Ex:

\[ R_1 = 15 \text{ k}\Omega \quad R_2 = 30 \text{ k}\Omega \]

\[ V_s = 12 \text{ V} \quad C = 250 \text{ nF} \]

The switch is open for a long time before closing at \( t = 0 \).

a) Find \( v_C(t = 0) \), the voltage on the capacitor at \( t = 0 \).

b) Find an expression for capacitor voltage, \( v_C(t > 0) \). Use numerical values (rather than symbolic values) for values in the expression.

c) How long must the switch be closed until the energy stored in the capacitor is \( w_C = 12.5 \text{ }\mu\text{J} \) 

\[ \text{Sol'n: a) At } t=0, \text{ the switch has been open for a long time and the } C \text{ has charged. No current is flowing into the } C, \text{ so it acts like an open circuit.} \]

\[ V_s = 12 \text{ V} \]

No current flows thru the \( R \)'s, so there is no \( V \)-drop across the \( R \)'s. Thus, \( V_c(0) = V_s = 12 \text{ V} \).

\[ v_c(0) = 12 \text{ V} \]
b) We use the general formula for RC circuits:

\[ v_c(t>0) = v_c(t\to\infty) + [v_c(0) - v_c(t\to\infty)] e^{-t/R_{Th2}C} \]

where \( R_{Th2} \) is the Thevenin resistance seen from the terminals where the \( C \) is connected using the switch in its position after \( t=0 \).

Also, \( v_c(t\to\infty) = v_{Th2} \), the Thevenin voltage for the circuit after \( t=0 \) (from terminals where \( C \) is connected).

![Diagram of RC circuit](image)

We have no current in \( R_2 \), so there is no \( v \)-drop across \( R_2 \). There is also no \( v \)-drop on the wire. For a \( v \)-loop on the right side, we must have \( V_{Th2} = 0V \) since the wire and \( R_2 \) have 0V drops.

\[ v_c(t\to\infty) = V_{Th2} = 0V \]

For \( R_{Th2} \), we turn off \( V_3 \), which becomes a wire.

\[ R_{Th2} = R_2 \text{ since } 0.1 \parallel R_1 = 0 \Omega \]

\[ = 30 \text{k}\Omega \]

Our time constant is \( \tau = 30 \text{k}\Omega \cdot 250\text{nF} = 7.5 \text{ ms} \)

\[ v_c(t>0) = v_c(0)e^{-t/\tau} = 12V e^{-t/7.5 \text{ ms}} \]
c) Energy for a C is $w_C = \frac{1}{2} CV_C^2$.

\[
12.5 \mu J = \left(\frac{1}{2}\right) 250 \text{nF} \cdot V_C^2
\]

\[
V_C = \sqrt{\frac{12.5 \mu J}{\left(\frac{1}{2}\right) 250 \text{nF}}} = \sqrt{\frac{12.5}{125}} \Rightarrow V = \sqrt{100} \quad V = 10 \text{ V}
\]

So we find $t$ when $V_C = 10 \text{ V}$.

\[
10 \text{ V} = 12Ve^{-t/7.5 \text{ ms}}
\]

or

\[
\frac{10}{12} = e^{-t/7.5 \text{ ms}}
\]

or

\[
\ln\left(\frac{10}{12}\right) = -\frac{t}{7.5 \text{ ms}}
\]

or

\[
t = 7.5 \text{ ms} \ln\left(\frac{12}{10}\right) = 7.5 \text{ ms} \cdot (0.182) \approx 1.37 \text{ ms}
\]

\[
t = 1.37 \text{ ms}
\]