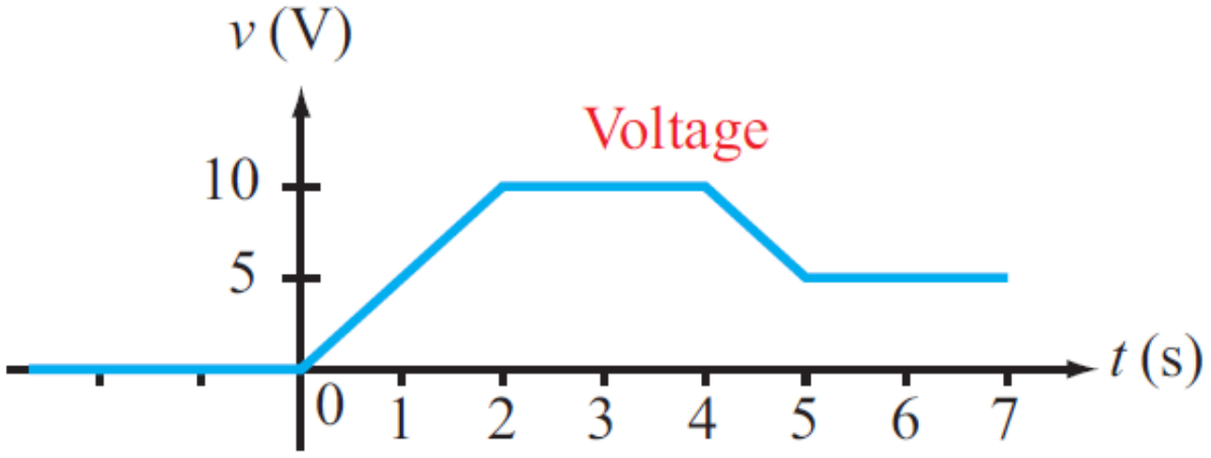
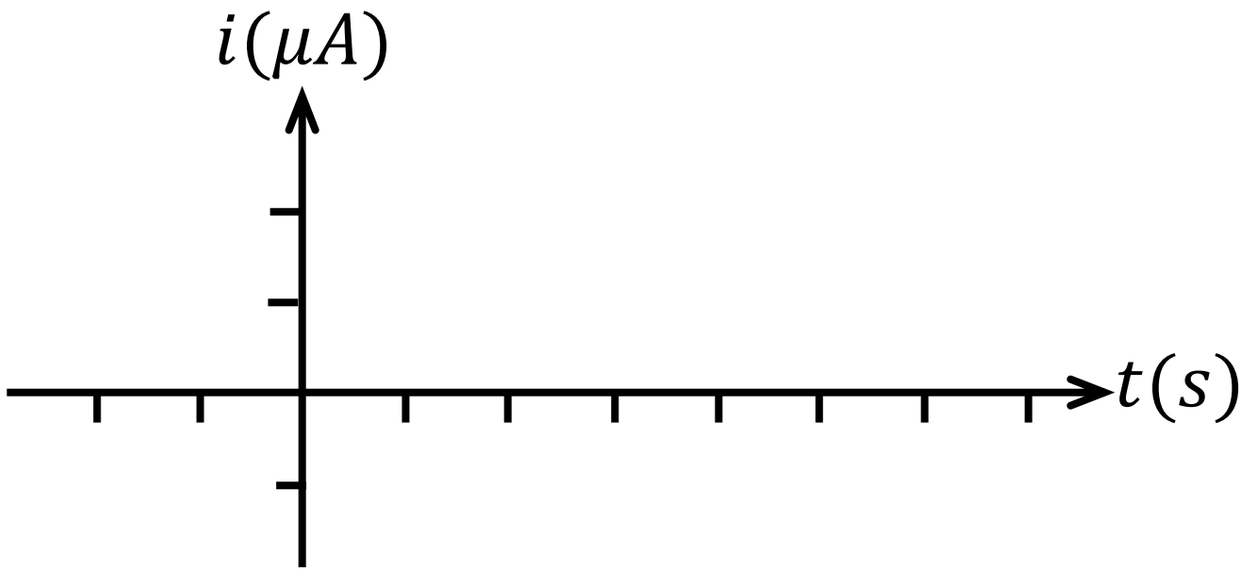
Last Class…

A voltage v was applied over a $0.6\mu F$ capacitor. Determine the corresponding waveforms for the current $ic(t)$. $= C \frac{dV_c(t)}{dt}$





THE OHIO STATE UNIVERSITY

COLLEGE OF ENGINEERING

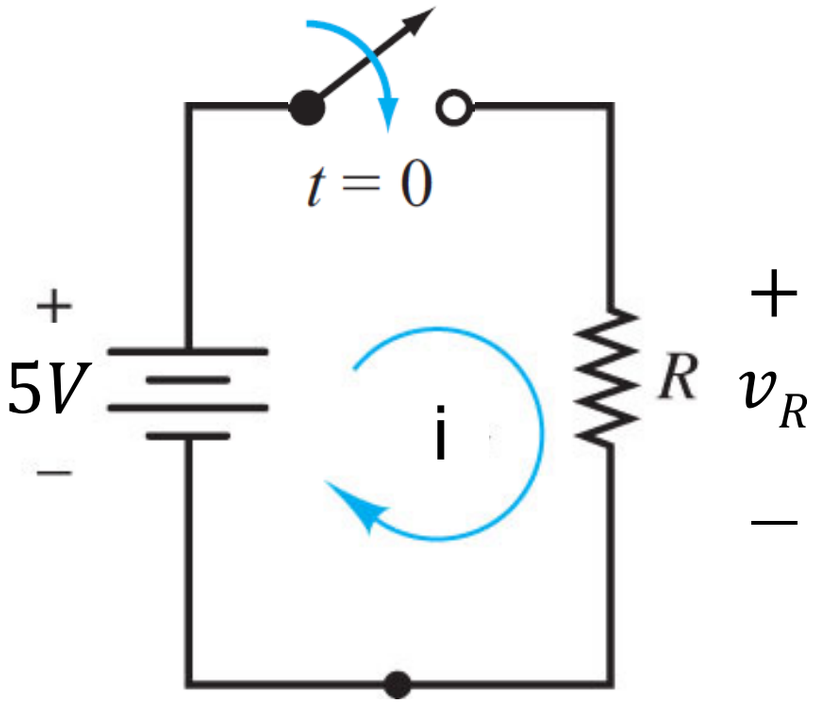
Transient Response of RC Circuits

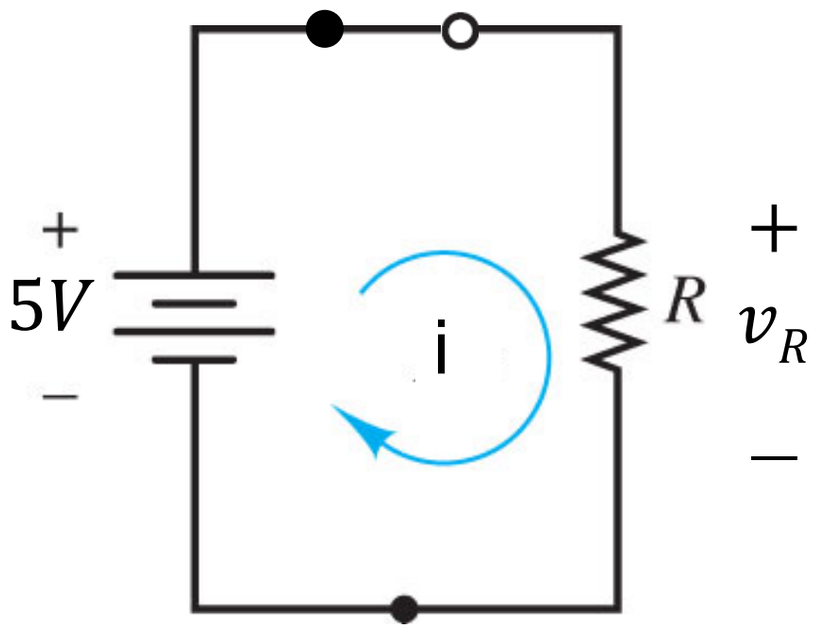
Today…

- Learning Objectives:
  - Understand what transient response is.
  - Analyze the transient responses of first order RC circuits.

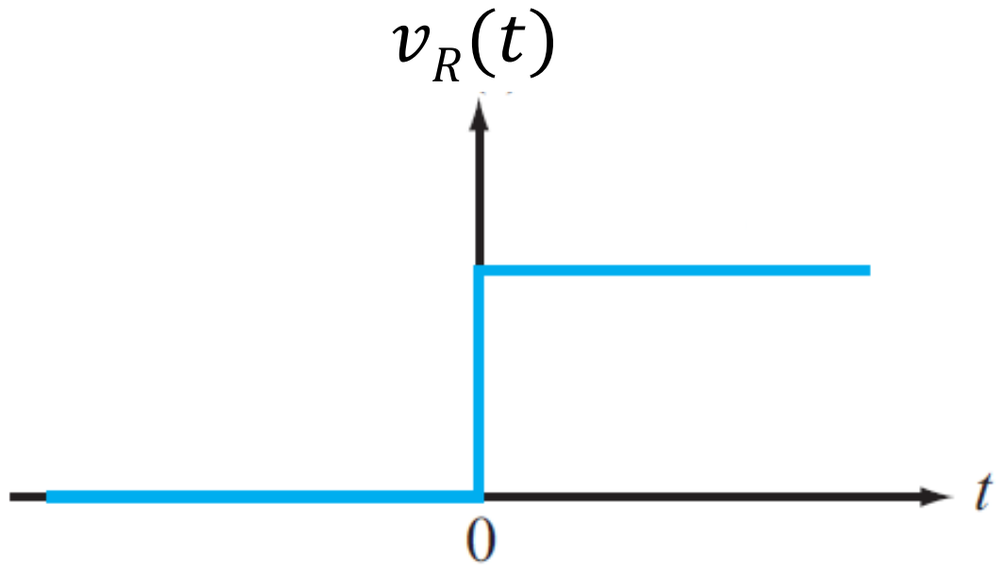
So far all our circuits have been DC and steady-state:

- System is not changing for a long time.
- Steady for enough time to reach equilibrium.



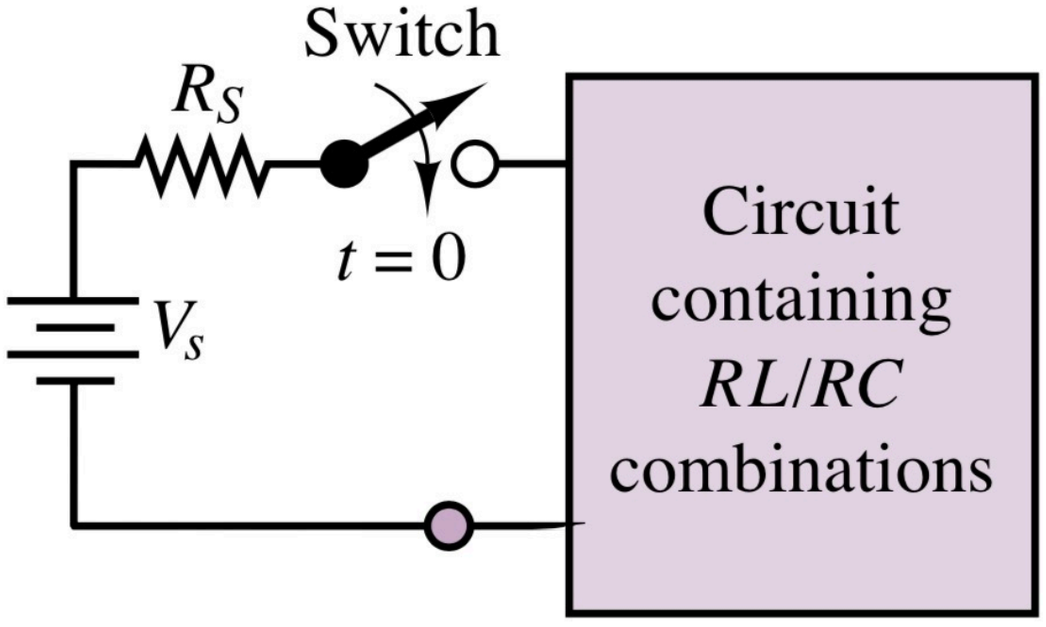


An ideal resistor can change its v and i instantly.



Transient Response

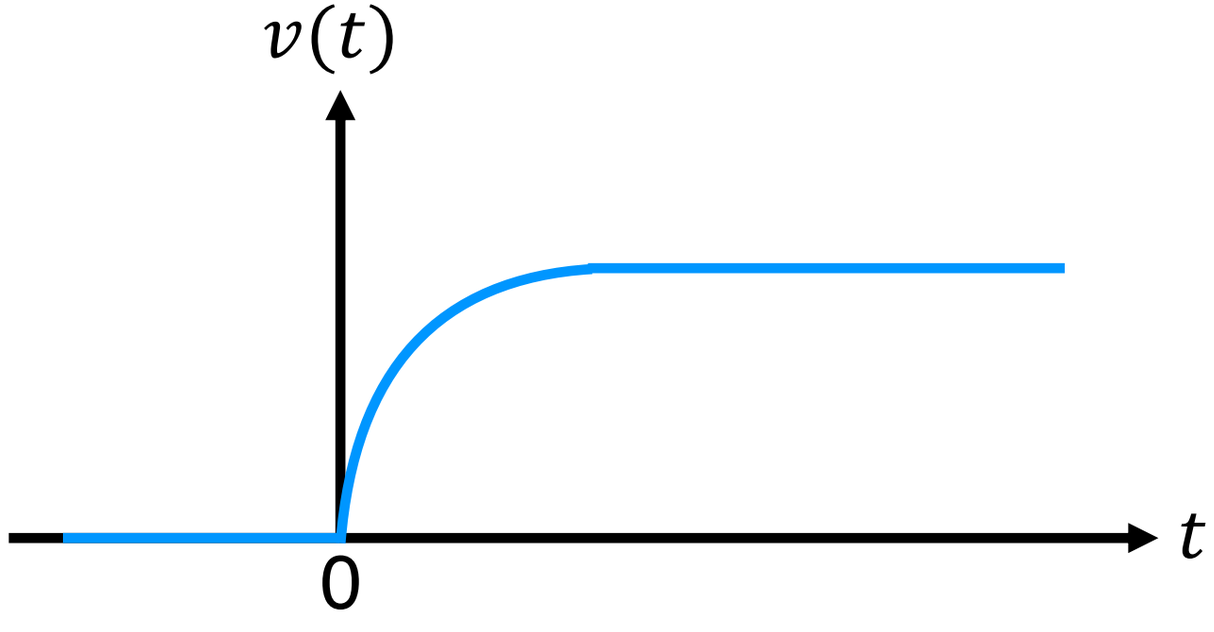
Transient response: represents the initial reaction immediately after a sudden change, such as closing or opening a switch.



DC circuit

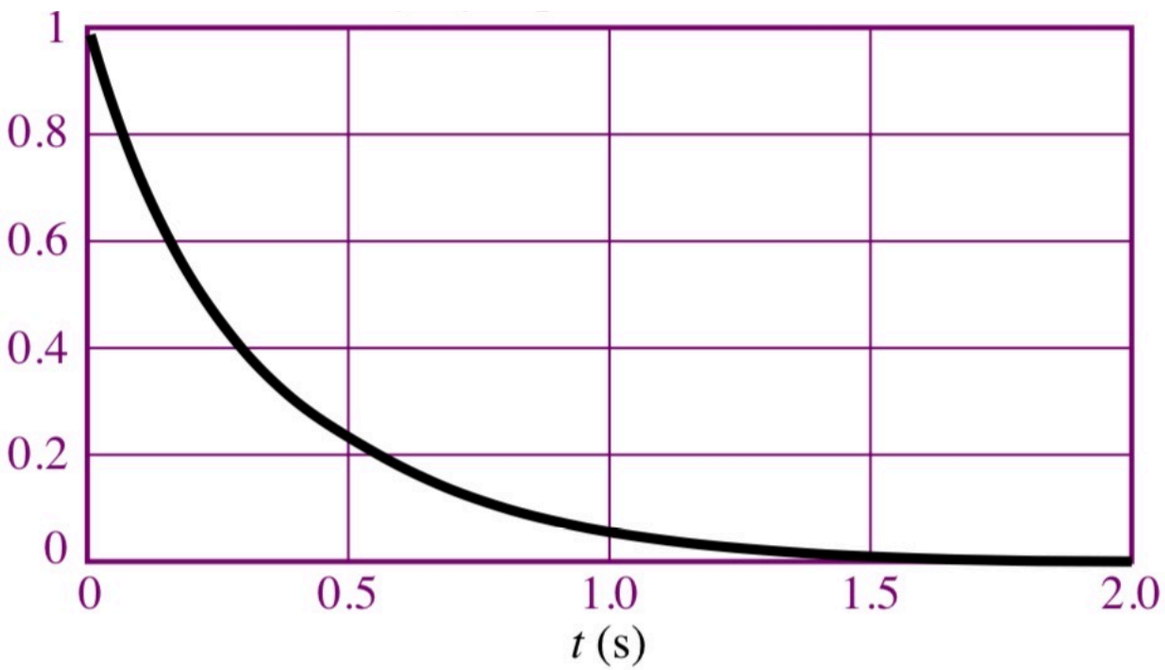
- Capacitor: open circuit
- Inductor: short circuit

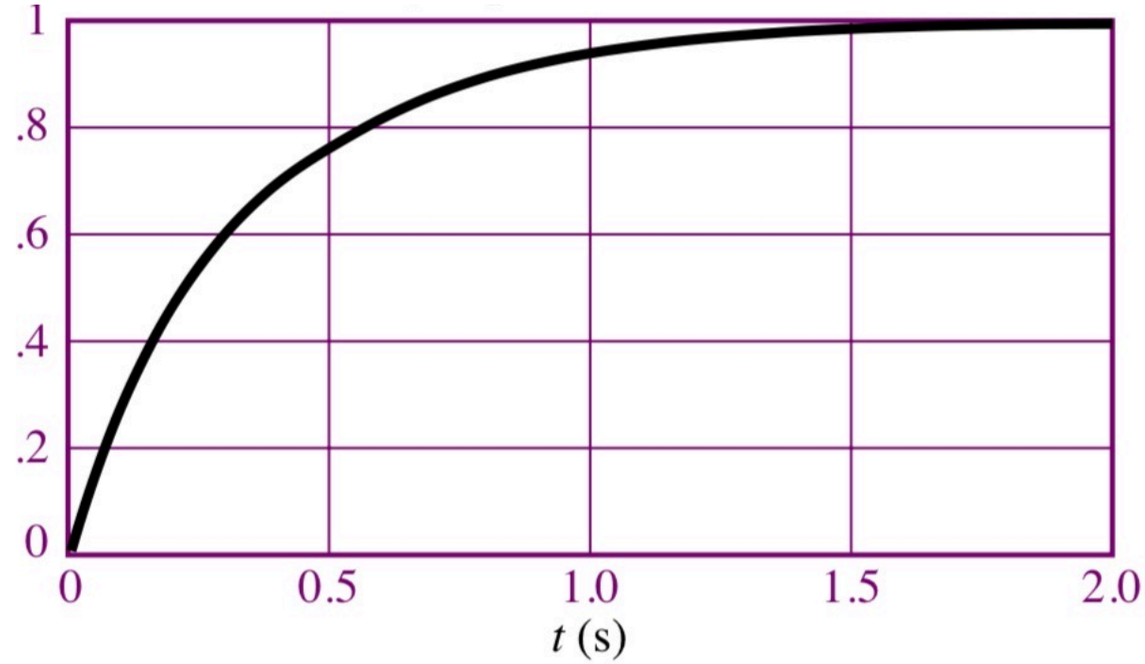
1. Physical switch.
2. Circuit element.
3. Voltage/current source.



First-Order Circuits

- A first-order circuit can only contain one energy storage element (a capacitor or an inductor).
- There are two types of first order circuits: RC and RL.

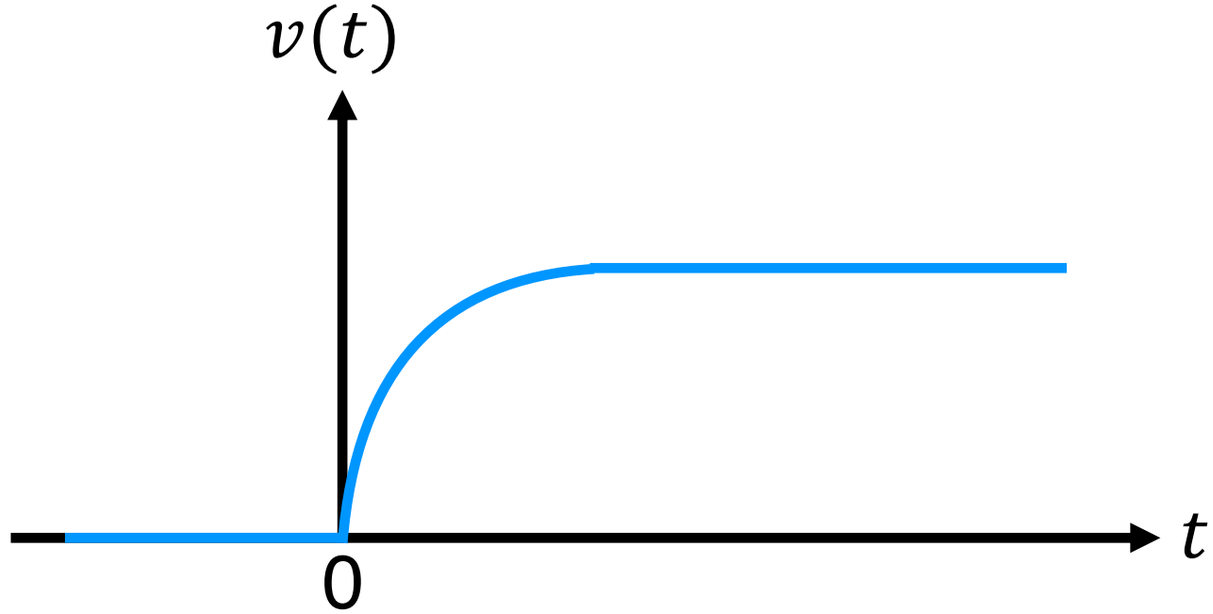




Time Constant

- τ which is a circuit time constant that controls the rate of decay of the exponential.
- It determines the time between steady states $v(0)$ and v(∞).

t	$v(t)$
τ	$63\%\ of\ K$
2τ	86%
3τ	95%
4τ	98%
5τ	99.3%
10τ	99.995%

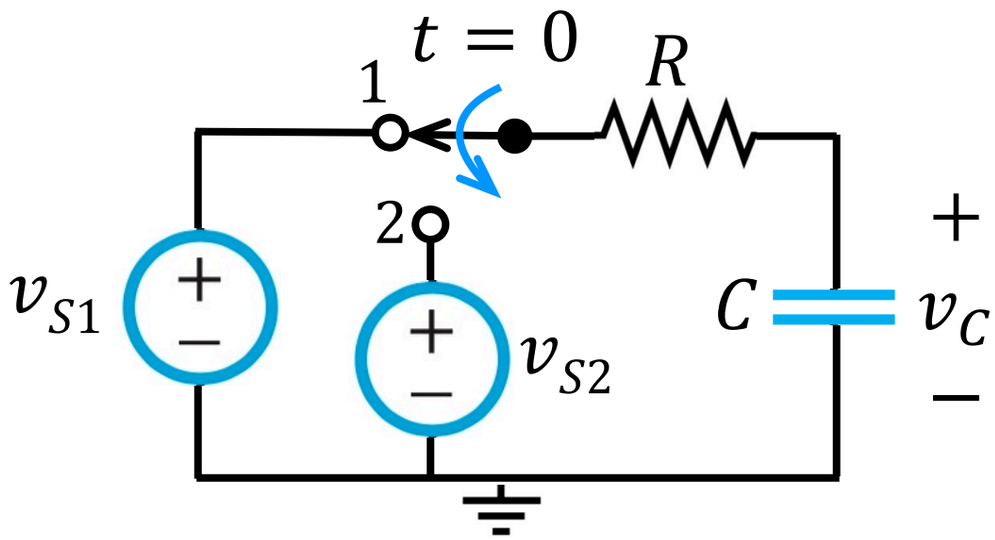


RC First-Order Circuit

1. Calculate the initial value of the capacitor $v_c(0)$ (e.g., when switch at 1).

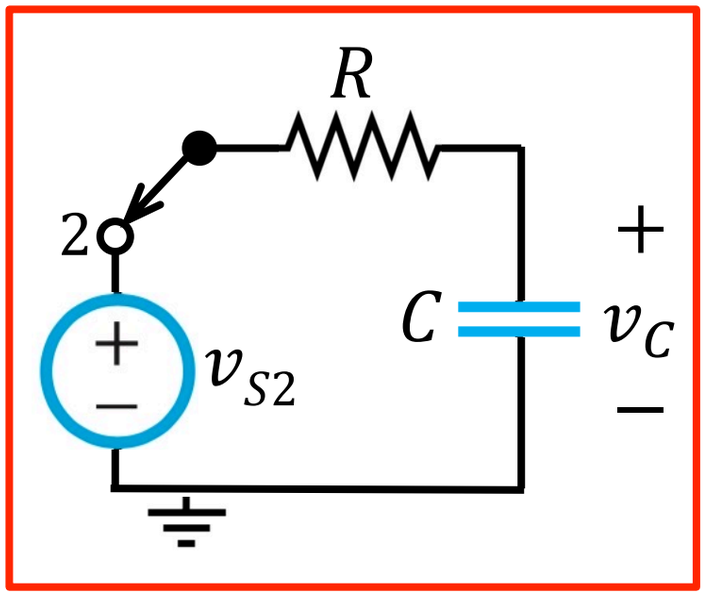
2. Calculate the steady-state response of the capacitor $v_c(\infty)$ (e.g., when switch at 2).

3. Solve for the transient response.



RC First-Order Circuit

Thevenin equivalent circuit with C as the load.

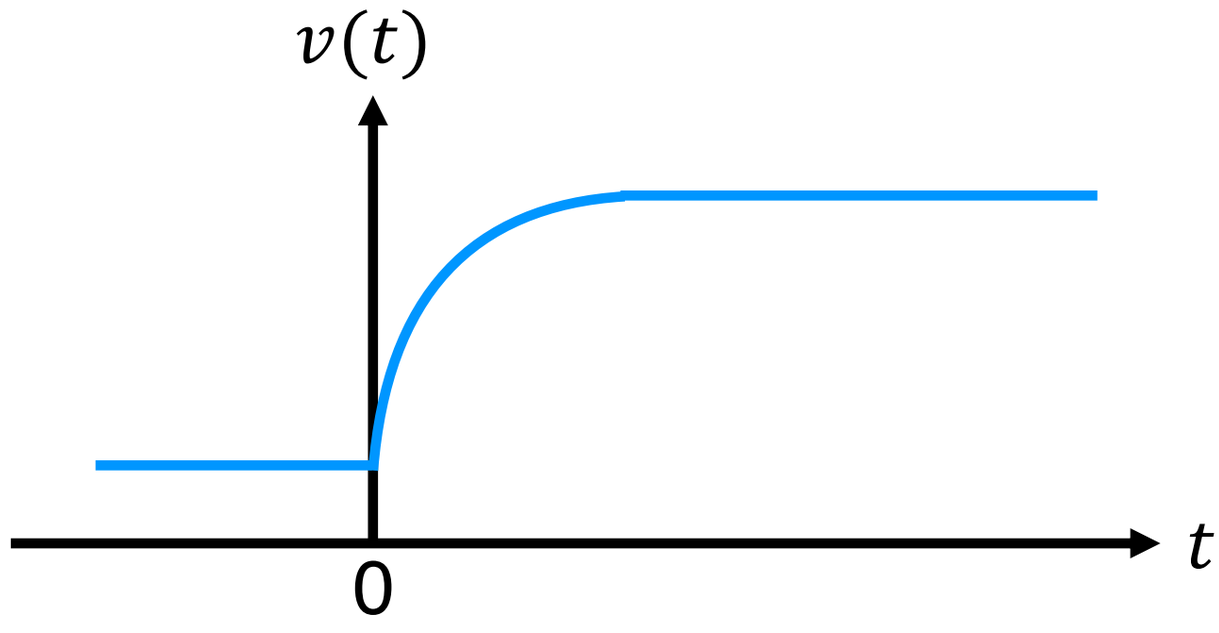


Replace R with R_{TH}

$$v_C(t) = v_C(\infty) + (v_C(0) - v_C(\infty))e^{-\frac{1}{RC}t}$$

What if the circuit does not look like this?

How do we calculate the transient response?



Example

"For a long time" before $t = 0$, $s_1 = open$ and $s_2 = closed$. At $t = 0$, $s_1 = closes$ and $s_2 = opens$. Find $v_C(t)$, for $t \geq 0$.