EECS 40, Fall 2007
Prof. Chang-Hasnain
Test #3

November 2, 2007
Total Time Allotted: 50 minutes
Total Points: 100

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

Last (Family) Name:____

First Name: ____

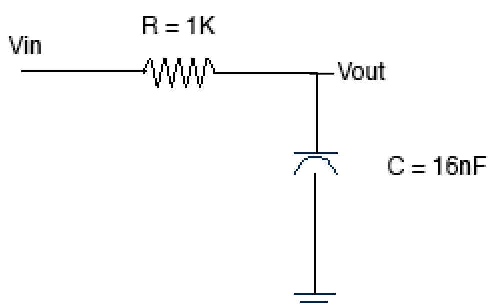
Student ID: ____________________________ **LAB Session**: ________________

Signature: ____

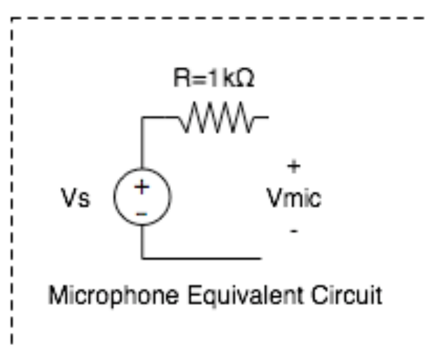
Score:	
Problem 1 (34 pts)	
Problem 2 (16 pts):	
Problem 3 (40 pts):	
Problem 4 (10 pts):	
Total	

1. (34 pts) Filter and Bode Plots
You are building your own electric bullhorn. To build the bullhorn you have bought a portable speaker and an off-the-shelf piezo-microphone. You want your bullhorn to work at human voice frequencies, which typically span from 100 Hz to 4kHz.

a) (4 pts) To avoid any high frequency feedback in your system, you decide to implement a first-order low pass filter with a cutoff frequency of 10 kHz. You have a 1k□ resistor sitting around. Design a passive low pass filter using that resistor and a capacitor (design the value) such that you will have a system with this transfer function. Draw the layout. Label V_{in} and V_{out} as well as the components with the proper values.



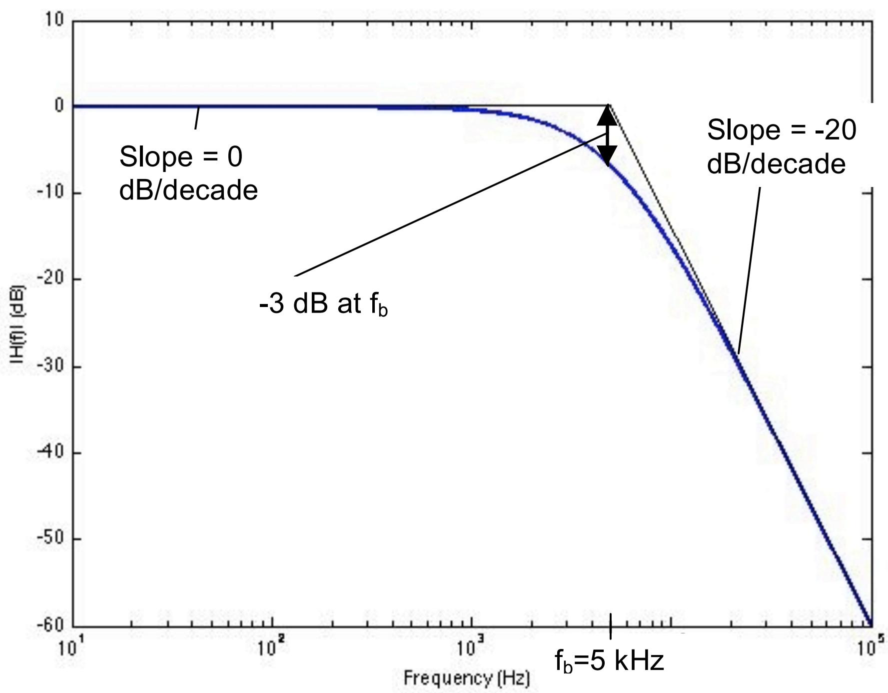
b) (6 pts) When you hook your microphone up to the filter you just designed and analyze the frequency response, you find that the frequency response of your microphone and filter is not how you designed it. You look at the datasheet for your microphone and notice that the equivalent circuit for it is:



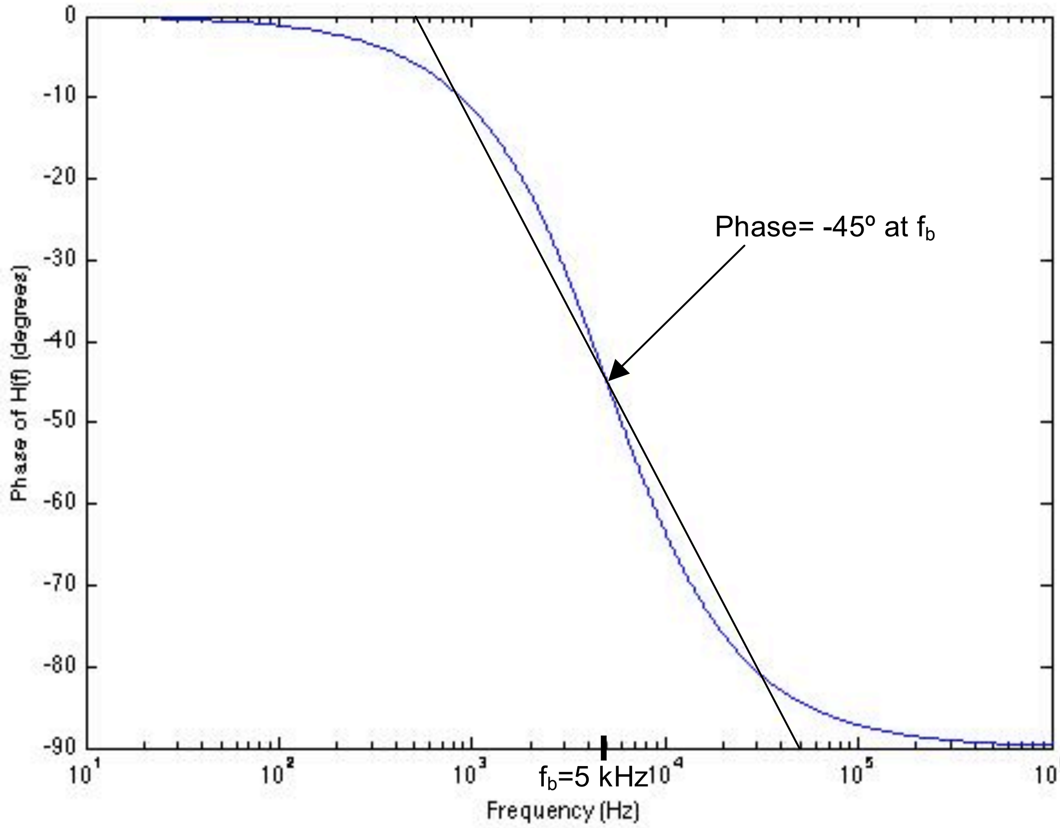
What went wrong and how do you correct your circuit so it operates how you intended?

Ans) The 1Kohm inside the microphone added in series with the 1K ohm makes the R of the system = 2K ohm, which makes the cut off frequency shift to 5kHz. To fix this issue, we can remove the resistor in the filter. Alternatively one could use an active filter or a unity gain op amp between the microphone and the passive filter.

c) (24 pts) Draw the Bode magnitude and phase plot of the filter you designed in (a) with the microphone in (b) as V_{in}. Define $H(f)=V_{out}/V_s$.
Use the straight line approximation for the Bode plots (solid line) as well as sketch in the actual response. Be sure to label all relevant points, slopes, axes and magnitude and phase at break frequency.



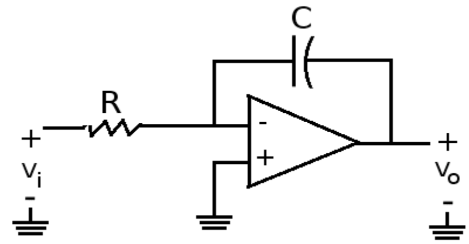
Key points to address:
Break frequency magnitude (3dB), break frequency, slope of low frequency, slope of high frequency, shape (low pass), x-axis (with unit), y axis (with unit)



Key points to address:
break frequency, 45deg, low frequency 0 deg, high frequency -90deg, shape, x-axis (with unit), y axis (with unit)

2. (16 pts) Op Amp

For the circuit shown on the right, initially, the capacitor is completely discharged. At time t=0, v_i is switched from 0V to 5V.



(a) (10 pts) Calculate an expression for $v_o(t)$ for t>0.

i = Vi/R
i = -C dv0/dt
i dt = -C dv0

If we integrate both sides, and use the fact i = Vi/R

$$V_o = -\frac{1}{RC}\int_0^t V_{in} dt$$

Vo = -5t/RC V

(b) (6 pts) Write an expression for the transfer function of this circuit. (Hint: Use phasors and complex impedance to find H(f).)

H(f) = - Z2/Z1
w = 2pi f
Z2 = 1/(jwC)
Z1 = R

H(f) = j 1/(2 pi f CR)

3. (40 pts) Consider the following transfer functions. Answer the following questions. NOTE: **NO PARTIAL CREDIT will be given for this problem.**

$$H_1(f) = \frac{1}{1 + j1000(\frac{f}{100} - \frac{900}{f})}$$

$$H_2(f) = \frac{1}{1 + j1000(\frac{f}{100} - \frac{100}{f})}$$

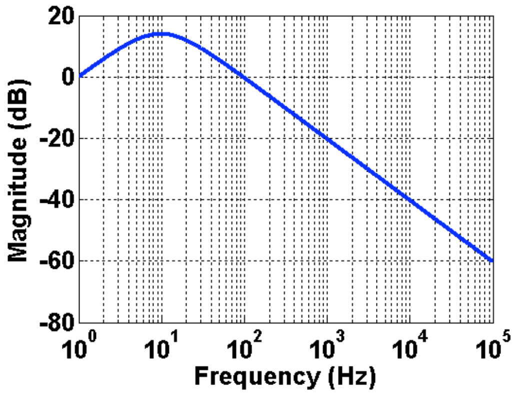
$$H_3(f) = \frac{1}{1 - \frac{f^2}{100} + j\frac{f}{10}}$$

$$H_4(f) = \frac{jf}{\left(1 + j\frac{f}{10}\right)^2}$$

	$H_1(f)$	$H_2(f)$	$H_3(f)$	$H_4(f)$
What is the filter function? (2 pts each) Choice from Band-pass, high-pass, low-pass and notch	BP	BP	LP	BP
What is the break or resonant frequency (Hz)? (3 pts each)	300	100	10	10
Match Bode Magnitude Plot (choice of a-i on next page) (3 pts each)	D (yellow) E (white) D (pink)	C (yellow) H (white) H (pink)	B (yellow) F (white) G (pink)	A (yellow) A (white) A (pink)
Match Bode Phase Plot (choice of 1-9) (2 pts each)	4 (yellow) 7 (white) 8 (pink)	1 (yellow) 1 (white) 1 (pink)	5 (yellow) 4 (white) 2 (pink)	3 (yellow) 3 (white) 3 (pink)

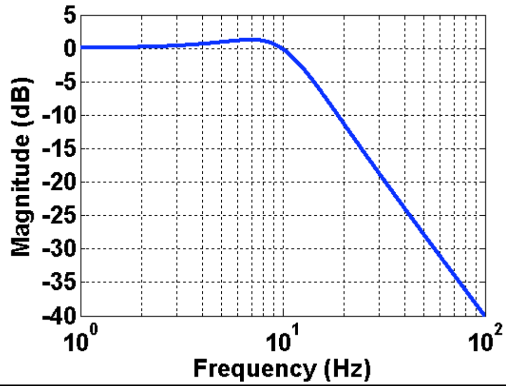
Note: The plots following this are from the yellow version of the test

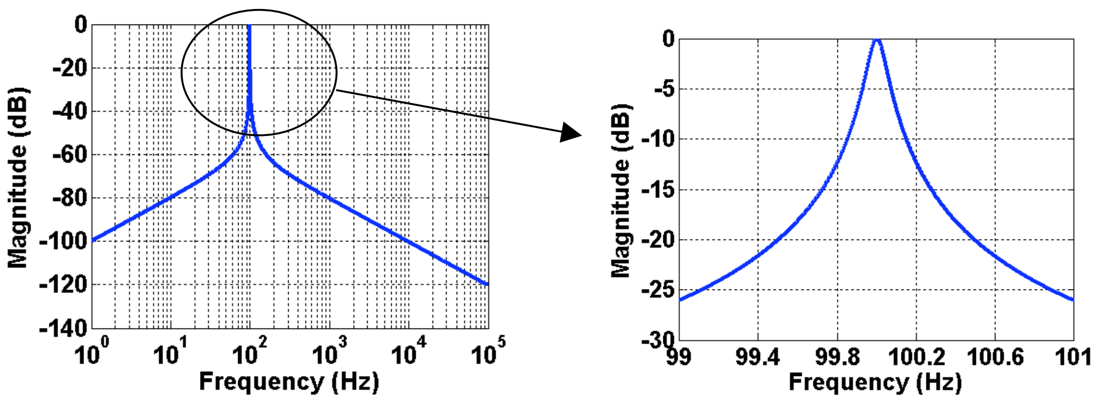
Problem 3: Bode Magnitude Plot Choice



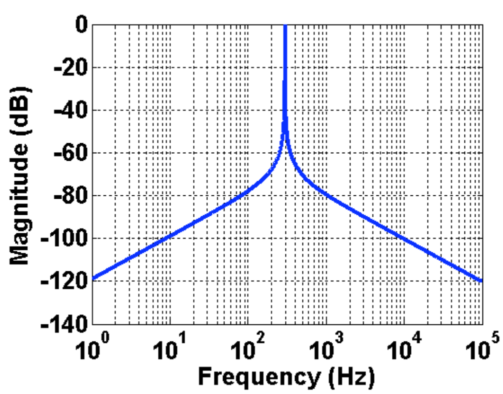
(a)

(b)

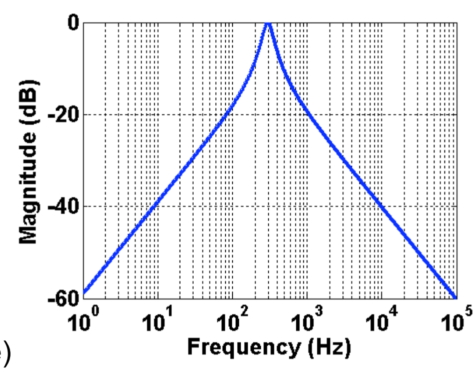




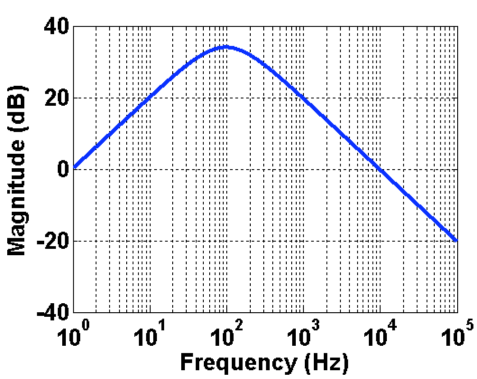
(c)



(d)

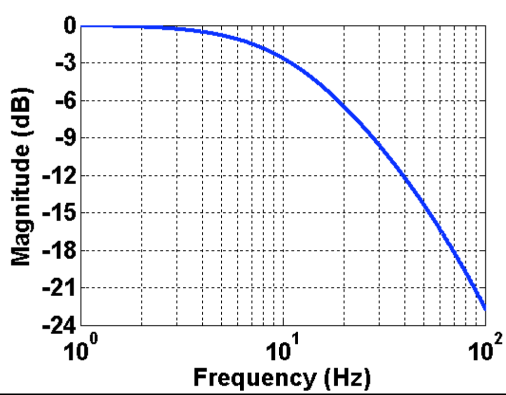


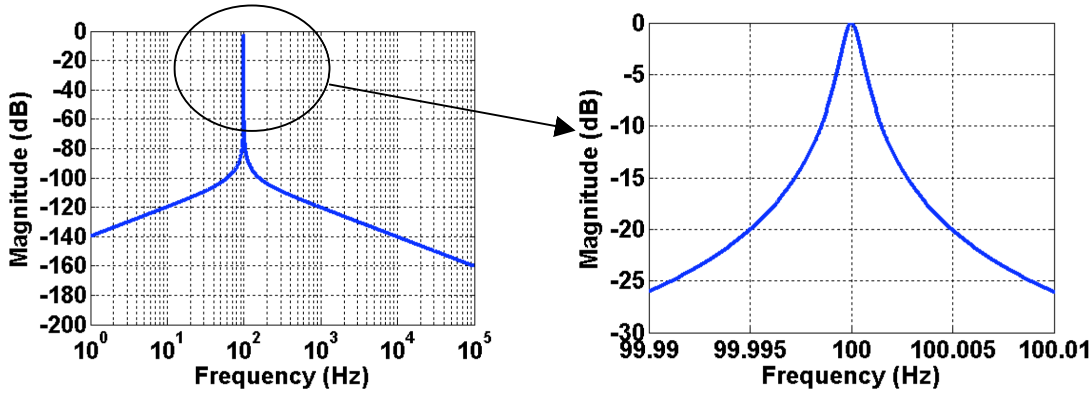
(e)



(f)

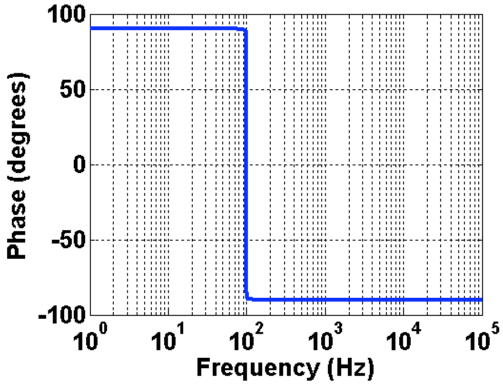
(g)



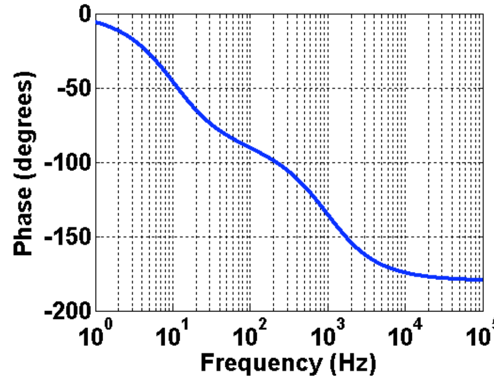

0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
Magnitude (dB)
10^0 10^1 10^2 10^3 10^4 10^5
Frequency (Hz)
0
-5
-10
-15
-20
-25
-30
Magnitude (dB)
99.99 99.995 100 100.005 100.01
Frequency (Hz)

(h)

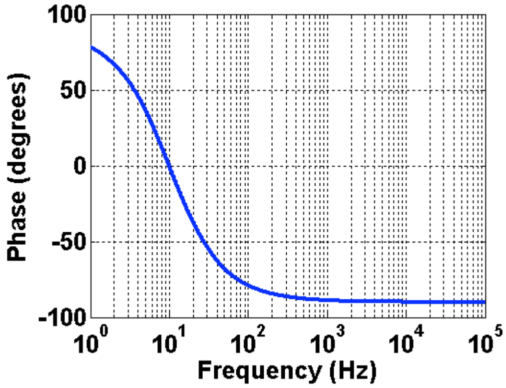
Problem 3: Bode Phase Plot Choices



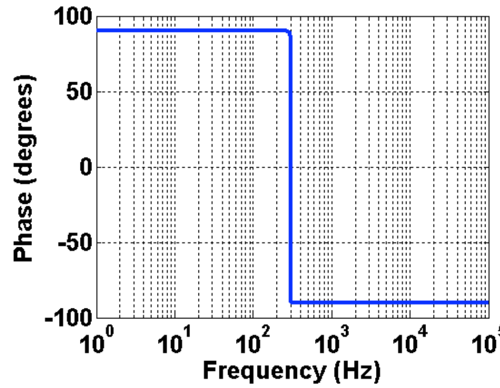
(1)



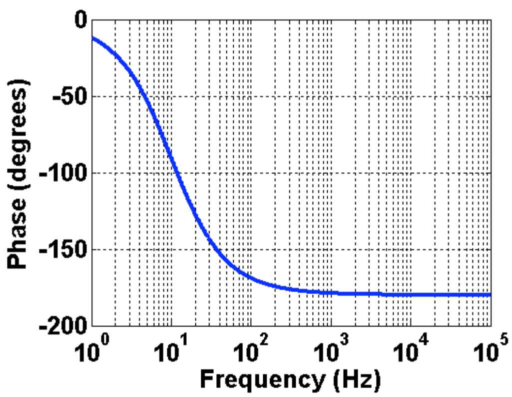
(2)



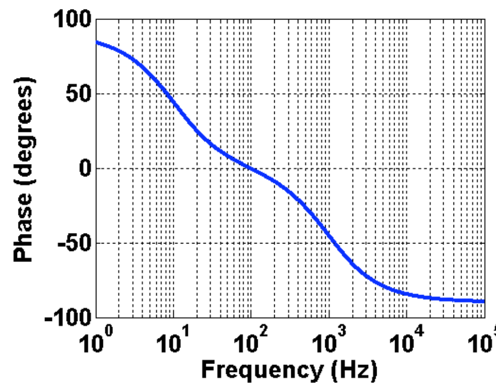
(3)



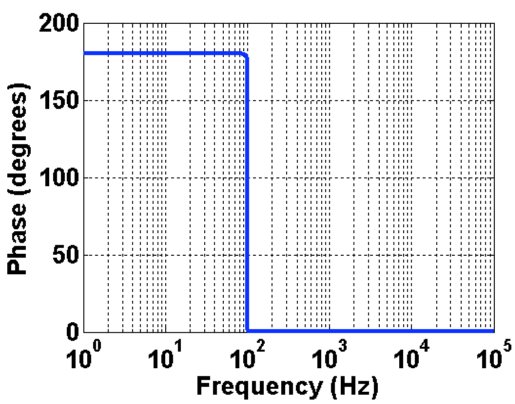
(4)



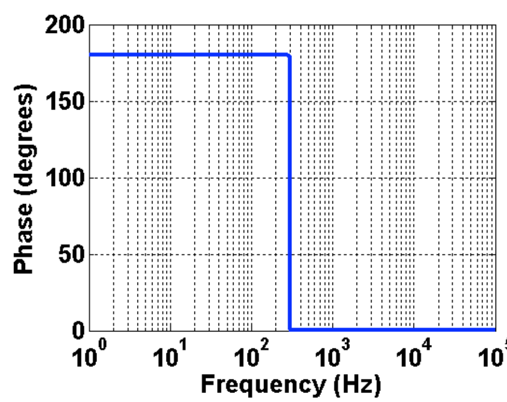
(5)



(6)



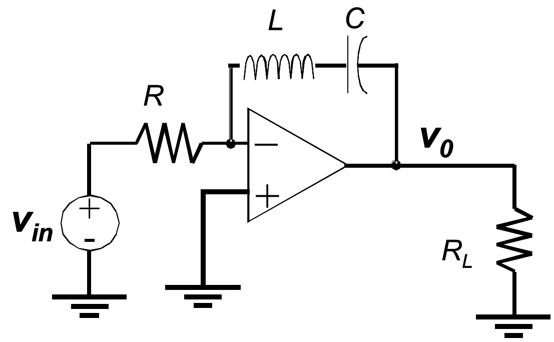
(7)



(8)

4. (10 pts) Op Amp

(a) (6 pts) Derive the transfer function $H(f) = \frac{V_{out}}{V_{in}}$.



H(f) = -Z2/Z1
Z1 = R
Z2 = j(wL – 1/(wC)) = j(2pi f L – 1/(2pi f C))

H(f) = j (4 pi^2 f^2 LC – 1)/(2 pi f RC)

(b) (2 pts) What is the input impedance?

R Ω

(c) (2 pts) What is the output impedance?

0 Ω