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EXAM 3
ELEE 2335
April 19, 1986

INSTRUCTIONS:

1. Sign your name on the upper left of this page.

2. All work is to be done in the spaces provided in this booklet. Use the backs if necessary. Indicate clearly where your work and answers may be found. Enclose your final answers in a box. No credit will be given unless the necessary work is shown. No crib sheets are allowed.

3. Make sure that some kind of clear distinction is obvious between complex quantities (phasors and impedances) and time domain functions. Underlined symbols, lines over symbols, or any other clear method will be acceptable. Show all of your units explicitly, both in your final answer and in your intermediate steps. Units in exam questions are placed within square brackets.

4. If your answers and work are not in ink, there will be no provision for changing your grade once the exam is returned to you. Do not use red ink.

1. 35
2. 35
3. 30

100

Signature: Solution Key

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2. 35
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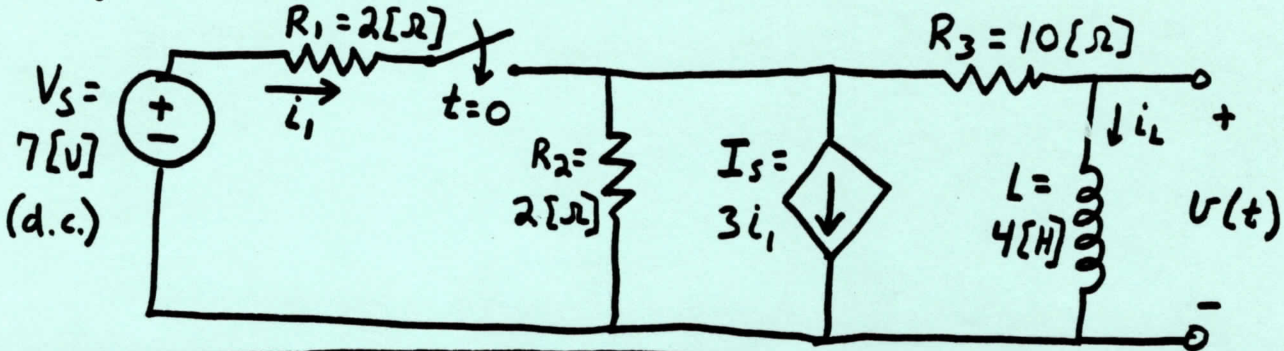
100

1. (35 Points) Assume that the circuit below has had the switch open for a long time. The switch closes at t = 0. Find v(t) for t > 0.

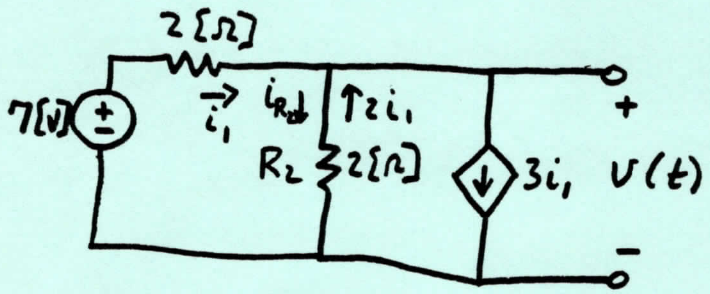


Solution:

initial conditions

$i_L = 0; \; t \le 0$

For $t = 0^+$, the following circuit results:



From KCL at top node, $i_{R_2} = -2i_1$ +5

KVL:

$$7[V] = i_1 R_1 - 2i_1 R_2$$

$$i_1 = \frac{7[V]}{-2[\Omega]} = -3.5[A]$$

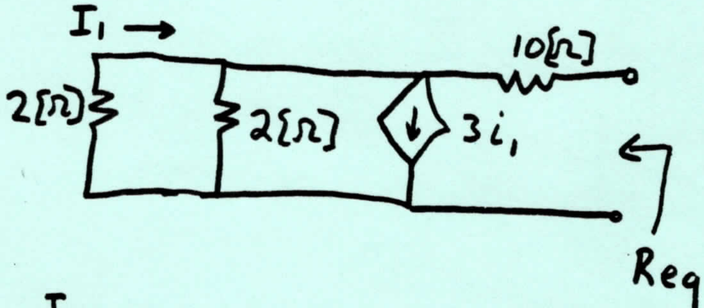
$$v(0^+) = -(2i_1)R_2 = 14[V]$$ +5

For $t = \infty$, $v(t) = 0$ since inductor acts as short circuit in steady state, DC sources. +5

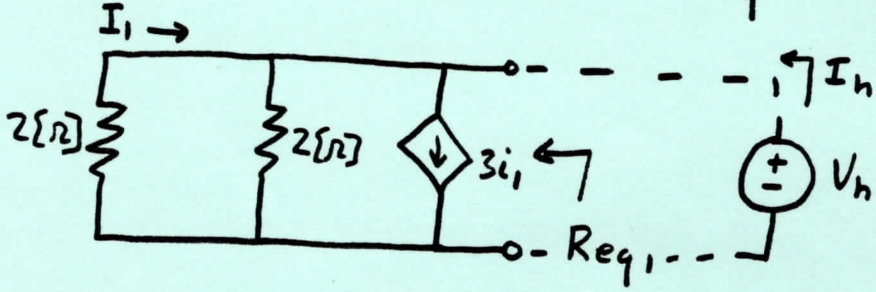
Room for Extra Work

Now, need τ.

$$\tau = \frac{L}{Req.} = \frac{L}{Req_1 + 10[\Omega]}$$



+5



$$Req_1 = \frac{V_n}{I_n}$$

$$I_n = \frac{V_n}{2} + \frac{V_n}{2} + 3i_1$$

$$i_1 = \frac{-V_n}{2}$$

$$I_n = \frac{2V_n}{2} - \frac{3V_n}{2} = -\frac{V_n}{2}$$

$$Req_1 = -2[\Omega]$$

$$Req = (10-2)[\Omega] = 8[\Omega]$$ +5

$$\tau = \frac{4[H]}{8[\Omega]} = .5[sec]$$

$$v(t) = A + Be^{-t/\tau}$$ +5

$$v(0) = 14[v] = A + B$$

$$v(\infty) = 0 = A \Rightarrow B = 14[v]$$

$$\boxed{v(t) = 14[v]\,e^{-2t}}$$ +5

math error

-3

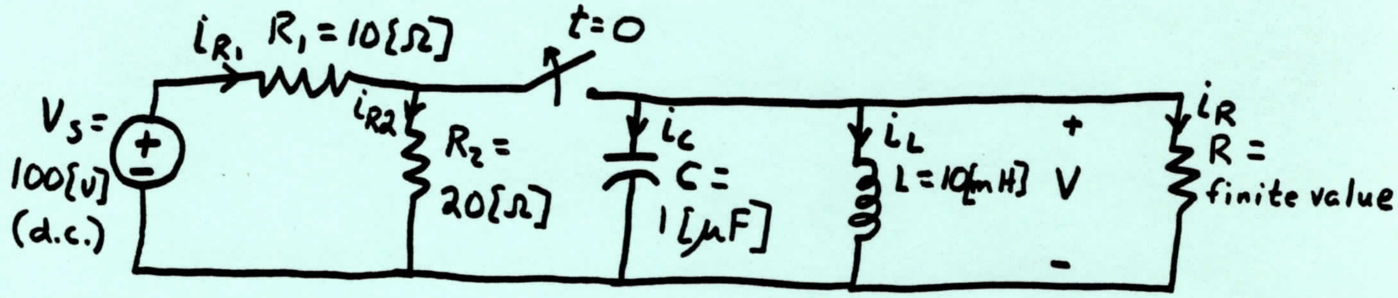
sign error

-3 to -5

other errors

-5 to -10

2. (35 Points) In the following circuit, the switch was closed for a long time before t = 0. The switch is opened at t = 0.



a) Determine the value of i_{R1}, i_{R2}, i_C, i_L, i_R, and v before the switch is opened ($t < 0$ or $t = 0^-$).

- the inductance is like a short-circuit on a d.c. steady-state, circuit:

$\boxed{i_{R1}(0^-) = i_L(0^-) = \frac{V_S}{R_1} = \frac{100}{10} = 10[A]}$; $\boxed{v(0^-) = 0}$; $\boxed{i_R(0^-) = 0\ [A]}$

$\boxed{i_{R2}(0^-) = 0[A]}$; -the capacitor like an open circuit: $\boxed{i_C(0^-) = 0[A]}$

b) How much should be the value of R to have a critically damped response for $t \geq 0$?

For $t > 0$, the circuit is a parallel RLC circuit. To have a critically damped response; $\alpha^2 = \omega_0^2 \Rightarrow$

$$\left(\frac{1}{2RC}\right)^2 = \left(\frac{1}{\sqrt{LC}}\right)^2 \Rightarrow R = \frac{\sqrt{LC}}{2C} = \frac{1}{2}\sqrt{\frac{L}{C}} = \frac{1}{2}\sqrt{\frac{10 \cdot 10^{-3}}{1 \cdot 10^{-6}}} = \boxed{50[\Omega]}$$

c) With the R value you obtained in b), determine v(t), for t ≥ 0.

For a critically damped circuit, the response is:

$$v(t) = (At + B)e^{-\alpha t};$$

$$\alpha = \frac{1}{2RC} = \frac{1}{2*50*1*10^{-6}} = 10^4 [1/s];$$

To obtain the constants A & B, are used informations known at $t=0^+$ (voltage on the capacitor: $v_c(0^+) = v_c(0^-) = 0 [V]$; the current on inductor: $i_L(0^+) = i_L(0^-) = 10 [A]$).

B →; $t=0^+$, $v(0^+) = 0 = (A \cdot 0 + B)*1 \Rightarrow B = 0 \Rightarrow$.

$$v(t) = Ate^{-10^4 t}$$

A →; $i_R(0^+) + i_L(0^+) + i_c(0^+) = 0$;

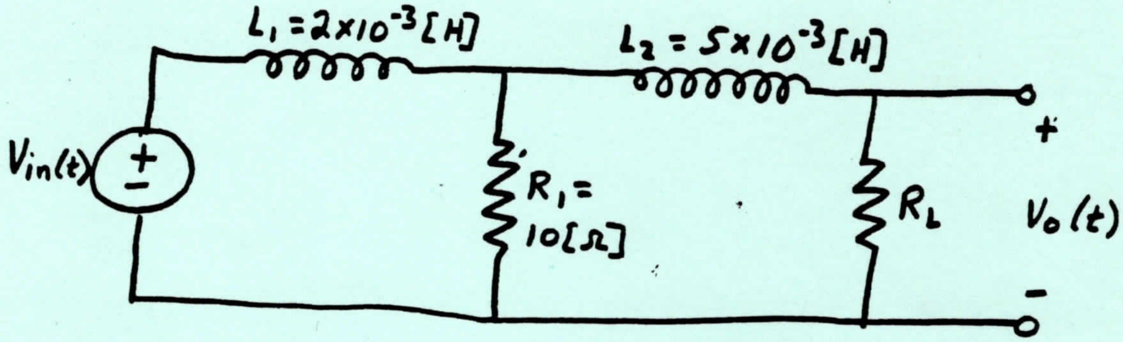
$$i_R(0^+) = \frac{v(0^+)}{R} = \frac{0}{R} = 0; \quad i_L(0^+) = i_L(0^-) = 10[A].$$

$$i_c(0^+) = C\left.\frac{dv}{dt}\right|_{0^+} = 1.10^{-6} A\left(e^{-10^4 t} - 10^{-4} t e^{-10^4 t}\right)_{t=0^+} = 10^{-6} A$$

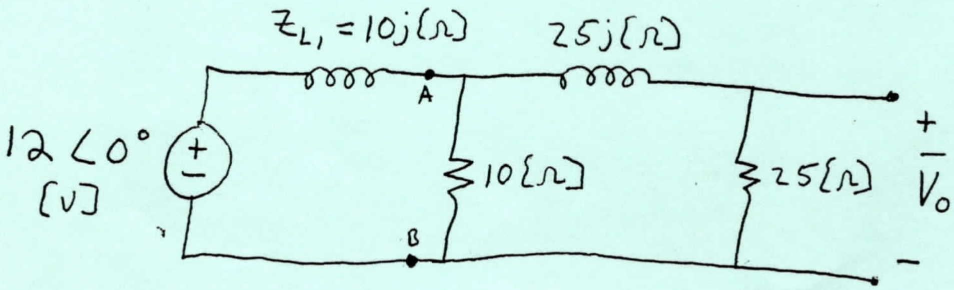
$$i_c(0^+) = -i_L(0^+) = -10 [A] = 10^{-6} A \;; \rightarrow A = -10^7 [V/s]. \rightarrow$$

$$\boxed{v(t) = -10^7 t\, e^{-10^4 t} [V]}$$

3. (30 Points) The circuit below is in the sinusoidal steady state. The voltage source $v_{in}(t) = 12\cos(5\times10^3 t)$ [Volts]. What is the steady state voltage $v_o(t)$ when $R_L = 25[\Omega]$?



Solution: Convert circuit to phasor domain.



Equivalent impedance seen at A and B is

$$\bar{Z}_{ab} = 10 \parallel (25+25j) = \frac{10(25+25j)}{10+25+25j} = \frac{353.5\angle 45^\circ}{35+25j}$$

$$\bar{Z}_{ab} = \frac{353.5\angle 45^\circ}{43.01\angle 35.5^\circ} = 8.22\angle 9.46^\circ\ [\Omega]$$

$$\bar{V}_{ab} = \frac{\bar{Z}_{ab}}{10j+\bar{Z}_{ab}}\, 12\angle 0^\circ = \frac{8.22\angle 9.46^\circ}{8.11+1.35j+10j}\, 12\angle 0^\circ$$

$$\bar{V}_{ab} = \frac{98.6\angle 9.46^\circ}{13.95\angle 54.45^\circ} = 7.068\angle -44.99^\circ\ [V]$$

$$\bar{V}_o = \left(\bar{V}_{ab}\right)\frac{25}{25+25j} = \frac{176.7\angle -44.99^\circ}{35.35\angle 45^\circ} = 5\angle -90^\circ\ [V]$$

$$\boxed{v_o(t) = 5\cos(5000t - 90^\circ)\ [V]}$$