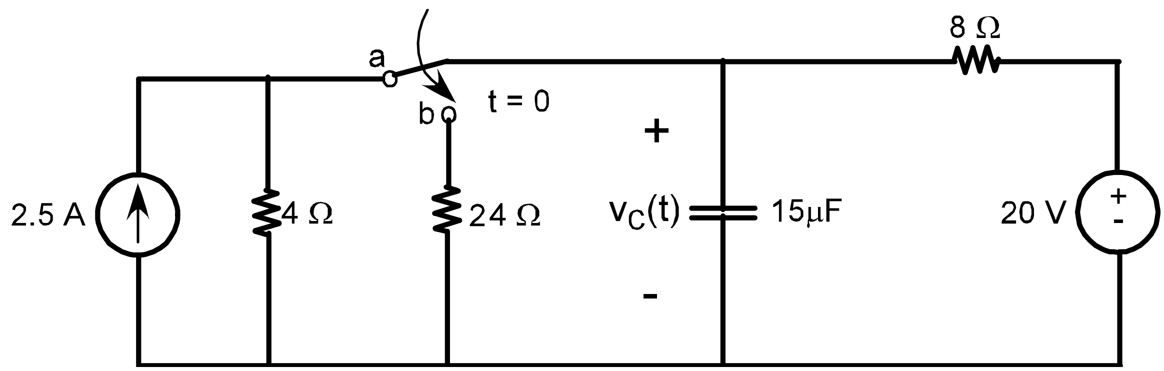
ROSE-HULMAN INSTITUTE OF TECHNOLOGY

ECE203 DC Circuits Spring 2016-2017

Homework Set #26
DUE Tuesday, May 16, 2017

1. In the circuit below, the switch is moved instantaneously from a to b at t = 0. Determine:
   a) Initial and final voltages across the capacitor.
   b) The time-constant, τ
   c) $v_C(t)$ and $i_C(t)$.



Since the switch has been closed for a long time, the capacitor has become fully charged before the switch is opened and is an open-circuit. Convert the current source to a Thevenin 10 V in series with 4 Ω to give a circulating current of:

$$I_{cir} = \frac{20-10}{8+4} = 0.8333 \text{ A}$$

$$\therefore \quad v_C(0^+) = v_C(0^-) = 20 - 8 \times 0.8333 = 13⅓ \text{ V}$$

i.e. the initial voltage, $\boxed{V_0 = 13⅓ \text{ V}}$

For t > 0, the capacitor becomes an open-circuit in steady-state and V_f is given by the voltage divider relationship:

$$V_f = 20\frac{24}{8+24} = \boxed{15 \text{ V}}$$

The Thevenin resistance seen by C is 6 Ω, so the time constant is:

$$\tau = RC = 15 \times 10^{-6} \times 6 = \boxed{90 \ \mu s}$$

Since: $v_C(t) = (V_0 - V_f)e^{-t/\tau} + V_f = (13.33-15)e^{-11111t} + 15 = 15 - 1.667e^{-11111t}$

Then: $\boxed{v_C(t) = 15 - 1.667e^{-11111t}}$

$$i_C(t) = C_{eq}\frac{dv_C}{dt} = 15 \times 10^{-6} \times (-1.667) \times (-11111)e^{-11111t}$$

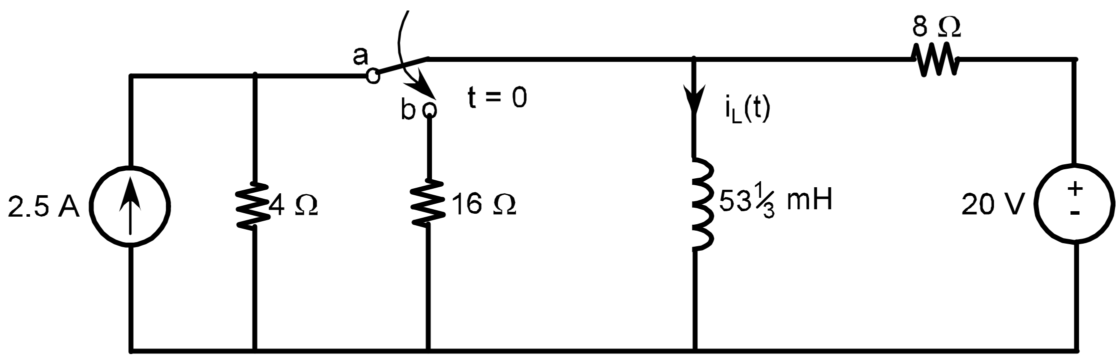
And: $\boxed{i_C(t) = 277.8e^{-11111t} \ mA}$

2. In the circuit below, the switch is moved instantaneously from a to b at t = 0. Determine:

a) Initial and final currents through the inductor.

b) The time-constant, τ

c) $i_L(t)$ and $v_L(t)$.



Since the switch has been closed for a long time, the inductor has become fully energized before the switch is opened and is a short-circuit.

$$\therefore \quad i_L(0^+) = i_L(0^-) = 2.5 + 2.5 = 5 \text{ A}$$

i.e. the initial current, $\boxed{I_0 = 5\text{A}}$

For t > 0, the inductor becomes a short-circuit in steady-state and $I_f = 2.5$ A.

The Thevenin resistance seen by L is 5⅓ Ω, so the time constant is:

$$\boxed{\tau = \frac{53.33\text{x}10^{-3}}{5.333} = 10\text{ ms}}$$

Since: $i_L(t) = (I_0 - I_f)e^{-t/\tau} + I_f = (5 - 2.5)e^{-100t} + 2.5 = 2.5 + 2.5e^{-100t}$

Then: $\boxed{i_L(t) = 2.5(1 + e^{-100t})\text{ A}}$

$$v_L(t) = L_{eq}\frac{di_L}{dt} = 0.05333 \ x \ (-2.5 \text{ x } 100e^{-100t})$$

And: $\boxed{v_L(t) = -13.33e^{-100t} \ V}$