Final
EE40
Fall 2014

NAME:____________________________ **SSID:**____________________________

Instructions

Read all of the instructions and all of the questions before beginning the exam.

There are 6 problems in this exam. The total score is 140 points. Points are given next to each problem to help you allocate time. Do not spend all your time on one problem.

Unless otherwise noted on a particular problem, you must show your work in the space provided, on the back of the exam pages or in the extra pages provided at the back of the exam.

Be sure to provide units where necessary.

GOOD LUCK!

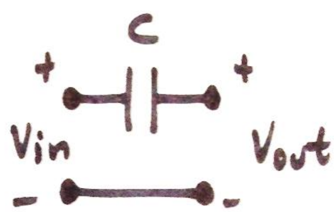
PROBLEM	POINTS	MAX
1		40
2		10
3		20
4		20
5		25
6		25

Problem 1 *Warm up (5 points each, 40 points total)*
Consider the circuits below. For each circuit, provide the transfer functions specified. All inputs are sinusoidal.

a)

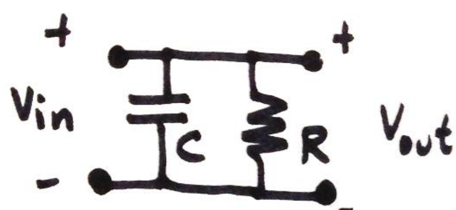
Solution:
$$\boldsymbol{H_v(\omega) = \frac{V_{out}}{V_{in}} =}$$

b)



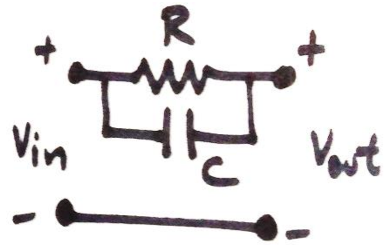
Solution:
$$\boldsymbol{H_v(\omega) = \frac{V_{out}}{V_{in}} =}$$

c)



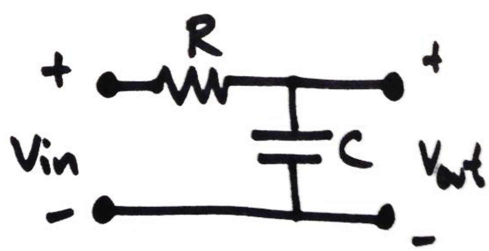
Solution:
$$\boldsymbol{H_v(\omega) = \frac{V_{out}}{V_{in}} =}$$

d)



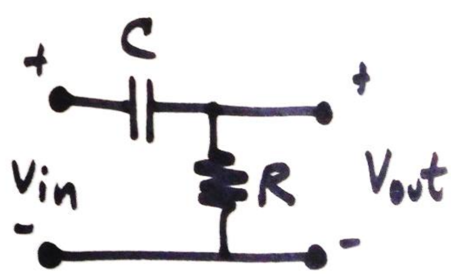
Solution:
$$\boldsymbol{H}_v(\omega) = \frac{\boldsymbol{V}_{out}}{\boldsymbol{V}_{in}} =$$

e)



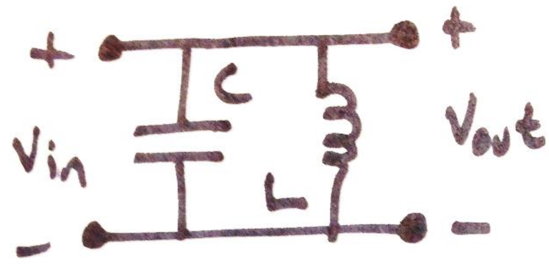
Solution:
$$\boldsymbol{H}_v(\omega) = \frac{\boldsymbol{V}_{out}}{\boldsymbol{V}_{in}} =$$

f)



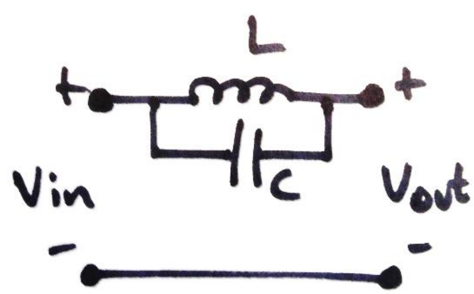
Solution:
$$\boldsymbol{H}_v(\omega) = \frac{\boldsymbol{V}_{out}}{\boldsymbol{V}_{in}} =$$

g)



Solution:
$$\boldsymbol{H}_v(\omega) = \frac{\boldsymbol{V}_{out}}{\boldsymbol{V}_{in}} =$$

h)

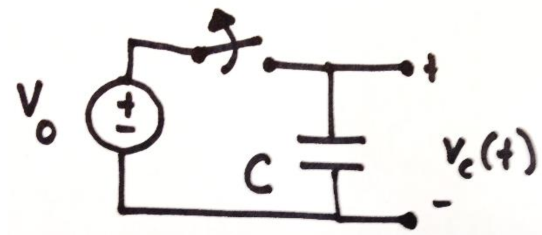


Solution:
$$\boldsymbol{H}_v(\omega) = \frac{\boldsymbol{V}_{out}}{\boldsymbol{V}_{in}} =$$

Extra Space

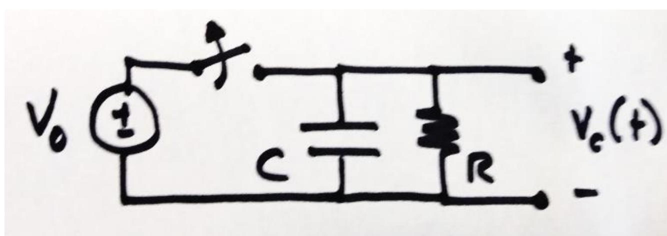
Problem 2 *(10 points)*

a) Consider the circuit below. The switch opens at t = 0. Provide an expression for $v_c(t)$ for t > 0. V_0 is a DC source. (5 points)



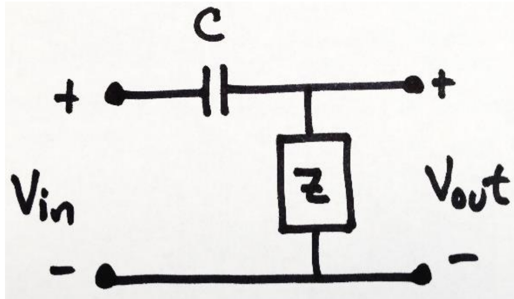
Solution:

b) Consider the circuit below. The switch opens at t = 0. Provide an expression for $v_c(t)$ for t > 0. (5 points)



Solution:

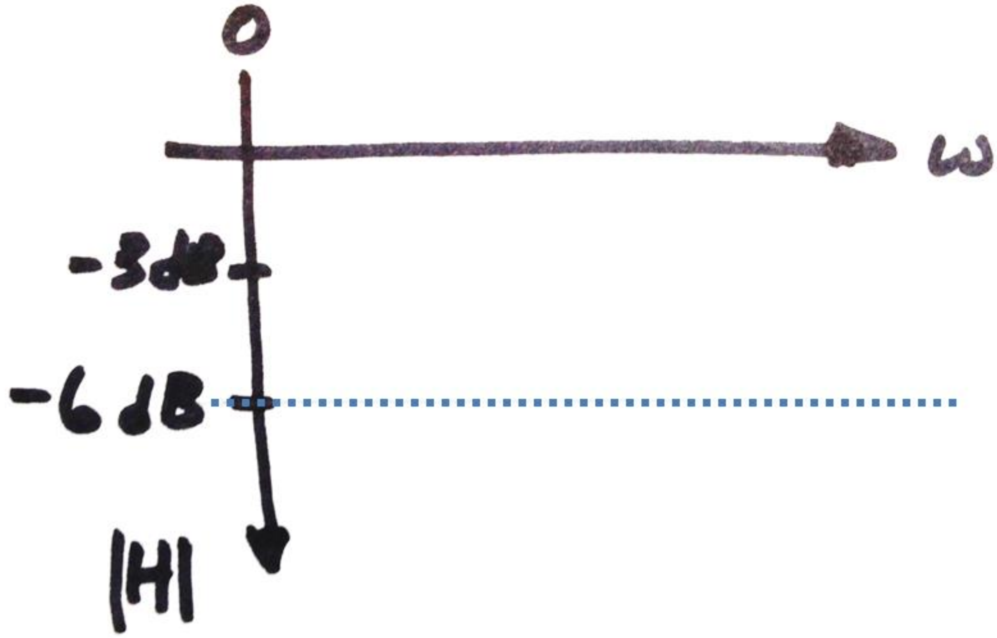
Problem 3 *(20 points)*
Consider the circuit below.



a) Provide the voltage transfer function for this circuit. (5 points)

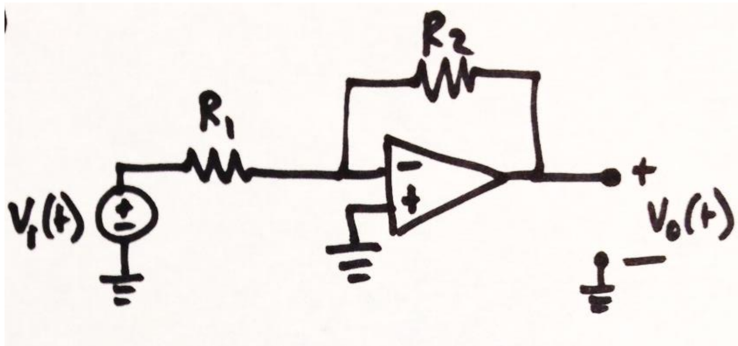
Solution:

b) If C = 12 μF, what type of component and component values must Z have such that the spectrum of the magnitude of the transfer function looks like that plotted below? (15 points)



Extra Space

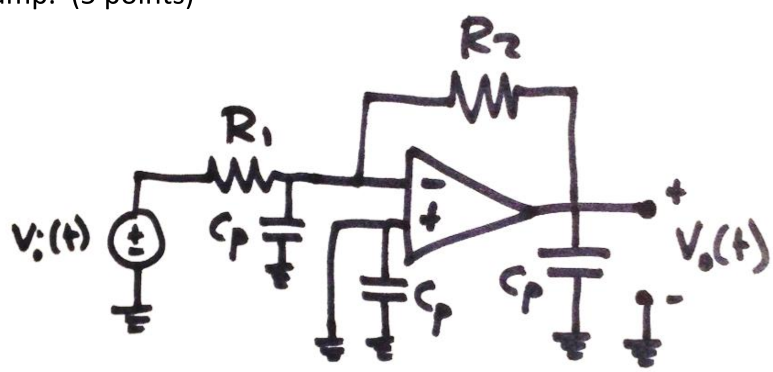
Problem 4 *(20 points)*
All op amps are ideal.
a) Consider the circuit below. (5 points)



Provide an expression for the voltage transfer function.

Solution:

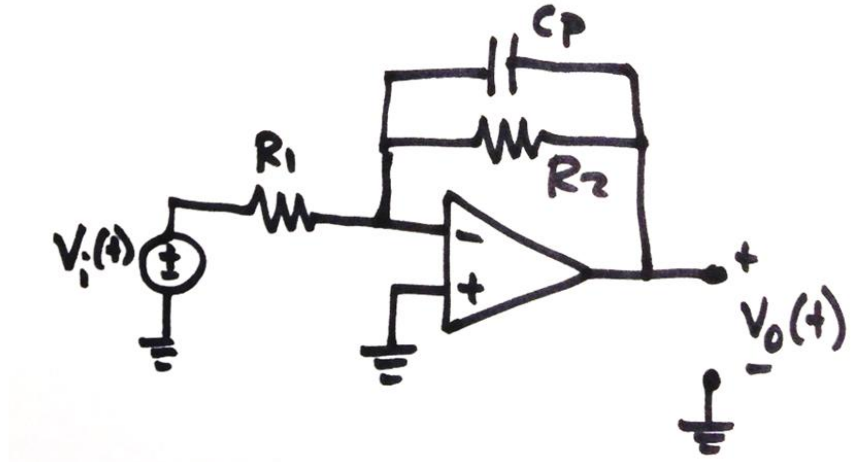
b) Consider the circuit below. We have now included parasitic capacitances to ground at each of the three terminals of the ideal op amp. (5 points)



Provide an expression for the voltage transfer function.

Solution:

c) Consider the circuit below. We have now only included a parasitic capacitance between the input and output of the ideal op amp. (10 points)



Provide an expression for the voltage transfer function.

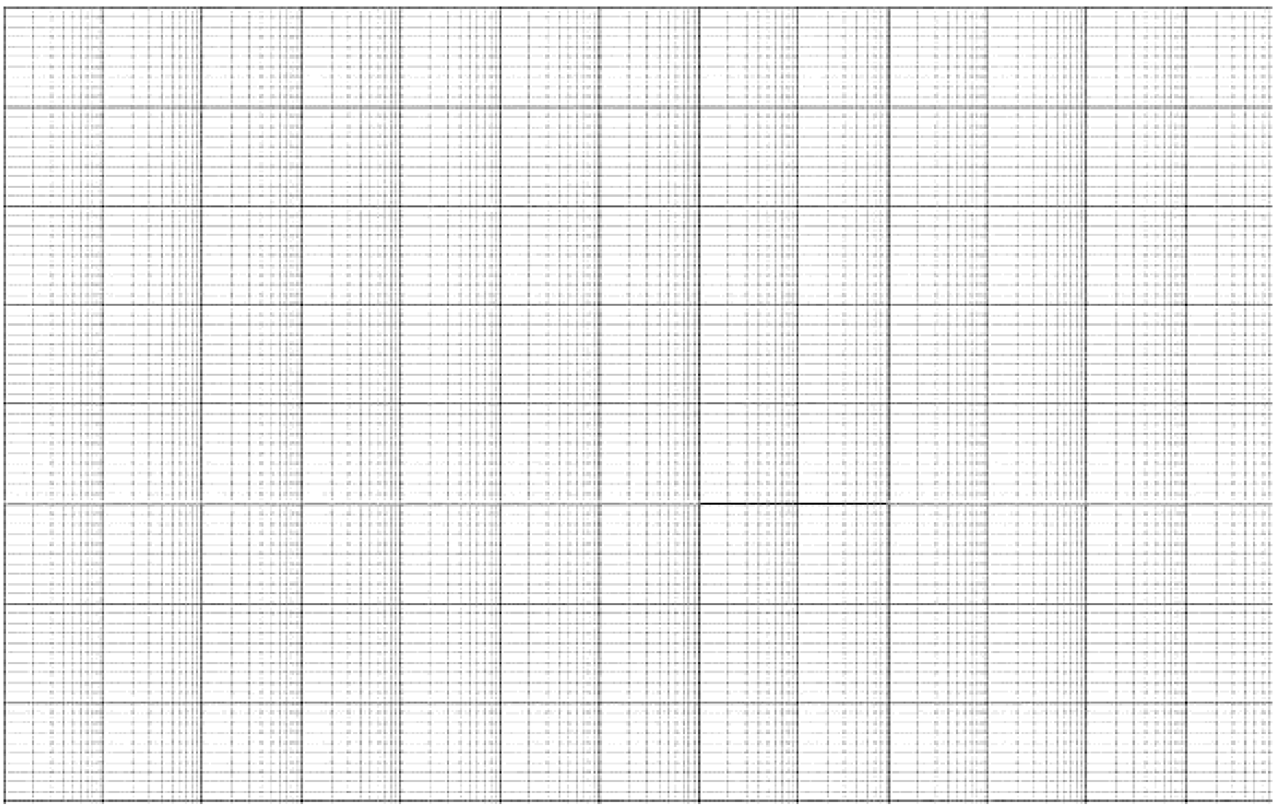
Solution:

Problem 5 *(25 points)*

We need to filter an incoming voltage signal, v_{in}, with an active highpass filter. The specs are:

- We can assume ideal op amps
- All ideal op amps have 5 pF parasitic capacitance between any the inverting input and the output
- A roll-off of |40 dB/decade|
- A cut-off frequency, fc, of 50MHz
- $|H(\omega \rightarrow \infty)|$ = 100 [V/V]

a) Draw the Bode plot of the magnitude of the desired transfer function below. (10 points)



b) Draw a circuit that can accomplish this. Clearly label v_{in} and v_{out} and keep all components symbolic. Explicitly draw the 5 pF parasitic capacitance between the inverting input and the output of the amplifier. (10 points)

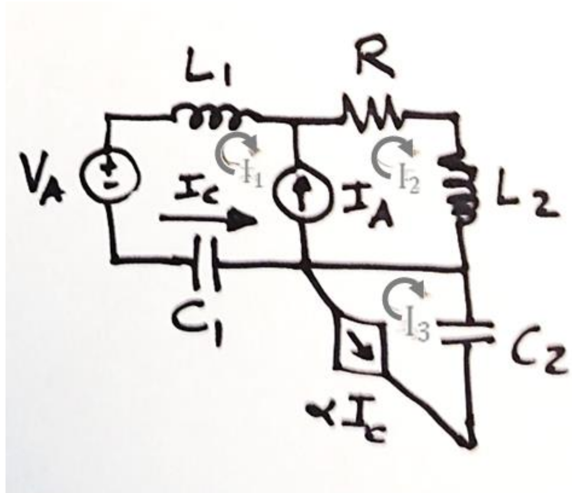
Solution:

c) Provide component values. (5 points)

Solution:

Extra Space

Problem 6 *(25 points)*
Consider the following circuit.



All sources are cosines, have the same frequency and zero phase shift.
All labelled currents and voltages are phasors.

Complete the equations below by entering values in all the boxes.
Use the labelled currents or you will lose points.
Assume V_A, I_A, α, L_1, R, L_2, C_1, C_2 are given.

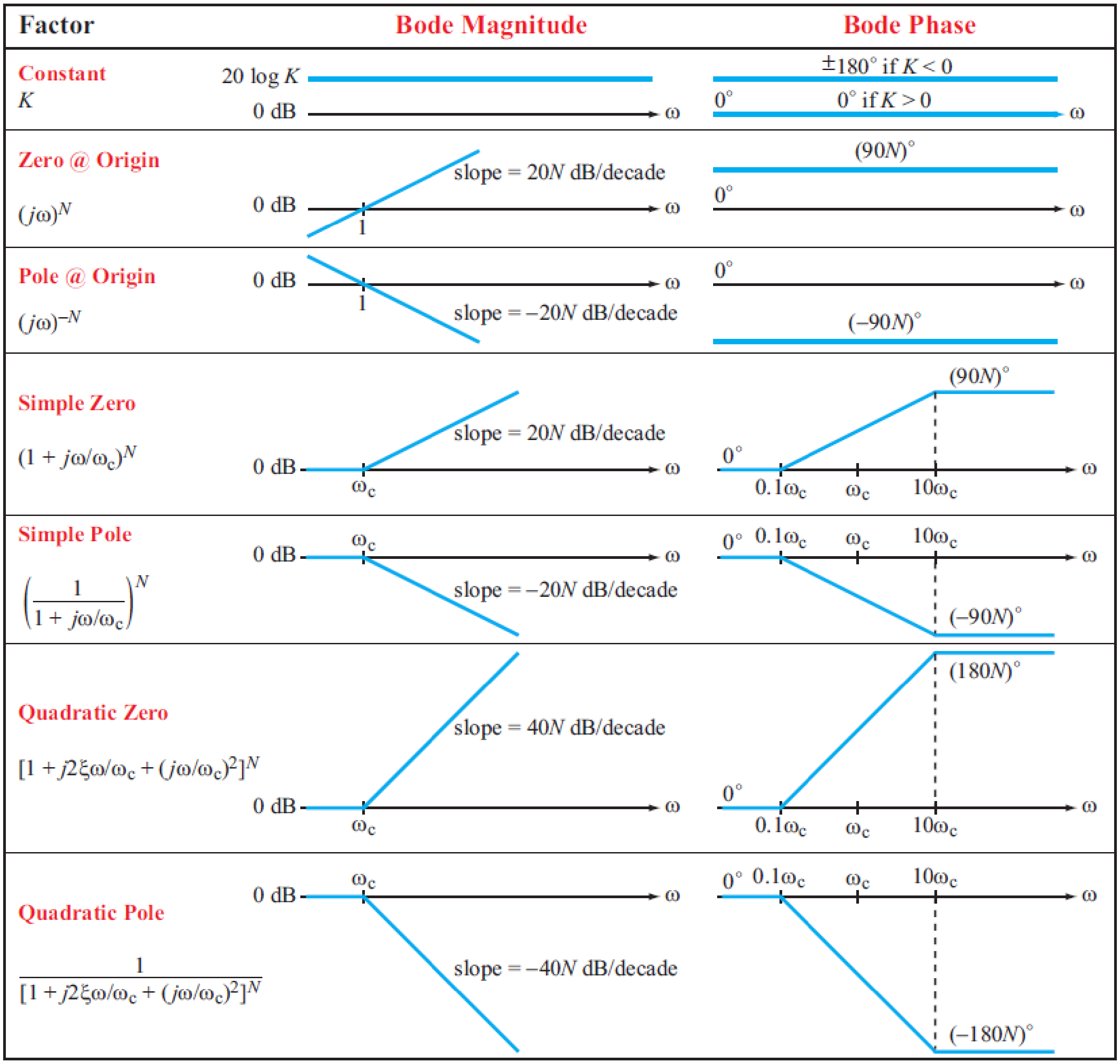
$$\square\, I_1 + \square\, I_2 + \square\, I_3 = \square$$

$$\square\, I_1 + \square\, I_2 + \square\, I_3 = \square$$

$$\square\, I_1 + \square\, I_2 + \square\, I_3 = \square$$

Extra Space

Scratch



Factor
Bode Magnitude
Bode Phase
Constant
K
20 log K
0 dB
ω
±180° if K < 0
0°
0° if K > 0
ω
Zero @ Origin
(jω)^N
slope = 20N dB/decade
0 dB
1
ω
(90N)°
0°
ω
Pole @ Origin
(jω)^−N
0 dB
1
ω
slope = −20N dB/decade
0°
ω
(−90N)°
Simple Zero
(1 + jω/ωc)^N
slope = 20N dB/decade
0 dB
ωc
ω
(90N)°
0°
0.1ωc
ωc
10ωc
ω
Simple Pole
(1/(1 + jω/ωc))^N
0 dB
ωc
ω
slope = −20N dB/decade
0°
0.1ωc
ωc
10ωc
ω
(−90N)°
Quadratic Zero
[1 + j2ξω/ωc + (jω/ωc)^2]^N
slope = 40N dB/decade
0 dB
ωc
ω
(180N)°
0°
0.1ωc
ωc
10ωc
ω
Quadratic Pole
1/[1 + j2ξω/ωc + (jω/ωc)^2]^N
0 dB
ωc
ω
slope = −40N dB/decade
0°
0.1ωc
ωc
10ωc
ω
(−180N)°