CIRCUITS DAY 14: RC CIRCUITS: INITIAL STATE, STEADY STATE & TIME CONSTANT

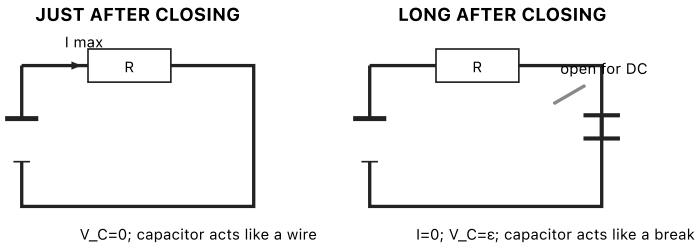
CED 11.8 · Skill 1.C · FRQ: TBR

PREDICT THE PHENOMENON

A bulb is in series with a resistor and an initially uncharged capacitor. The switch closes. Is the current largest **immediately / long after / the same at all times**?

Observation source: a safe charging demonstration, the site RC bench, or the paired state sketches.

SAME BRANCH AT TWO LIMITING TIMES



Always name the time before simplifying an RC circuit.

NOTES / REASONING

INITIAL AND STEADY-STATE MODELS

At t=0⁺: an initially uncharged capacitor has $V_C = 0$, so it acts like a wire and current is maximum.
At steady state: $V_C = \varepsilon$, so the capacitor branch carries no DC current and acts like a break.

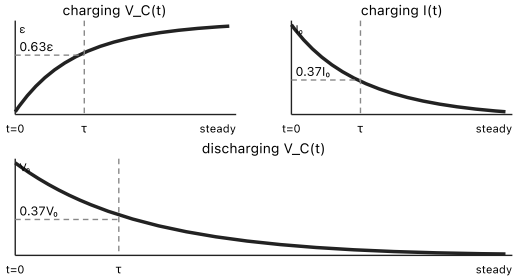
WE DO For $\varepsilon = 10\ \text{V}$ and $R = 25\ \text{k}\Omega$, find initial and steady-state current.

THE TIME CONSTANT

$$\tau = RC$$

At one time constant, a charging capacitor reaches about 63% of its final voltage. A discharging capacitor has about 37% of its initial voltage remaining.

QUALITATIVE RC TRACES



CALCULATE For $R = 25\ \text{k}\Omega$ and $C = 200\ \mu\text{F}$, find τ, $V_C(\tau)$, and the charging current at τ. Use the 63%/37% landmarks.

PRACTICE

1. A 15 kΩ resistor and 400 μF capacitor form an RC branch. Find τ.

2. A 12 V capacitor discharges. Estimate its voltage after one τ.

3. For a 9 V source and 30 kΩ resistor, find the initial charging current.

4. Sketch V_C(t) and I(t), label t=0, one τ, and steady state.