EE2005 Electronic Devices and Circuits **Tutorial 3 @ Week7-8**

1. The voltage across and the current through a capacitor are shown in Figure 1. Determine the value of the capacitance.

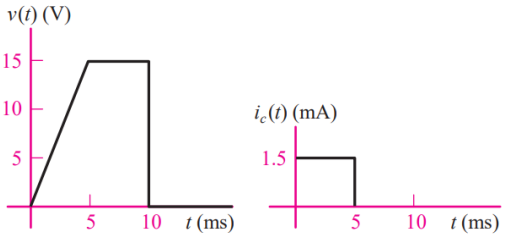


Figure 1

Hint: apply the capacitor law $i(t) = C\frac{dv(t)}{dt}$ to equate dv/dt and i(t) during 0 – 5ms of figure 1, then find out C.

Ans: 0.5 μF

2. Determine v_C (t) for t > 0. The voltage across the capacitor in Figure 2 just before the switch is changed is given below.

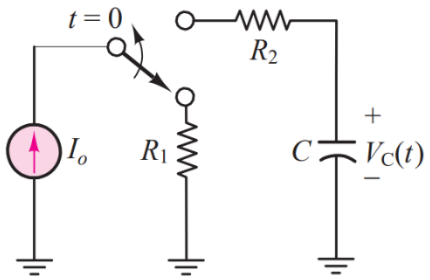


Figure 2

Given:
v_C (0−) = −10V, R_1 = 100 Ω, I_o = 20 mA, R_2 = 10 Ω, C = 1mF

Hint: apply the capacitor law $i(t) = C\frac{dv(t)}{dt}$. Io is a current source, so dv/dt is a constant. Also, the voltage across C must be continuous, i.e. v_C (0+) = v_C (0−).

Ans: $v(t) = -10 + 20t$ V

3. Find i(t) in the circuit of Figure 3 for t > 0. Assume that the switch has been closed for a long time.

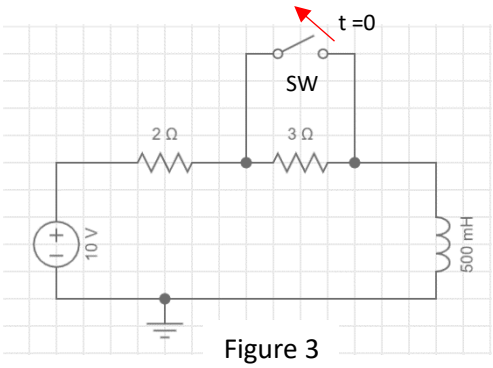


Figure 3

Hint: first determine i(0-), i(0+), I(∞), the equivalent resistance R_{TH} seen by the inductor without considering the 10v source, the time constant τ. Apply the general first order equation on inductor to determine i(t), for t >0.

Ans: $\tau = 0.1$s, $i(t) = 2 + 3e^{-10t}$ A

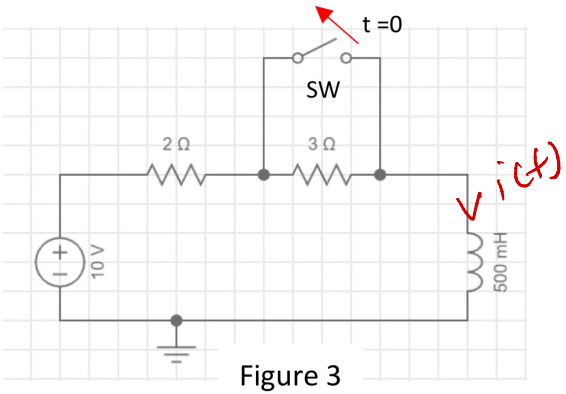


Figure 3

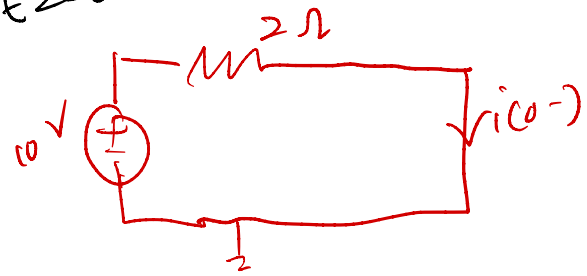
$i(0-) = i(0+)$

$i(0+) = i(0-)$

$i(0-) \rightarrow$ steady state

$\text{short} \rightarrow$ —

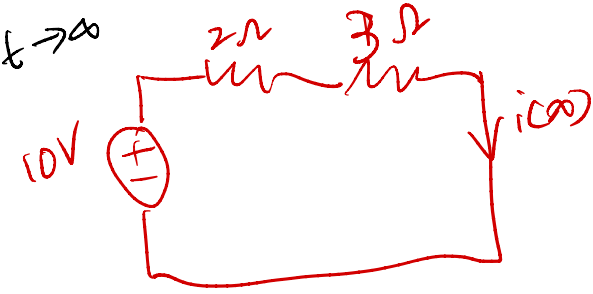
$t < 0$



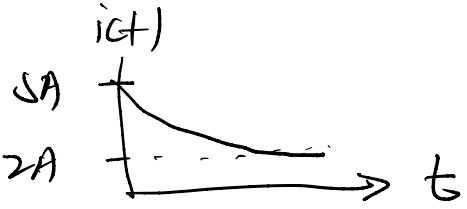
$\Rightarrow i(0-) = \frac{10}{2} = 5A$

$\Rightarrow i(0+) = 5A$

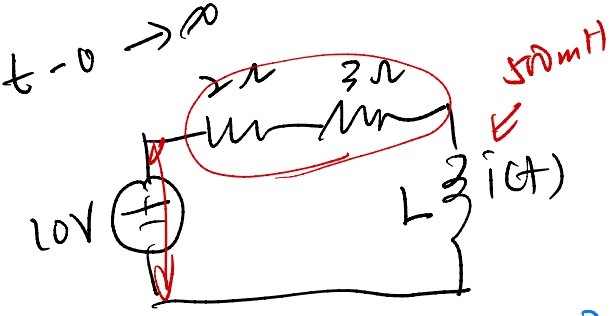
$t \rightarrow \infty$



$\Rightarrow i(\infty) = \frac{10}{2+3} = 2A$



$t = 0 \rightarrow \infty$



$\tau = \frac{L}{R_{TH}} \rightarrow 2+3 = 5\Omega$

$\tau = \frac{500 \times 10^{-3}}{5} = 0.1s$

$i(t) = i(\infty) + [i(0+) - i(\infty)]\, e^{-t/\tau}$

$i(t) = 2 + [5-2]\, e^{-t/0.1} \Rightarrow 2 + 3e^{-10t}\ A$

4. The switch in Figure 4 has been in position A for a long time. At t = 0, the switch moves to B. Determine v(t).

   Hint: first determine v(0-), v(0+), v(∞), the time constant τ. Apply the general first order equation on inductor to determine v(t), for t > 0.

   Ans: $\tau = 1.5\text{s}, v(t) = 30 - 17.86e^{-t/1.5}$ V

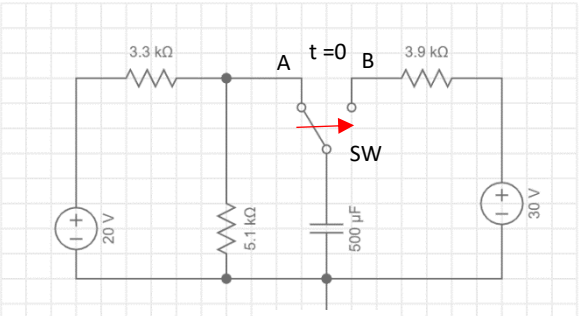


Figure 4

5. Find v(t) for t >0 in the circuit of Figure 5. Assume the switch has been open for a long time and is closed at t = 0. Calculate v(t) at t = 0.5.

   Hint: first determine v(0-), v(0+), v(∞), the equivalent resistance R_{TH} seen by the capacitor without considering the voltage sources, the time constant τ. Apply the general first order equation on inductor to determine v(t), for t >0. Then determine v(0.5).

   Ans: v(∞)=9.375 V; $v(t) = 9.375 + 5.625e^{-1.333t}$ V

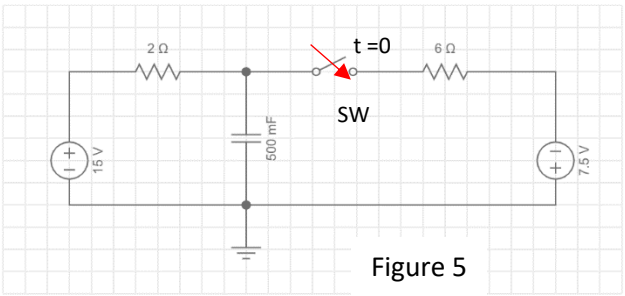


Figure 5

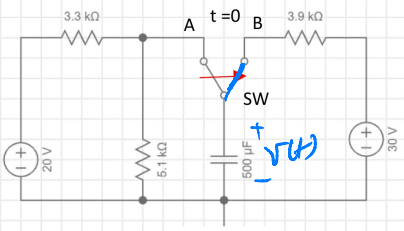
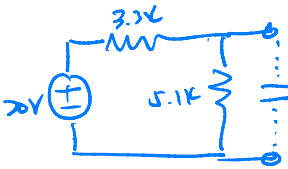


Figure 4

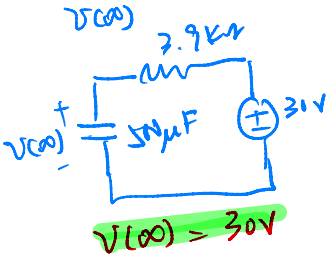
To determine $v(t)$ $t>0$

$v(0^+) = v(0^-)$

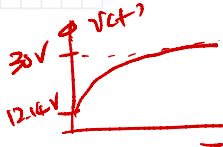
$\pm \rightarrow \frac{1}{9}$



$v(0^-) = 20 \frac{5.1}{3.3+5.1} = 12.14\,V = v(0^+)$



$v(\infty) = 30V$



$v(t) = v(0+) + [v(\infty) - v(0+)][1 - e^{-t/\tau}]$

$\tau = RC = (3.9K\Omega)(50\mu F)$

$= 1.95\,s$

We put all the values into (*), we have

$v(t) = 12.14 + [30 - 12.14](1 - e^{-t/1.95})$

$v(t) = 12.14 + 17.86(1 - e^{-0.5128t})$

$= 12.14 + 17.86 - 17.86\,e^{-0.5128t}$

$v(t) = 30 - 17.86\,e^{-0.5128t}$

At $t=0$ $v(0) = 30 - 17.86 = 12.14\,V$

At $t \rightarrow \infty$ $v(\infty) = 30 - 0 = 30\,V$

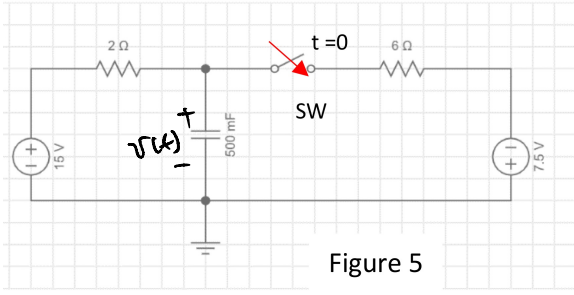
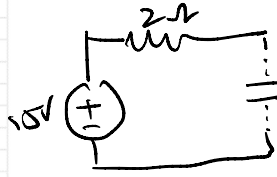
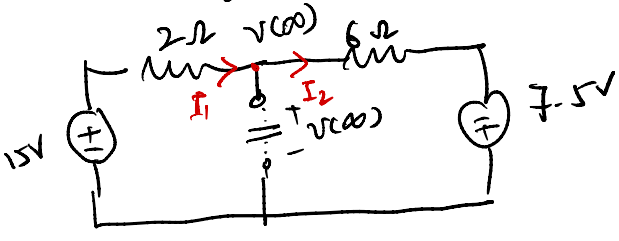


Figure 5

$v(0+) = v(0-)$ for capacitor



At $t \to \infty$



$I_1 - I_2 = 0$

$\frac{15 - v(\infty)}{2} = \frac{v(\infty) + 7.5}{6}$ (3)

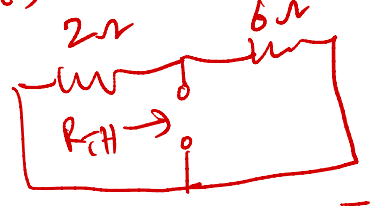
$\Rightarrow 45 - 3v(\infty) = v(\infty) + 7.5$

$\Rightarrow 37.5 = 4v(\infty)$

$v(\infty) = 9.375$ V

for $t > 0$

$v(t) = v(\infty) + [v(0+) - v(\infty)]\, e^{-t/\tau}$



$R_{TH} = 2 \| 6 = 1.5\,\Omega$

$\tau = R_{TH} C = 1.5 \times 0.5 = 0.75$

$v(t) = 9.375 + [15 - 9.375]\, e^{-1.333\,t}$ V

$= 9.375 + 5.625\, e^{-1.333\,t}$