Solution

College of Technological Studied, Electronics Department
Electrical Circuits (ENT#140)

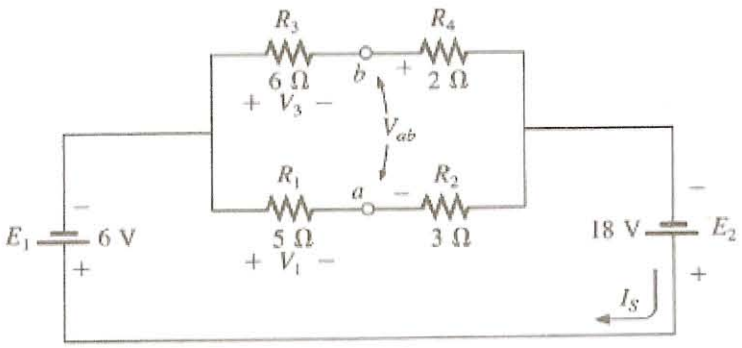
Final Exam

Name: Date:

Problem-1:

For the circuit shown below, to calculate the following:

1. V_1.
2. V_3.
3. V_{ab}.
4. I_s.



Solution-1:

1) $V_1 = \frac{R_1 E}{R_1 + R_2} = \frac{(5\Omega)\times(12V)}{(5\Omega)+(3\Omega)} = \frac{60V}{8\Omega} = 7.5V \Rightarrow V_1 = 7.5V$

2) $V_3 = \frac{R_3 E}{R_3 + R_4} = \frac{(6\Omega)\times(12V)}{(6\Omega)+(2\Omega)} = \frac{72V}{8\Omega} = 9V \Rightarrow V_3 = 9V$

From the simple figure, with clockwise direction starting at terminal (a)

$\therefore +V_1 - V_3 + V_{ab} = 0 \leftarrow$ (KVL)

$V_{ab} = V_3 - V_1 \rightarrow V_{ab} = 9V - 7.5V = 1.5V \Rightarrow V_{ab} = 1.5V$

By Ohm's Law

$I_1 = \frac{V_1}{R_1} = \frac{7.5V}{5\Omega} = 1.5A \Rightarrow I_1 = 1.5A$

$I_3 = \frac{V_3}{R_3} = \frac{9V}{6\Omega} = 1.5A \Rightarrow I_3 = 1.5A$

By (KCL) $I_s = I_1 + I_3 \Rightarrow I_s = (1.5A) + (1.5A) = 3A$

$I_s = 3A$

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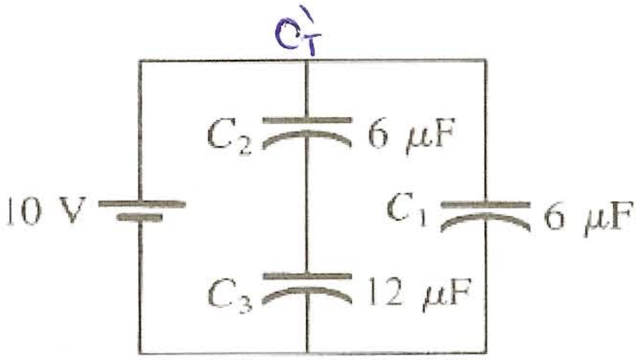
Problem-2:

Find the voltage across and charge on each capacitor for the circuit shown below.

This is mean to calculate the following: V and Q on the C_1, C_2 and C_3.



Solution-2:

$\because C = \frac{Q}{V} \therefore C'_T = \frac{C_2 \times C_3}{C_2 + C_3} = \frac{6 \times 12}{6 + 12} = 4 \mu F \Rightarrow \boxed{C'_T = 4 \mu F}$ *

$\therefore Q'_T = Q_2 = Q_3 \Rightarrow Q'_T = C'_T \cdot V = (4 \mu F) \times (10 V) = 40 \mu c$

$\boxed{Q'_T = 40 \mu c}$ *

$\therefore V_2 = \frac{Q'_T}{C_2} = \frac{40 \mu c}{6 \mu F} = 6.67 V \Rightarrow \boxed{V_2 = 6.67 V}$ *

$V_3 = \frac{Q'_T}{C_3} = \frac{40 \mu c}{12 \mu F} = 3.33 V \Rightarrow \boxed{V_3 = 3.33 V}$ *

$Q_1 = C_1 V_1 = (6 \mu F) \times (10 V) = 60 \mu c$

$\boxed{Q_1 = 60 \mu c}$ *

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Problem-3:

For the network shown below:

a. **Find the mathematical expression for the voltage across the capacitor after the switch is thrown into position 1.**

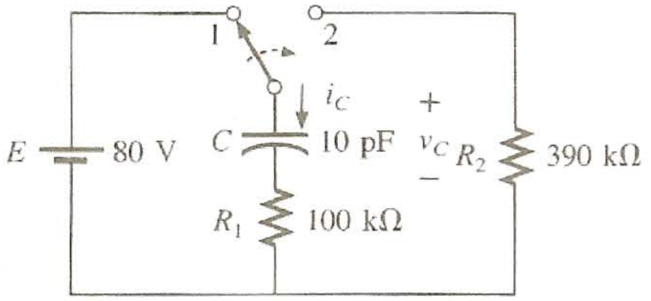
b. **Repeat part (a) for the current i_C.**

c. **Find the mathematical expressions for the voltage v_C and current i_C if the switch is thrown into position 2 at a time equal to five time constants of the charging circuit.**

d. **Plot the waveforms of v_C and i_C for period of time extending from t=0 to t=30µs.**

$\tau = R.C \Rightarrow \tau = (100\times10^{3})\times(10\times10^{-12})$

$\tau = 1\mu s$



Position (1) **Solution-3:**

$V_c = E(1 - e^{-t/\tau})$

$V_c = 80(1 - e^{-t/1\mu s})$

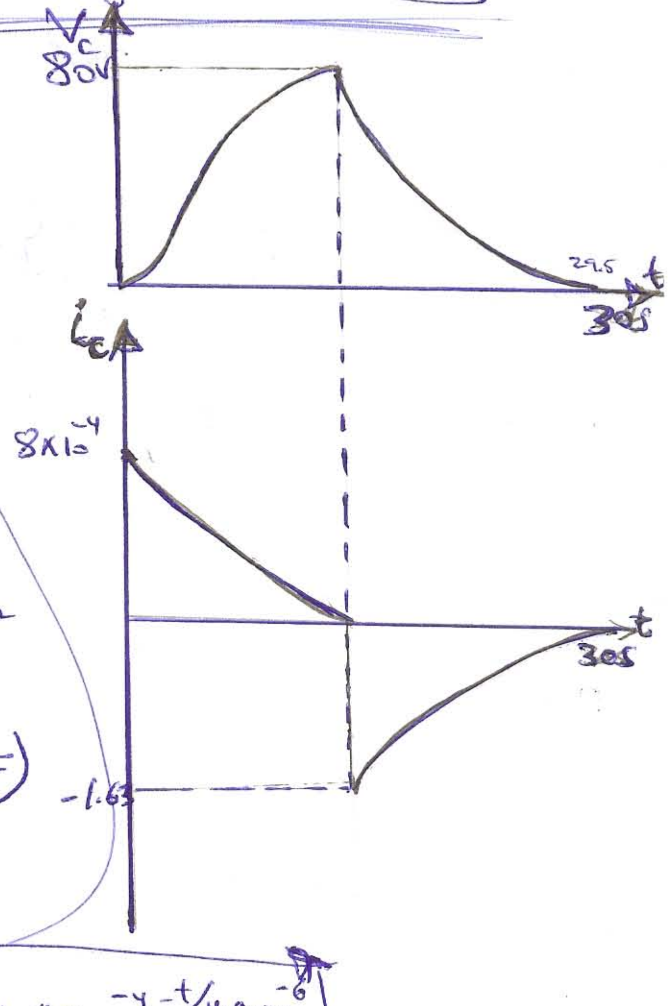
$V_c = 80(1 - e^{-t/1\times10^{-6}s})$

$i_c = \frac{E}{R} e^{-t/\tau}$

$i_c = \frac{80V}{100\times10^{3}\Omega} e^{-t/1\times10^{-6}s}$

$i_c = 8\times10^{-4} e^{-t/1\times10^{-6}s}$

Draw just approximatly:



Position (2):

$R_T = R_1 + R_2 \Rightarrow R_T = 100k\Omega + 390k\Omega$

$R_T = 490k\Omega$

$\tau' = R_T.C \Rightarrow \tau' = (490k\Omega)\times(10\times10^{-12}F)$

$\tau' = 4.9\times10^{-6}s$

Discharge phase $V_c = E e^{-t/\tau}$

$V_c = 80V e^{-t/4.9\times10^{-6}s}$

$i_c = -I_i e^{-t/\tau} \Rightarrow i_c = \frac{-80}{490k\Omega} e^{-t/4.9\times10^{-6}} \Rightarrow i_c = -1.63\times10^{-4} e^{-t/4.9\times10^{-6}}$

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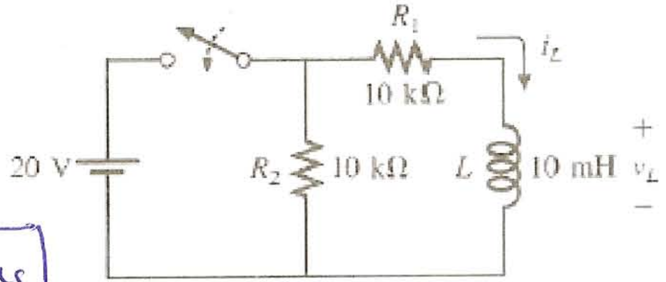
Problem-4:

For the network shown below:

a. **Determine the mathematical expression for the current i_L and voltage v_L after the switch is closed.**

b. **Repeat part (a) if the switch is opened after a period of five time constants has passed.**

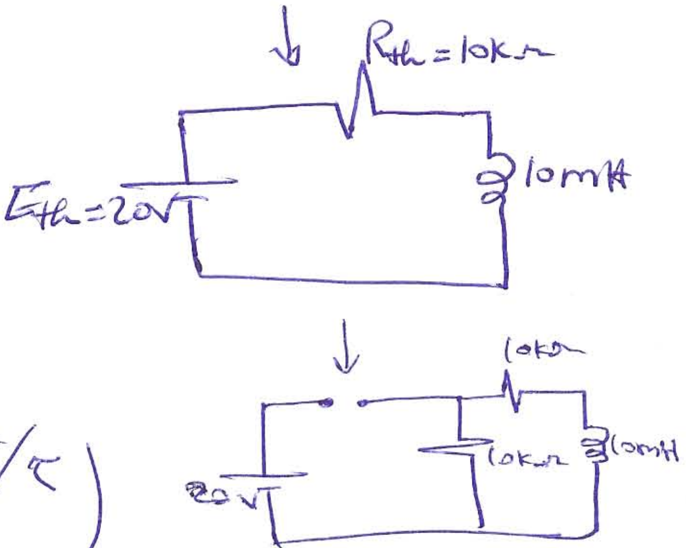


(a) $I_m = \frac{20}{10k} = 2mA$

$\therefore i_L = 2m(1 - e^{-t/\tau})$

$\tau = \frac{L}{R} = \frac{10m}{10k} = 1\mu s \rightarrow \boxed{\tau = 1\mu s}$

Solution-4:



(b) Switch is opened after $t = 5\tau$

$\tau = \frac{L}{R_1 + R_2} = \frac{10m}{20k} = 0.5\mu s$

$i_L = 2m\, e^{-t/0.5\mu s}$

$V_L = E\left(1 + \frac{R_2}{R_1}\right) \cdot (1 - e^{-t/\tau})$

$V_L = 20(1+1) \cdot (1 - e^{-t/\tau}) = 40(1 - e^{-t/\tau})$

$\boxed{V_L = 40(1 - e^{-t/\tau})}$

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Problem-5 [Additional Point]:

For the network shown below:

a. Find the mathematical expression for the current i_L and voltage v_L after the switch is closed.

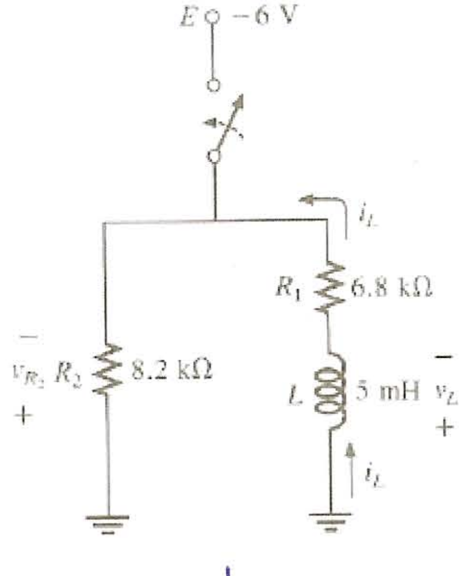
b. Find the mathematical expressions for the voltage v_L and current i_L if the switch is opened after a period of five time constants has passed.

c. Plot the waveforms of v_L and i_L for the time period defined by parts (a) and (b).

d. Sketch the waveform for the defined polarities and directions.

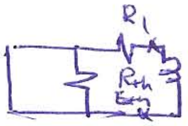
e. Find the current through the inductor after it is reached its final value.

$\tau = \frac{L}{R_1} = \frac{5\times10^{-3}}{6.8\times10^{3}} = 0.73\mu s$



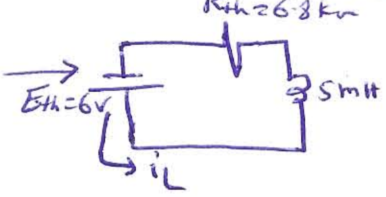
Solution-5:

(a) i_L, V_L when S is closed →



$R_{th} = R_1 = 6.8K$

$E_{th} = 6V$



$\therefore i_L = \frac{E_{th}}{R_{th}}(1-e^{-t/\tau})$

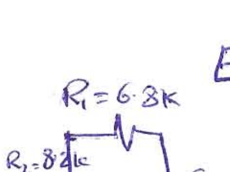
$I_m = \frac{E_{th}}{R_{th}} = \frac{6V}{6.8k\Omega} = 0.88mA$

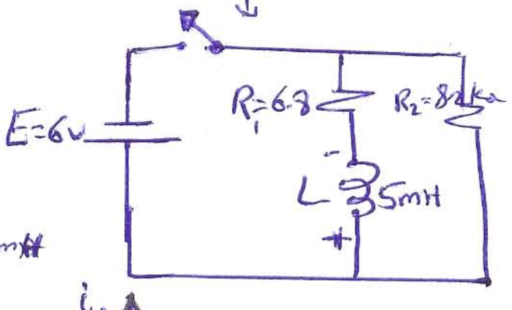
$\tau = \frac{L}{R_{th}} = \frac{5m}{6.8K} = 0.735\mu s$

$i_L = 0.88(1-e^{-t/0.735\mu s})$

$V_L = 6e^{-t/0.735\mu s}$

(b) If S is opened after 5τ





$\tau_2 = \frac{L}{(R_1+R_2)} = \frac{5m}{(6.8k+8.2k)} = \frac{5m}{15K}$

$\tau_2 = \frac{5m}{15k} \Rightarrow \tau = 0.333\mu s$

$V_L = V_i(1-e^{-t/\tau_2}) \Rightarrow V_L = E(1+\frac{R_1}{R_2})$

$V_L = 6(1+\frac{8.2}{6.8}) = 13.23V$

$\therefore V_L = -13.23(1-e^{-t/0.333\mu s})$

$i_L = I_m e^{-t/\tau_2} \Rightarrow i_L = 0.88m\, e^{-t/0.333\mu s}$