EE 40/42/100, Spring 2007
Prof. Chang-Hasnain
Midterm #1

February 21, 2007
Total Time Allotted: 80 minutes
Total Points: 100

1. This is a closed book exam. However, you are allowed to bring one page (8.5" x 11"), single-sided notes.
2. No electronic devices, i.e. calculators, cell phones, computers, etc.
3. SHOW all the steps on the exam. Answers without steps will be given only a small percentage of credits. Partial credits will be given if you have proper steps but no final answers.
4. Draw BOXES around your final answers.
5. **Remember to put down units.** Points will be taken off for answers without units.

Last (Family) Name: Landry

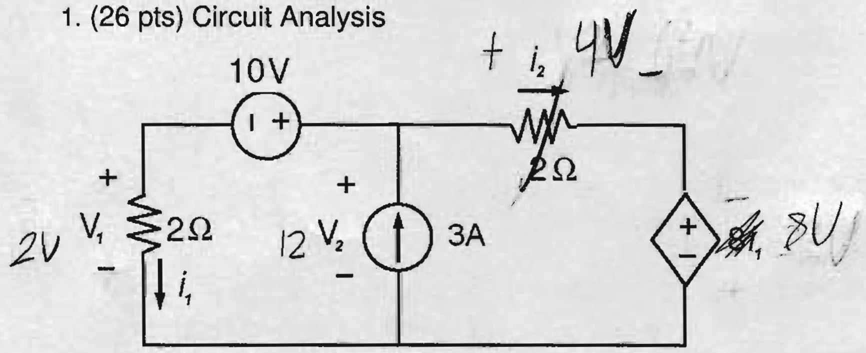
First Name: Mark

Student ID: 18672112 Discussion Session: Tues 1:00-2:00

Signature: Mark Landry

Score:		
Problem 1 (26 pts)	26	24W
Problem 2 (27 pts):	~~26.5~~ 27	CW
Problem 3 (32 pts)	32	
Problem 4 (15 pts)	15	
Total	~~99.5~~ 100	24W

1. (26 pts) Circuit Analysis



(a) (4 pts) Express i_1 in terms of V_1 and constants given in this problem.

$i_1 = \frac{V_1}{2\Omega}$

(b) (4 pts) Express i_2 in terms of V_1 AND V_2 and/or constants given in the problem.

$2i_2 + 8i_1 - V_2 = 0$

$-2i_2 + 4V_1 - V_2 = 0$

$i_2 = \frac{V_2}{2} - 2V_1$

(c) (10 pts) Write two equations in V_1 and V_2 that can be used to solve the circuit (Hint: Use KCL or KVL.).

$V_1 + 10V = V_2$

$\frac{V_1}{2} + i_2 = 3 \Rightarrow \frac{V_1}{2} + \frac{V_2}{2} - 2V_1 = 3 \Rightarrow \frac{V_2}{2} - \frac{3}{2}V_1 = 3 \Rightarrow V_2 - 3V_1 = 6$

(d) (8 pts) Solve for V_1, V_2, i_1 and i_2.

$-V_2 + V_1 = -10$

$V_2 - 3V_1 = 6$

$-2V_1 = -4$

$V_1 = 2V$

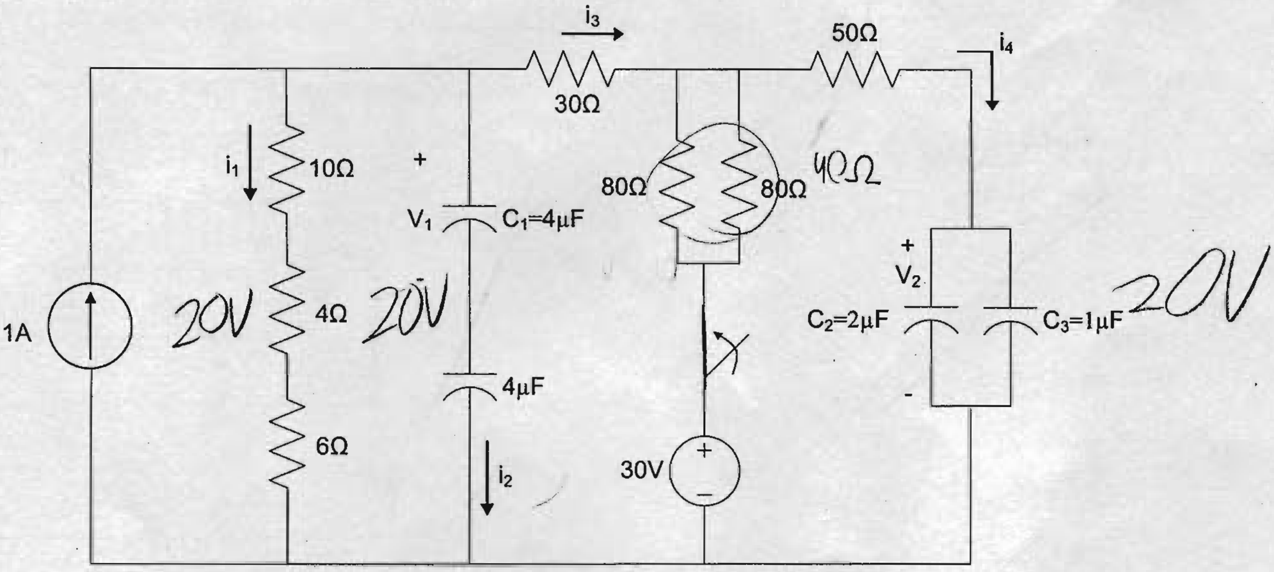
$V_2 = 2V + 10V = 12V$

$i_1 = \frac{V_1}{2} = 1A$

$i_2 = \frac{V_2}{2} - 2V_1 = 6 - 4 = 2A$

$i_1 = 1A$
$i_2 = 2A$
$V_1 = 2V$
$V_2 = 12V$

2. (27 pts) First-Order Circuit. **Remember to put down units.**



a) (12 pts) At t=0, the switch closes. Find the indicated current and voltages at t=0⁻ s, immediately **BEFORE** the switch closes. Note the current source has been active for a long time before the switch closes.

Provide the steps or explanation for your answers, e.g. using KCL/KVL, etc.

i_4	0 A
V_1	10V
V_2	20V
i_1	1 A
i_2	0 A
i_3	0 A

Since the swith has been open infinitely long, the circuit is in steady state. This means the capacitors act as open circuits, ∴ $i_4, i_2, i_3 = 0$, which, by KCL, means $i_1 = 1A$. Then C_1 acts as a voltage divider, so $V_1 = \frac{1}{2}(10i_1 + 4i_1 + 6i_1) = 10V$ by KVL. likewize, C_2 has the full voltage since i_3 and i_4 are 0. So $V_2 = (10i_1 + 4i_1 + 6i_1) = 20V$

12

b) (3 pts) At t=0⁺ s, immediately **AFTER** the switch closes. Which quantities will be different? **Explain.**

i_3 and i_4 and i_2 will be different. This is because the voltage across the resistors (near the voltage source) is now non-zero, inducing a current. V_1 and V_2 stay the same since capacitor voltages cannot change instantaniously, and ~~i_1~~ stays the same since the voltage across there resistors does not change

~~2.5~~ 3

15 ~~14.5~~

c) (12 pts) Find the current and voltages after a very, very long time.

Provide the steps or explanation for your answers, e.g. using KCL/KVL, etc.

i_4	0 A
v_1	100/9 V
v_2	$\frac{230}{9}$ V
i_1	$\frac{10}{9}$ A
i_2	0 A
i_3	$-\frac{1}{9}$ A

$i_4 = 0A$ since capacitor becomes short

$i_2 = 0A$ "

$i_1 + i_3 = 1 \quad i_3 = 1 - i_1$

first combine 80Ω resistors into 40Ω resistor. Then KVL:

$-6i_1 - 4i_1 - 10i_1 + 30i_3 + 40i_3 + 30 = 0$

$-6i_1 - 4i_1 - 10i_1 + 70 - 70i_1 + 30 = 0$

$100 = 90i_1$

$i_1 = \frac{10}{9}A$

$i_3 = -\frac{1}{9}A$

by KVL

$V_2 - 30 - 40i_3 = 0$

$V_2 = 30 + 40(-\frac{1}{9})$

$= \frac{230}{9} V$

$-2V_1 + i_1(10\Omega + 4\Omega + 6\Omega) = 0$

$V = \frac{10}{9} \cdot \frac{1}{2}(20)$

$= \frac{100}{9} V$

12 JZ.

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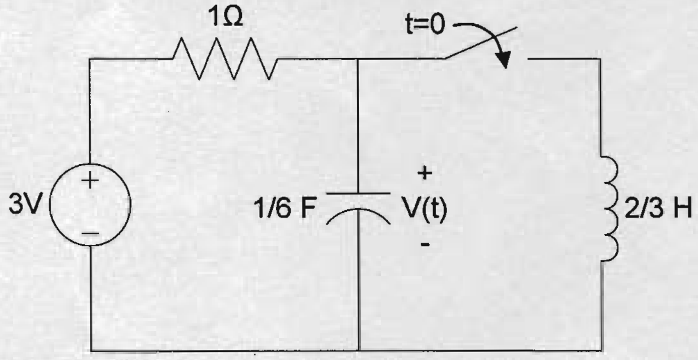
3. (32 pts) Second-Order Circuit. **Remember to put down units.**



The switch is closed at t=0. The goal is to find the voltage across the capacitor, V(t).

a.) (2 pts) For t<0, assume that the switch was open and remained open for a very long time. Find V(0-).

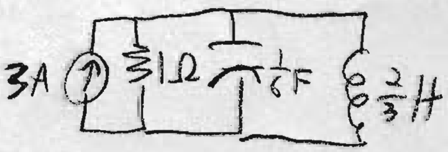
i=0, so by KVL $V(0-) - 3V = 0 \Rightarrow$ $\boxed{V(0-) = 3V}$ ✓

b.) (4 pts) What is V(0+)? Explain.

V(0+) is 3V still since $i = C\frac{dV_c}{dt}$ implies that Voltage in a capacitor cannot change instantaneously. ✓

c.) (10 pts) Derive the second-order differential equation for V(t) for t>0. (Hint: Use KVL/KCL)

Norton equiv: $I_N = \frac{V_{th}}{R_{th}} = 3A$



$$\boxed{\frac{d^2V}{dt} + 6\frac{dV}{dt} + 9V = 0}$$ ✓

$i_R + i_C + i_L = 3A \qquad i_R = \frac{V}{R},\ i_C = C\frac{dV}{dt},\ \frac{di_L}{dt} = \frac{V}{L}$

$$\frac{di_R}{dt} + \frac{di_C}{dt} + \frac{di_L}{dt} = 0$$

$$\frac{1}{R}\frac{dV}{dt} + C\frac{d^2V}{dt} + \frac{V}{L} = 0$$

$$\boxed{\frac{d^2V}{dt} + \frac{1}{RC}\frac{dV}{dt} + \frac{1}{LC}V = 0}$$

d.) (3 pts) What is α? What is ω_0? Is this critically damped, underdamped, or overdamped?

$\alpha = \frac{6}{2} = 3/s$

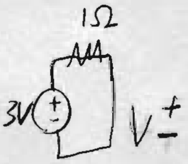
$\omega_0 = \sqrt{9} = 3/s$

$\alpha = \omega_0$, so critically damped

✓

e.) (3 pts) What is the particular solution?

at $t = \infty$, circuit becomes:



so $V = 0V$

✓

f.) (10 pts) Find the complementary (homogeneous) solution.

complementary solution

=

$Ae^{-\alpha t} + Bte^{-\alpha t}$

$= Ae^{-3t} + Bte^{-3t}$ Since particular is 0, this is also the complete solution. ∴ we can use initial conditions.

$V(0) = A = 3V$

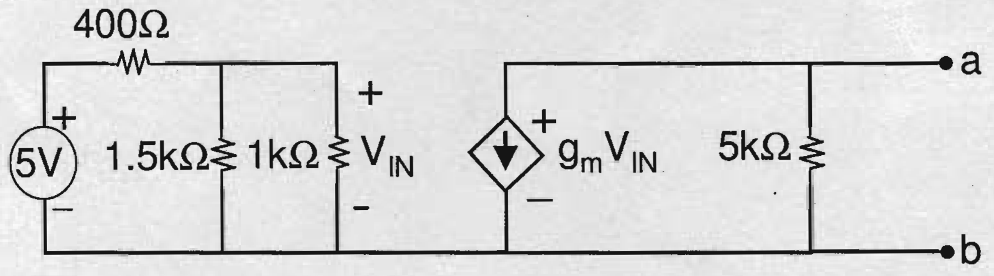
$V'(0) = (-3Ae^{-3t} + Be^{-3t} + -3Bte^{-3t})\big|_{t=0} = B - 3A = \frac{i_c(0)}{C} = 0$

$B = 3A = 9V$

so $V(t) = [3e^{-3t/1s} + 9te^{-3t/1s}]$ Volts

✓ Good

4. (15 pts) Equivalent Circuit. **Remember to put down units.**



Here g_m= 1 mA/V = 1 mS	**Remember, 1 m=10^{-3} and 1 k=10^3.**

a.) (3 pts) What is V_{in}?

Voltage divider: $V_{in} = 5V \cdot \left(\frac{\left(\frac{1}{1.5k} + \frac{1}{1k}\right)^{-1}}{400 + \left(\frac{1}{1.5k} + \frac{1}{1k}\right)^{-1}} \right) = 5 \cdot \left(\frac{\frac{3}{5} \cdot 1000}{400 \cdot \frac{3}{5} \cdot 1000} \right)$ ✓

$= 5 \cdot \left(\frac{600}{1000} \right) = \boxed{3V}$

b.) (4 pts) What is V_{ab}?

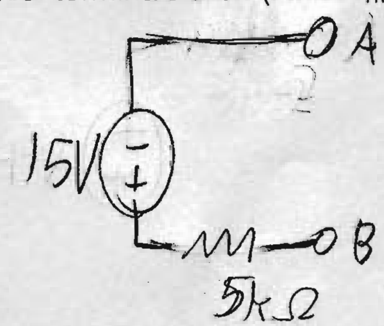
$V_{ab} = V_{5k\Omega} = -IR = g_m V_{in} 5k = 1 \cdot 10^{-3} \cdot 3 \cdot 5 \cdot 10^3 = \boxed{15V}$ ✓

c.) (6 pts) What is the Thevenin equivalent circuit for terminals a-b? (Find R_{Th},V_{Th}).

$V_{th} = V_{ab} = \boxed{15V}$

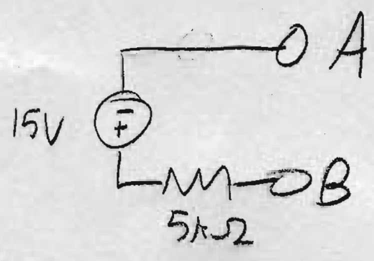
$I_{sc} = g_m V_{in} = 10^{-3} \cdot 3 = 3mA$

$R_{th} = \frac{V_{th}}{I_{sc}} = \frac{15V}{3mA} = \boxed{5k\Omega}$



✓

d.) (2 pts) Draw the Thevenin equivalent circuit



✓

+15
ZHB