EECS 40, 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: Perfect

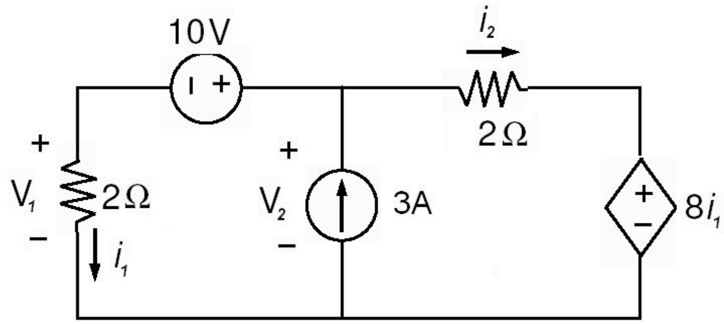
First Name: Peter

Student ID: 00000000 Discussion Session: ________________

Signature: ____

Score:	
Problem 1 (26 pts)	
Problem 2 (28 pts):	
Problem 3 (32 pts)	
Problem 4 (14 pts)	
Total	

1. (26 pts) Circuit Analysis



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

$V_1 = 2\ i_1$

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

$i_2 = 3 - V_1/2$

(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.).

$10+V_1 - V_2 = 0$

$2x(3 - V_1/2)+8x(V_1/2) - V_2 = 0$

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

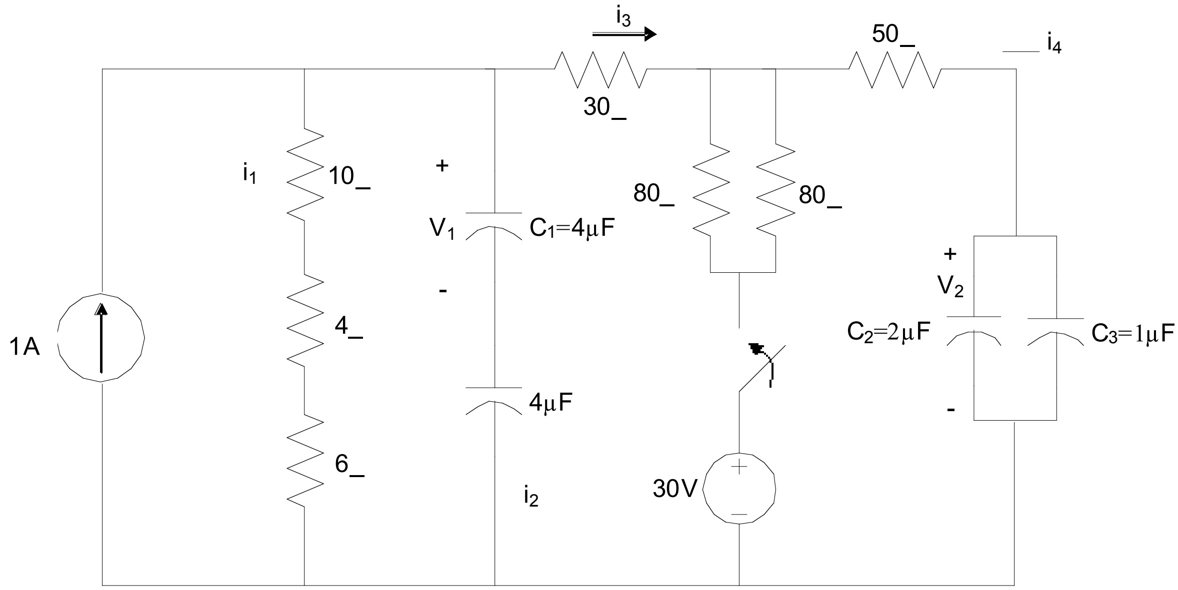
$V_1 = 2$ V

$V_1 = 12$ V

$i_1 = 1$ A

$i_2 = 2$ A

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_1	1A
i_2	0A
i_3	0A
i_4	0A
V_1	10V
V_2	20V

All capacitors are open circuits, all currents but i_1 are 0. i_1 is the same as the current source.

$$V_1 = \left(\frac{(10\Omega + 4\Omega + 6\Omega) * 1A}{2}\right) = 10Volts$$

$$V_1 = (10\Omega + 4\Omega + 6\Omega) * 1A = 20Volts$$

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

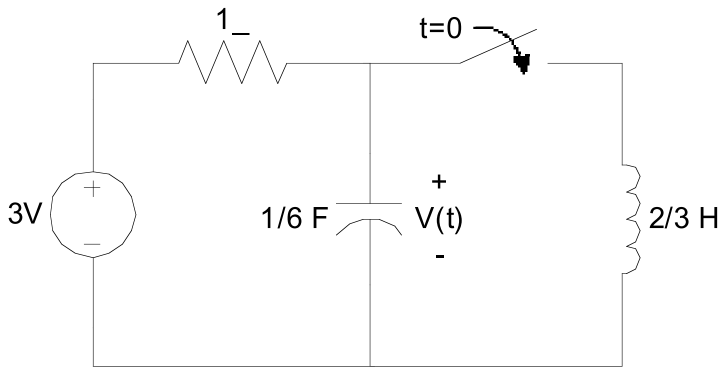
All the currents may be different, so i_1, i_2, i_3, and i_4 may change (in fact i_1 does not). Voltages across capacitors cannot change instantaneously because this will result in infinite current flow.

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_1	1.11A
i_2	0A
i_3	-0.11A
i_4	0A
v_1	11.11V
v_2	25.56V

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-).

V(0-) = 3 V

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

V(0+)=3V.
Because voltage across capacitor can not change abruptly.

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

Using KVL:

$$-3 + R(i_C(t) + i_L(t)) + V(t) = 0$$

$$-3 + R\left(C\frac{dV(t)}{dt} + \frac{1}{L}\int_{0+}^{t} V(t')dt' + i_L(0+)\right) + V(t) = 0$$

$$RC\frac{d^2V(t)}{dt^2} + \frac{R}{L}V(t) + \frac{dV(t)}{dt} = 0$$

or using KCL:

$$\frac{V(t)-3}{R} + i_C(t) + i_L(t) = 0$$

$$\frac{V(t)-3}{R} + C\frac{dV(t)}{dt} + \frac{1}{L}\int_{0+}^{t} V(t')dt' + i_L(0+) = 0$$

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

In standard form:

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

$$\frac{d^2V(t)}{dt^2} + 6\frac{dV(t)}{dt} + 9V(t) = 0$$

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

$$\alpha = 6/2 = 3 rad/s$$
$$\omega_0 = \sqrt{9} = 3 rad/s$$
$$\zeta = \frac{\alpha}{\omega_0} = 1$$

Critically damped.

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

$v_p(t)$=0 V since after a long time, the inductor acts as a short circuit.

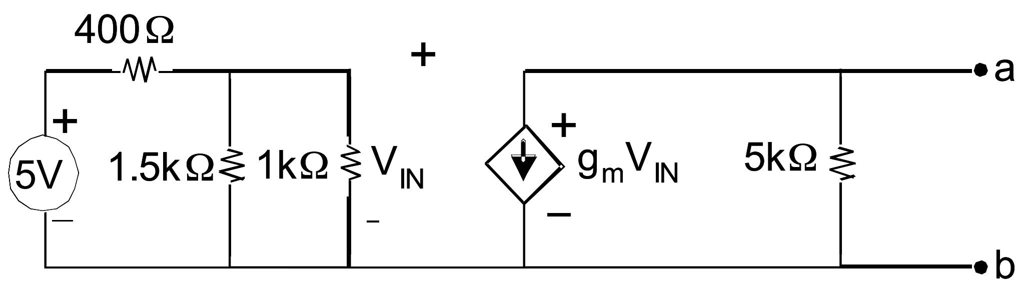
f.) (10 pts) Find the complementary (homogeneous) solution.

$v_c(t)=k_1 e^{-3t} + k_2 te^{-3t}$
$v(t)= v_p(t)+ v_c(t)= k_1 e^{-3t} + k_2 te^{-3t}$

$v(0)= 3 = k_1$
$dv(t)/dt |_{t=0}=0=-3 k_1 + k_2 =-9+ k_2$

$k_2 =9$
$v_c(t)=3 e^{-3t} + 9 te^{-3t}$

4. (14 pts) Equivalent Circuit. **Remember to put down units.**



a.) (5 pts) What is V_{in}?

1500x1000/(1500+1000)=600 Ω
V_{in} = 5 x 600/(600+400)=3 V

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

V_{ab} = - g_mV_{in} x 5000 V
= - g_mx3 x 5000 V
= - g_mx15000 V

c.) (5 pts) What is the Thevenin equivalent circuit for terminals a-b? (Find R_{Th},V_{Th}). Answer in terms of g_m.

V_{Th} =V_{ab} = - g_mx15000 V
R_{Th} = V_{Th}/I_{sc} = - g_mx15000 /(- g_mx3) =5000 Ω