Ex:

After being open for a long time, the switch closes at \( t = 0 \). \( v_C(t = 0^-) = 0 \text{V} \). Find \( v_C(t) \) for \( t > 0 \).

**sol’n:** Use the general form of solution for RC problems.

\[
v_C(t > 0) = v_C(t \to \infty) + [v_C(0^+) - v_C(t \to \infty)] e^{-\frac{t}{R_C C}}
\]

We now proceed to find the following values:

- \( v_C(0^+) \), \( v_C(t \to \infty) \), and \( R_C C \)

To find \( v_C(0^+) \), we consider \( t = 0^- \) and find \( v_C(0^-) \). Since \( v_C \) is an energy variable that cannot change instantly, we have \( v_C(0^+) = v_C(0^-) \).

At \( t = 0^- \), currents and voltages have stabilized, and all time derivatives of currents and voltages are zero.

Thus, \( i_C = C \frac{dv_C}{dt} = C \cdot 0 = 0 \). \( C \) looks like open.
Example 1 (cont.)

\( t = 0^- : \ C = \text{open} \), switch open

From the circuit diagram, we cannot determine \( v_c(0^-) \). The \( C \) could be charged to some voltage, and it would remain at that voltage forever.

Fortunately, the problem states that \( v_c(0^-) = 0V \).

\( t = 0^+ : \ v_c \) cannot change instantly, so

\[ v_c(0^+) = v_c(0^-) = 0V \]

If needed a circuit model at \( t=0^+ \), we would model the \( C \) as a \( v \ source \) with value \( 0V \). In other words, \( C = \text{wire} \) at \( t=0^+ \).

To find \( v_c(t \rightarrow \infty) \), we again use the idea that currents and voltages are stable and \( C = \text{open} \).
\( t \to \infty: \quad C = \text{open}, \quad \text{switch closed} \)

Since no current flows, the voltage drop across the 2k\( \Omega \) and 3k\( \Omega \) \( R' \)'s is 0V.
Thus, we have 15V across \( C \): 

\( v_C(t \to \infty) = 15V \)

To find \( R_{Th} \), we remove \( C \) and find the Thevenin equivalent resistance seen looking into the terminals where \( C \) was connected.

For the circuit we are using here, we can find \( R_{Th} \) by turning off the independent 15V source:

\( R_{Th} = 2k\Omega + 3k\Omega = 5k\Omega \)

\( R_{Th}C = 5k\Omega \times 0.2\mu F = \frac{1}{5ms} \)

\( \therefore v_C(t>0) = 15V + (0V - 15V) e^{-\frac{t}{1ms}} \)

\( v_C(t \to \infty) \quad v_C(0^-) \quad v_C(t \to \infty) \)