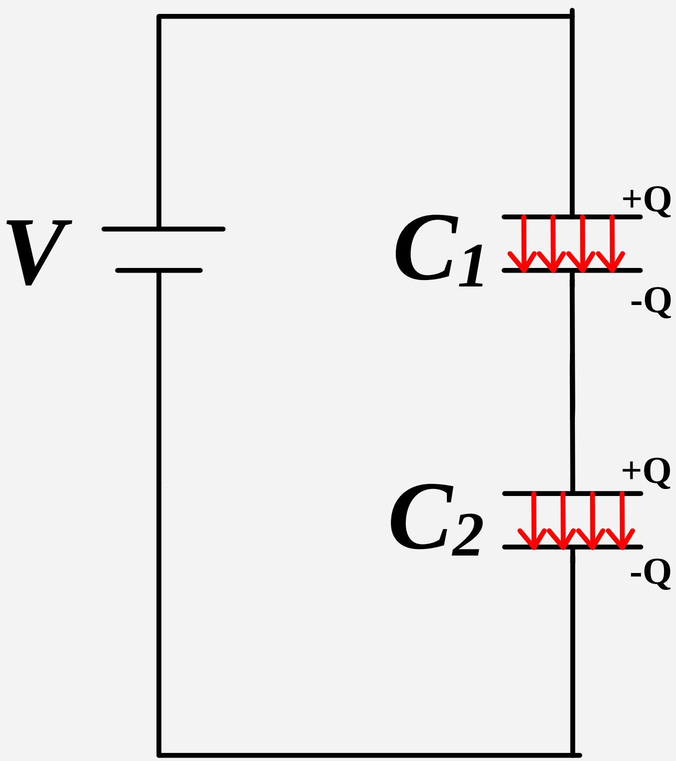

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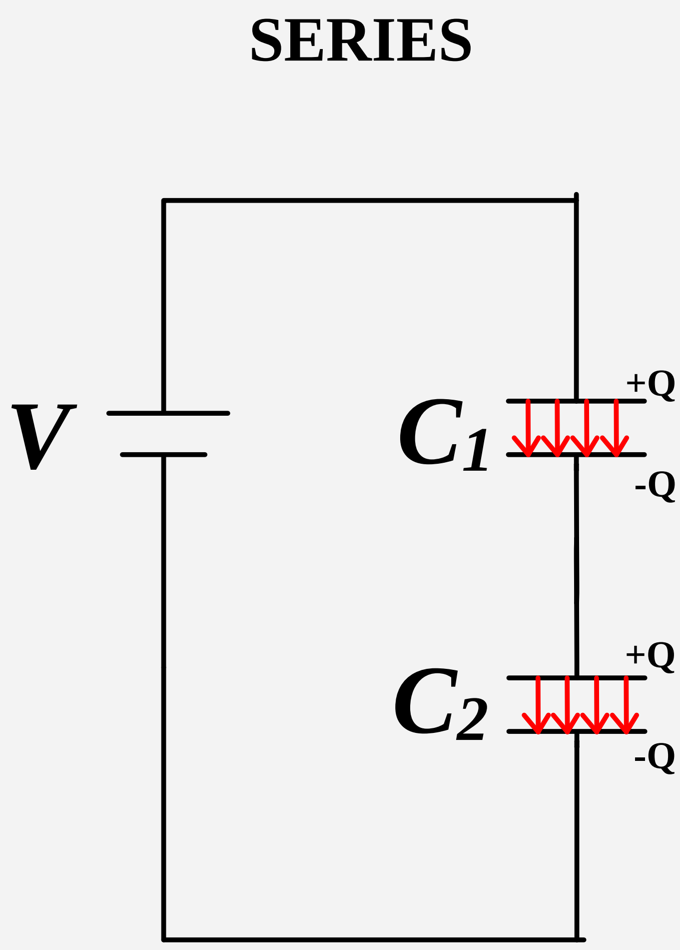

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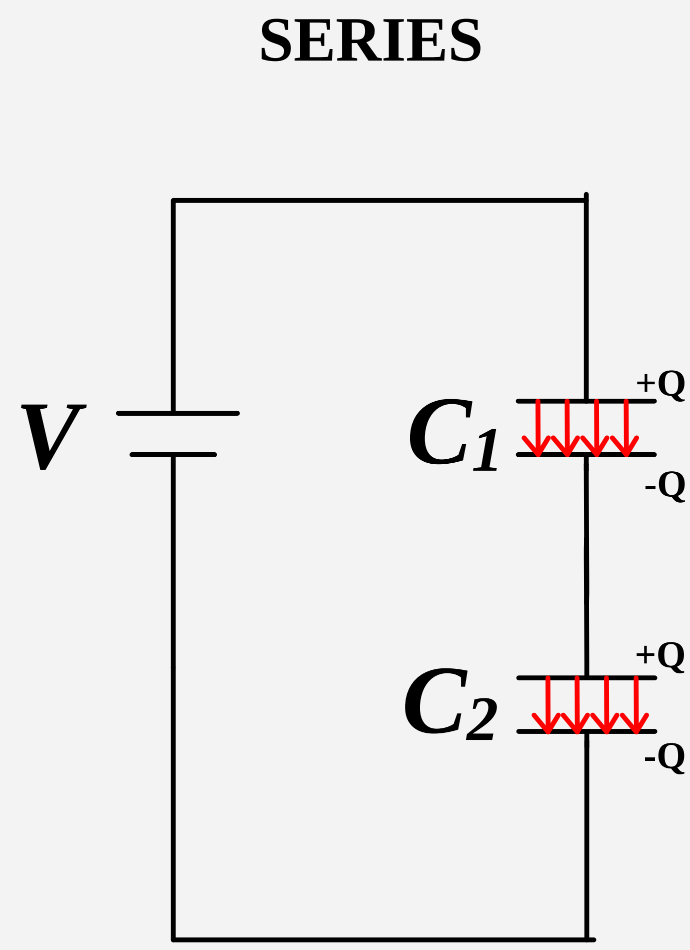
$$1/C = (\frac{1}{C_1} + \frac{1}{C_2})$$

- This means that the circuit on the right can be represented by the following circuit.



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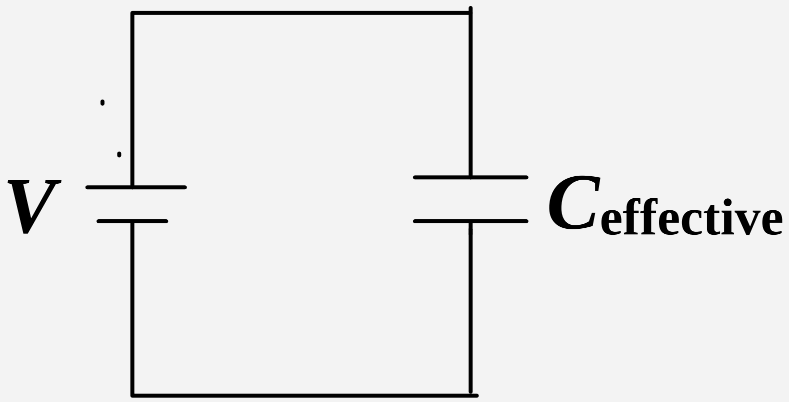

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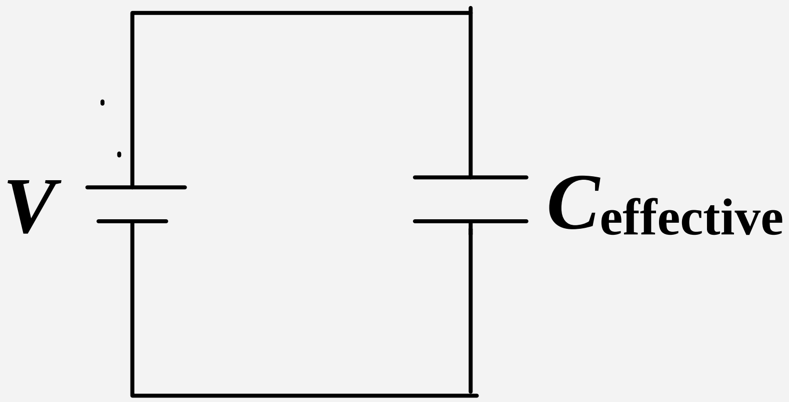

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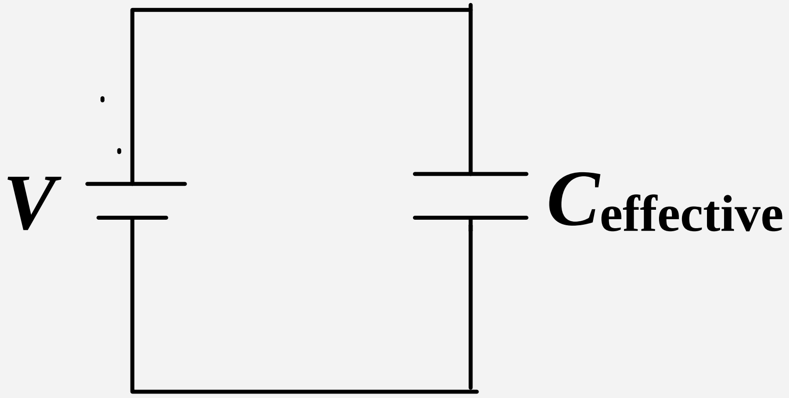
- If we generalize for capacitors connected in series:

$$\frac{1}{C_{\text{effective}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$



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- Series circuits:
  - Capacitors in series have identical charges.
  - For capacitors in series, you need to add the *reciprocal* of the capacitance of each capacitor in order to find the *reciprocal* of the effective capacitance.

# Dielectrics

Let's move to the chalk board.