EECS 40, Fall 2007
Prof. Chang-Hasnain
Final Exam

December 13, 2007
Total Time Allotted: 180 minutes
Total Points: 200

1. This is a closed book exam. However, you are allowed to bring **five** pages (8.5” x 11”), single-sided.
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. 1 point will be taken off per missed unit.**

Last (Family) Name:____

First Name: ____

Student ID: ____________________________ **LAB Session** : ________________

Signature: ____

Score:	
Problem 1 (30 pts)	
Problem 2 (40 pts):	
Problem 3 (30 pts):	
Problem 4 (40 pts):	
Problem 5 (40 pts):	
Problem 6 (20 pts):	
Total	

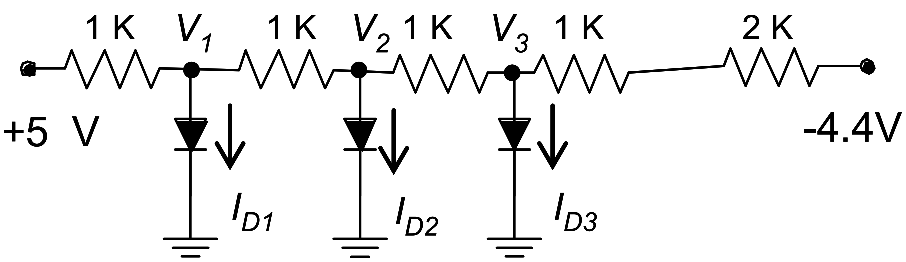
1. (30 pts) Diode Circuits

Use ideal diode 0.6V ON-OFF model for all parts of this problem:

If $V_D < 0.6$, then the diode is OFF and does not pass current (I_D=0)

If $I_D >= 0$, then the diode is ON and V_D=0.6

a) (10 pts) Find the V_1, I_{D1}, V_2, I_{D2}, V_3, and I_{D3}.



Answer)

V1 = 0.6V
Id1 = 3.4mA

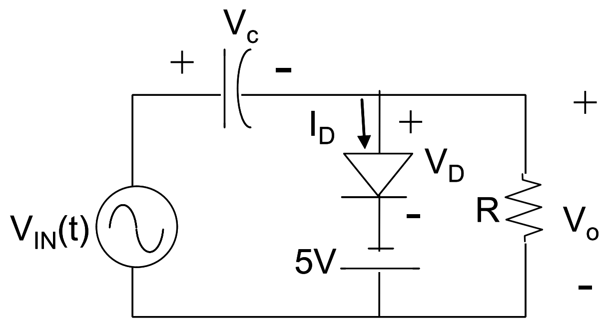
V2 = 0.6 - 1 = -0.4V
Id2 = 0A

V3 = 0.6 - 2 = -1.4V
Id3 = 0A

Let's say i1 and i2 as the current through the first and second register.
i1 = 0.6-(-4.4)/5K = 1mA
i2 = (5-0.6)/1K = 4.4mA

id1 = i1 - i2

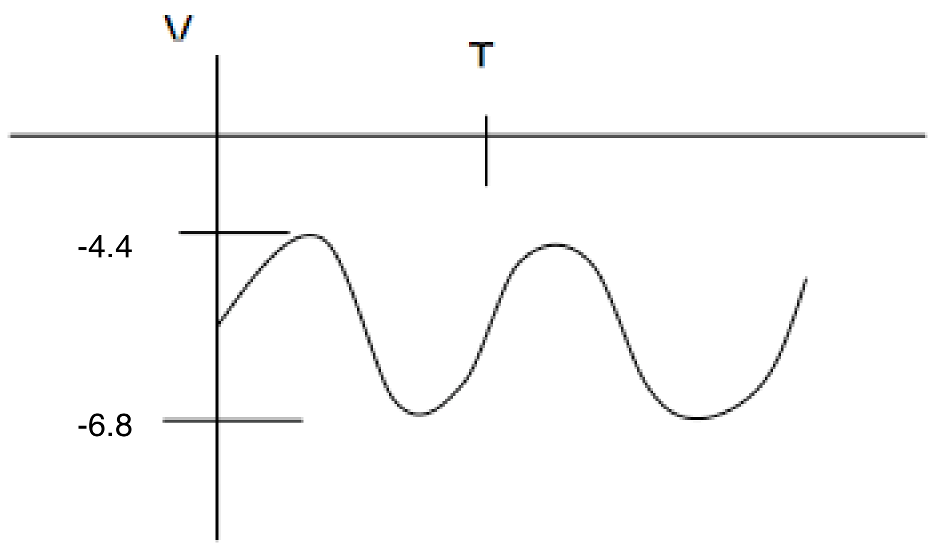
b) (10 pts) Consider the capacitance large. Suppose $V_{IN}(t) = 1.2 \sin(2\pi t/T)$ V. Assume the circuit has been operating for some time. (Use 0.6V ON-OFF model for diode)



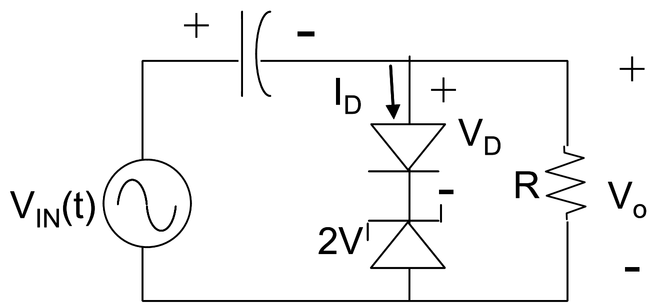
What is Vo? What is Vc? Sketch Vo, labeling maxima and minima (don't worry about the period or any other details).

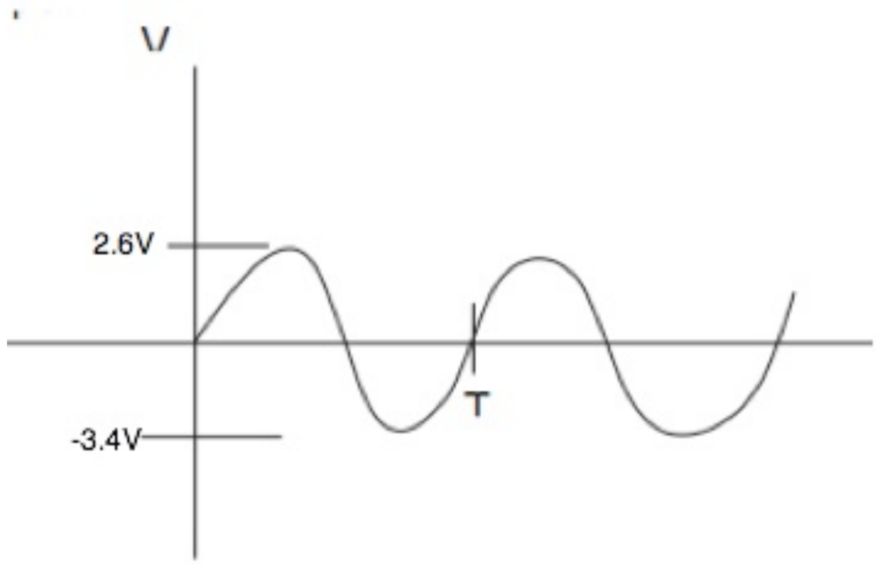
Answer)

$V_o = 1.2 \sin(2\pi t/T) - (1.2 - 5 + 0.6) = 1.2 \sin(2\pi t/T) - 5.6$ V
$V_c = 5.6$V

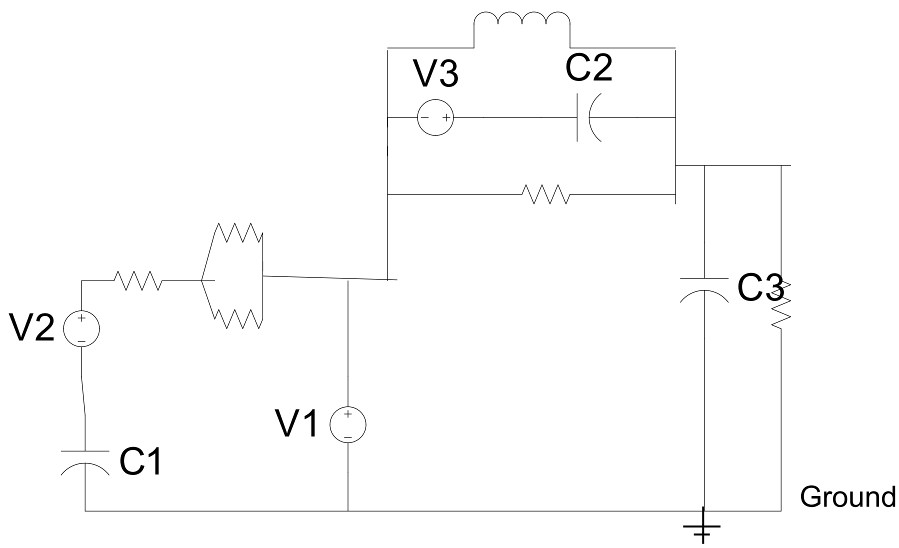


c) (10 pts) Replace the battery by a Zener diode with breakdown voltage of 2V.
Given $V_{IN}(t)$= *3 sin(2πt/T)* V. (Use 0.6V ON-OFF model). Sketch Vo.





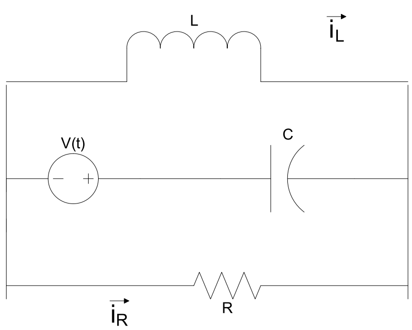
2. (40 pts)
a. (12 pts, steady state) Assume the following circuit has been operating for a long time. V1, V2, V3 are all DC voltages. The inductor has an inductance of L and all resistors have a resistance R. Find the voltages Vc1, Vc2, Vc3 across each of the capacitors (following the convention that the curved side is the negative terminal).



Answer)

Vc1 = V1-V2 (4 pts)
Vc2 = V3 (4 pts)
Vc3 = V1 (4 pts)

b. (10 pts, writing differential equations) Suppose you are given R, L, C, and V(t). Write down two differential equations where your only unknowns are $i_R(t)$ and $i_L(t)$ and their derivates. You are NOT required to solve these equations (though in theory you could).



Answer)

Diff eq1: $L\, di_L(t)/dt = i_R(t)\, R$ *(5 pts)*

Diff eq2: $CR\, di_R(t)/dt + C\, dV(t)/dt = i_R(t) + i_L(t)$ *(5 pts)*

c. (10 points RC, RL)
For the following circuit, the element on the middle branch is a current source. Suppose i(t) = I_0 (where I_0 is a positive current) for t< 0, and i(t) = 0 for t>0. Find the voltage across the inductor as a function of time, for t>0.

Answer)
$i(t) = I_0 e^{\wedge}(-tR/L)$
-L d i(t)/dt = i(t) R

$$V_L(t) = L\frac{I_0 e^{-tR/L}}{dt} = -I_0 R e^{-tR/L}$$

If L is increased, then how does that affect $V_L(5)$ (increase or decrease) ?

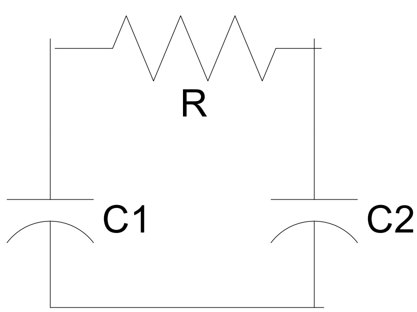
Answer)
As L increases, at the same time, t=5, $V_L(t)$ increases. So the answer is - increase (3 pts)

Suppose you replaced the resistor by an open circuit. What would theoretically happen to your voltage $V_L(t)$ at t=0 ? (3 pts).

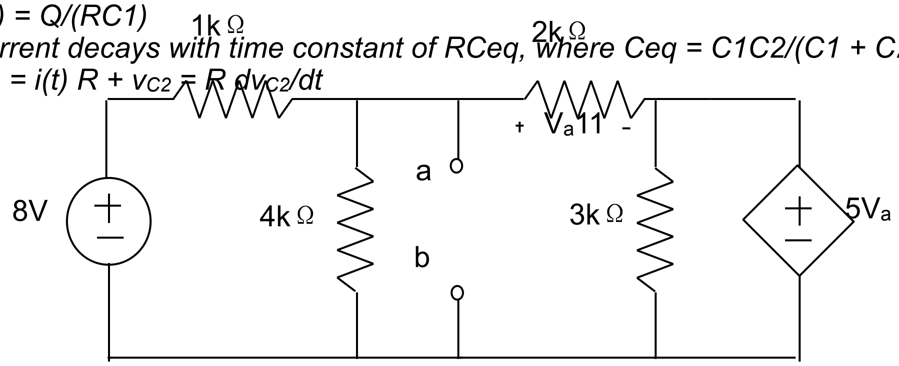
Answer)
It would go to -infinity voltage, because i(t) is step function (from I_0 to 0), so di(t)/dt is delta function.

d. Suppose in the circuit below that C1 is initially charged up with charge Q at time t=0. The other capacitor is initially uncharged. Write an expression for i(t), for t>0, in terms of charge Q, resistance R, and capacitances C1 and C2. (8 pts)

Answer)
*i(t) = Q/RC1 e^(-t/(R*Ceq)) (for t>0)*



Q = CV, VC(0) = Q/C1
I(0) = Q/(RC1)
Current decays with time constant of RCeq, where Ceq = C1C2/(C1 + C2) (C1 and C2 in series)
$v_{C1} = i(t) R + v_{C2} = R\, dv_{C2}/dt$



3. (30 pts)

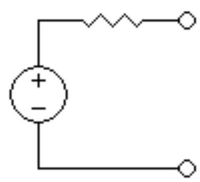
In the circuit above, a load will be connected between the a and b terminals.

a) (8 pts) What is the Thevenin equivalent voltage and resistance between the a and b terminals?

Answer)
Req = 3/4 k Ohm
Veq = 6V

b) (2 pts) Draw the Thevenin equivalent circuit

Answer)



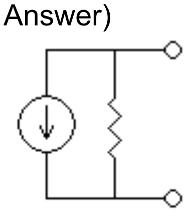
Veq   Req

c) (8 pts) What is the Norton equivalent current and resistance?

Answer)
Req = 3/4 KOhm
Ieq = 8mA

d) (2 pts) Draw the Norton equivalent circuit

Answer)



Ieq   Req

e) (5 pts) If R_L is connected between a and b, what should the value of R_L be to get maximum power?

Answer)
Req = RL

f) (5 pts) What is the maximum power absorbed by the load from part e?

Answer)
P = (Veq/2)^2/Req =12 mW

4. (40 pts) Consider the following transfer functions. Answer the following questions.

$$H_1(f) = \frac{\frac{j10f}{3}}{1 + j1000(\frac{f}{300} - \frac{300}{f})}$$

$$H_2(f) = \frac{1}{1 + j1000(\frac{f}{10} - \frac{360}{f})}$$

$$H_3(f) = \frac{j\frac{f}{10}}{1 - \frac{f^2}{100} + j\frac{f}{10}}$$

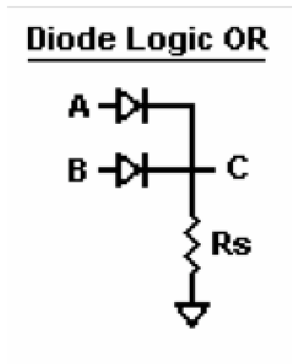
$$H_4(f) = \frac{j}{\left(1 + j\frac{f}{20}\right)^2}$$

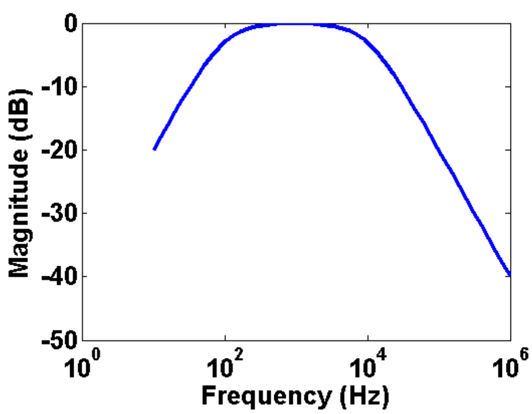
a) (20 pts)

	$H_1(f)$	$H_2(f)$	$H_3(f)$	$H_4(f)$
What is the filter function? (2 pts each) Choice from Band-pass, high-pass, low-pass and notch	HP	BP	BP	LP
What is the break or resonant frequency (Hz)? (3 pts each)	300	60	10	20

b) (10 pts) sketch the magnitude plot of H_5 below (label all important points and values)

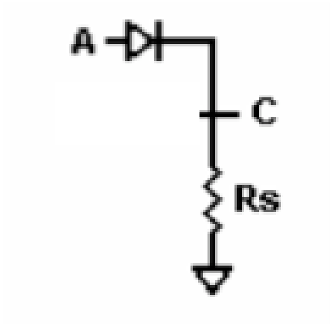
$$H_5(f) = \frac{j\frac{f}{10^2}}{\left(1+j\frac{f}{10^2}\right)} \mathbf{g} \frac{1}{\left(1+j\frac{f}{10^4}\right)}$$

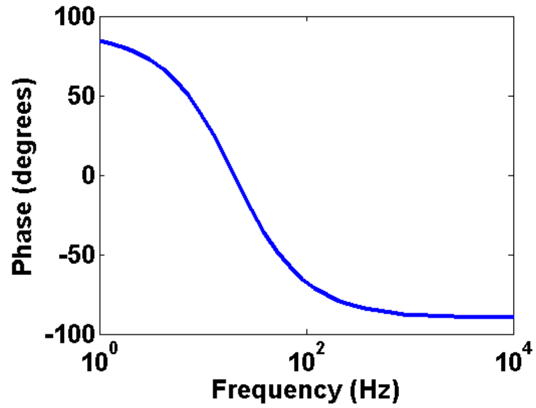




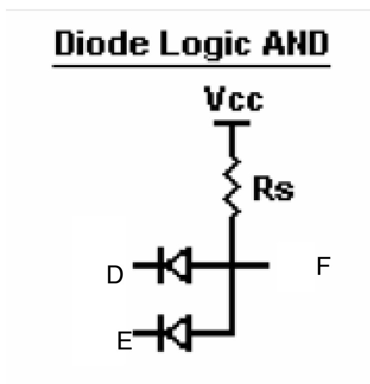
c) (10 pts) sketch the phase plot of H_4 (label all important points and values)

$$H_4(f) = \frac{j}{\left(1+j\frac{f}{20}\right)^2}$$





The phase plot starts 90 degree and ends 90 degree.



5. (40 pts) Diode Logic Circuits

You are given diodes, resistors and a 5V power supply. Input logic high signals will be +5 V and logic low signals will be 0 V. For the output, a signal Vout>4 V is considered logic high, and Vout<1 V is logic low.

a) (8 pts) Implement the function C=A+B with diode logic. Clearly label A, B, C and diode terminals.

Answer)

b) (4 pts) If the maximum current allowed for a diode is 10mA, how do you pick the resistor(s) value in your circuit? Assume a 0.6V forward drop for all diodes. (4 points)

Answer)

Rs should be more than 440 Ohm

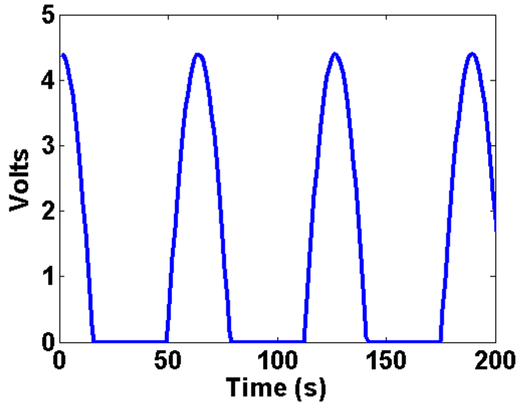
10mA x Rs = 4.4V

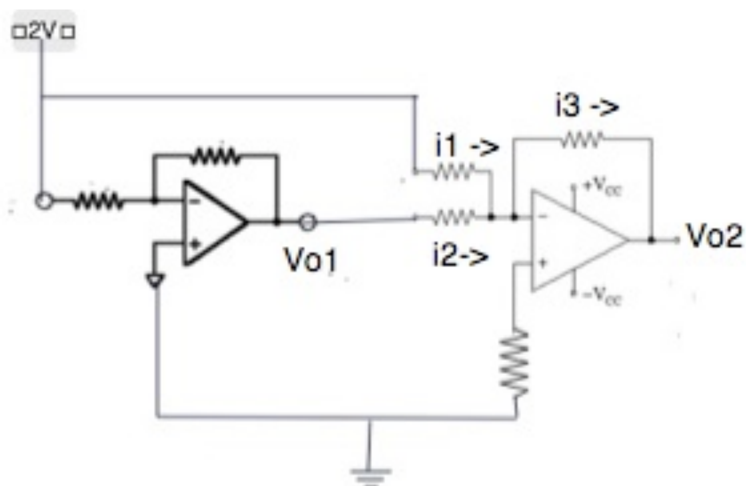
Rs = 4.4V/10mA = 440 Ohm

c) (8 pts) If you tie B to ground and apply Vin=5cos(t) V to A, draw the waveform of C. Assume a 0.6V forward drop for all diodes.

Answer)

The equivalent circuit for after grounding B is as follows, so the output should be 0.6V drop down from the positive input, and 0V for the negative input.





d)(10 pts) Implements function F=D·E with diode logic. Clearly label D, E, F and diode terminals. Again maximum current allowed for the diode is 10mA.

Answer)

Rs is more than 440 Ohm.

e) (10 pts) If you connect node C to D, fill in the table below (with the voltage at F). Assume a 0.6V forward drop for all diodes. Does the circuit implement F= (A+B)·C? Why?

Answer)

A (V)	B(V)	E(V)	F(V)

0	0	0	0.6
0	5	0	0.6
5	0	0	0.6
5	5	0	0.6
0	0	5	2.8
0	5	5	5
5	0	5	5
5	5	5	5

The circuit does NOT implement F= (A+B)·C, because when A=B=0(logic low), E=5V(logic high), the output F is 2.8V, which is not a legal logic low state.

6. Labs (20 pts)

Part I

a) Suppose you have the following circuit with an ideal voltage source in series with a resistor Rs, ideal ammeter in series with a resistor Ra, and an ideal voltmeter in parallel with a resistor Rv and wish to compute the power absorption of R. If you were computing the power absorbed by R using the ammeter and voltmeter values, which instrument does not read the correct value and why?

b) How you would rearrange the circuit so that instrument that you found in part a) now reads the correct value?

c) With the correction from part b) circuit if you multiply the ammeter's output by the voltmeter's output, is this exactly the power absorbed by R? Why or why not?

Answer)

a) The voltmeter, since it measures across both Ra and R.
b) Put Ammeter not the series with R.
c) No, ammeter measures current through R and Rv.

Part II

LMC6482 op-amps are oriented with pin 1 in top left.

Using the diagram on the next page.
a) Draw a circuit diagram for this circuit.

b) What is the output at pin 1 of the bottom LMC6482 with respect to ground?

Answer)

(a)

(b) 0 V

Vo1 = -2 V 1k/1k = -2V
i1 = -2V/1k = -2mA
i2 = 2V/1k = 2mA
i3 = i1 + i2 = 0 mA
Vo2 = 0 V