ECE 301
Fall Semester, 2005
HW #5

wlg
Due: Nov 8

Name ____________________
Print (last, first)

Use engineering paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. **Do neat work. Underline your answers. Show how you got your equations. Be sure to show how you got your answers.** Each problem counts 10 points.

(1) You are given the op-amp circuit of Figure 1. It is desired that V_o be the average of the input signals. That is,

$$V_o = \frac{-[V_1 + V_2 + V_3]}{3}$$

Assume $R_1 = R_2 = R_3 = 12\ \text{k}\Omega$. Find the value of R_{FB}. On your own.

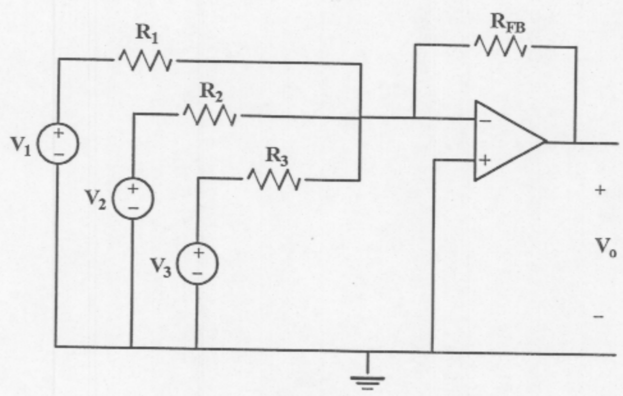


Figure 1: Circuit for problem 1.

(2) You are given the following op amp circuit of Figure 2. Solve for V_o in terms of V_{in}.
Ans: $V_o = -8V_{in}$.

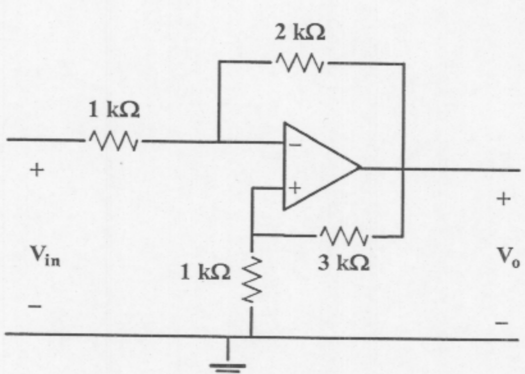


Figure 2: Circuit for problem 2.

(3) You are given the op amp circuit of Figure 3. Solve for V_o in terms of V_{in}. Ans: $V_o = 16.8V_{in}$.

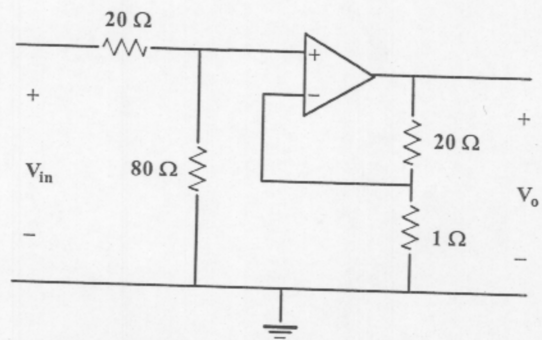


Figure 3: Op amp circuit for problem 3.

(4) You are given the op amp circuit of Figure 4. Solve for V_o in terms of V_{in}. Ans: $V_o = V_{in}/3$.

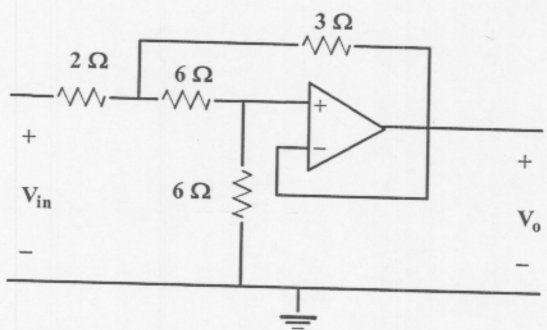


Figure 4: Op amp circuit for problem 4.

(5) You are given the op amp configuration of Figure 5 that solves a first order differential equation. Determine the differential equation.

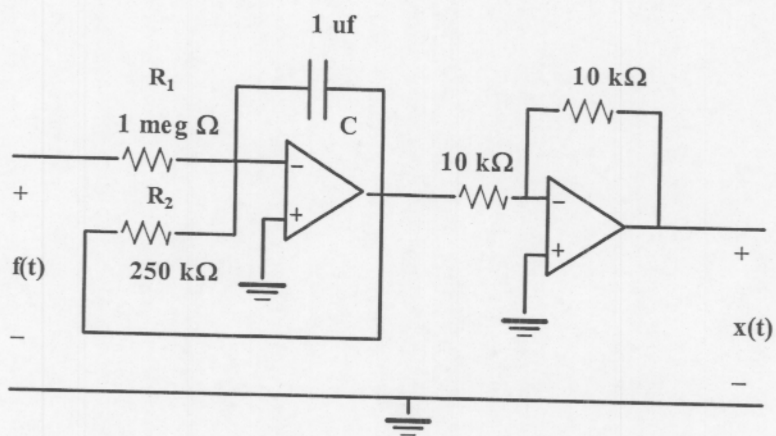


Figure 5: Op amp circuit for problem 5.

(6) The circuit of problem (5) can be used as a low pass filter. If $R_1 = R_2 = 1\ k\Omega$ and $C = 0.1\ \mu F$ give the filter transfer function. What is the low frequency cut-off point in rad/sec?

(7) Use the freqs function of MATLAB to plot the frequency response of the above filter.

(8) You are given the op amp circuit of Figure 8. This configuration can be used for a high-pass filter.

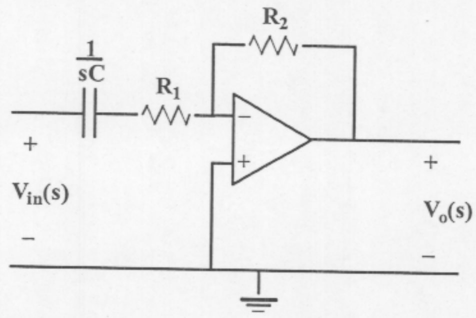


Figure 8: Op amp circuit for problem 8.

Show that the transfer function between the output and input of the configuration is,

$$\frac{V_o(s)}{V_{in}(s)} = \frac{-sR_2C_1}{(1+sR_1C_1)}$$

(a) Assume $C_1 = 1\ \mu F$. Determine the value of R_1 so that the cut-off frequency of the filter is $\omega = 2000$ rad/sec.

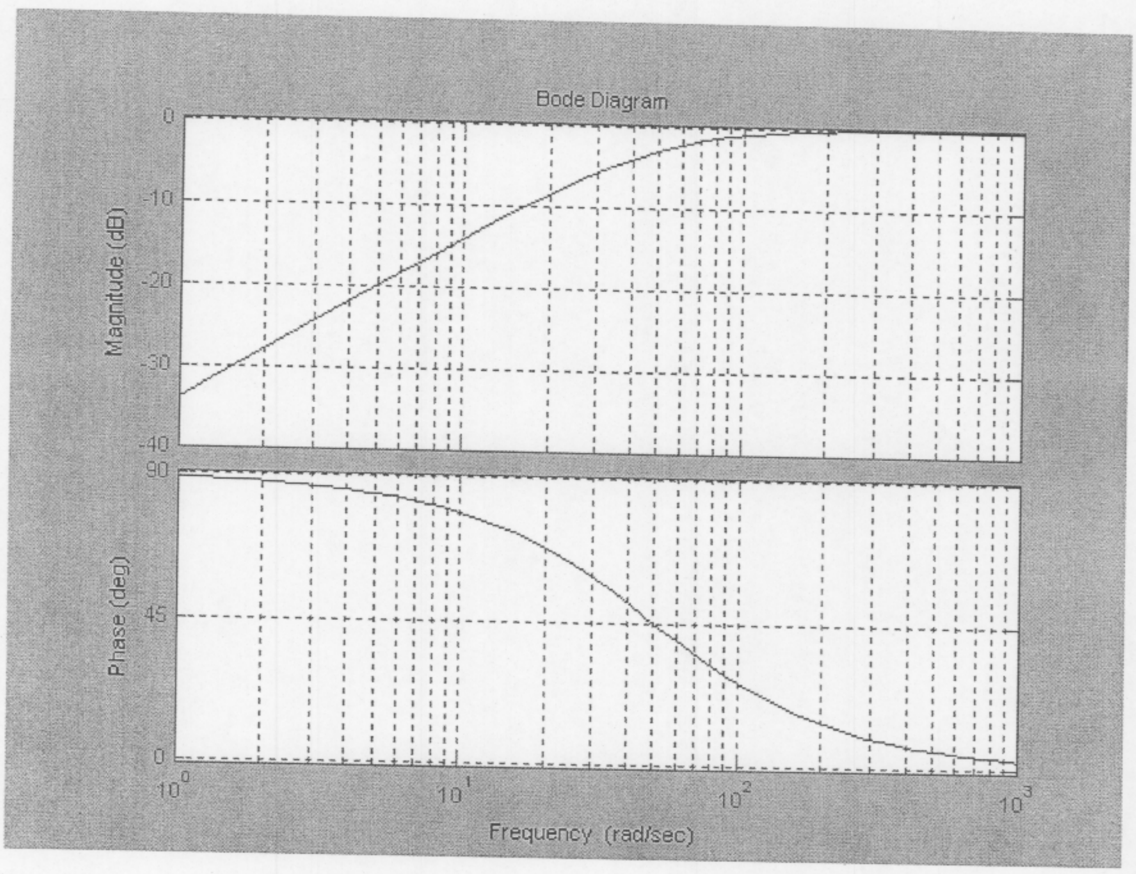
(b) Determine the value of R_2 so that the gain of the filter as ω approaches infinity is 1.

(c) Use the bode statement of MATLAB to find the bode plot for the filter.

Programs are given on the following pages to illustrate how to obtain bode plots and freqs (linear frequency response) plots.

```
% program to show  students how to use the bode statement to obtain a bode plot.
% This program is written for G(s) = 0.02s/(1+0.02s)
% This is a frist order high pass filter, On office computer: October 25,2005, wlg,
% Program name is:  simple_bode2.m

num = [0.02 0];
den = [0.02 1];
bode(num,den)                    % This is the bode statement
grid
```

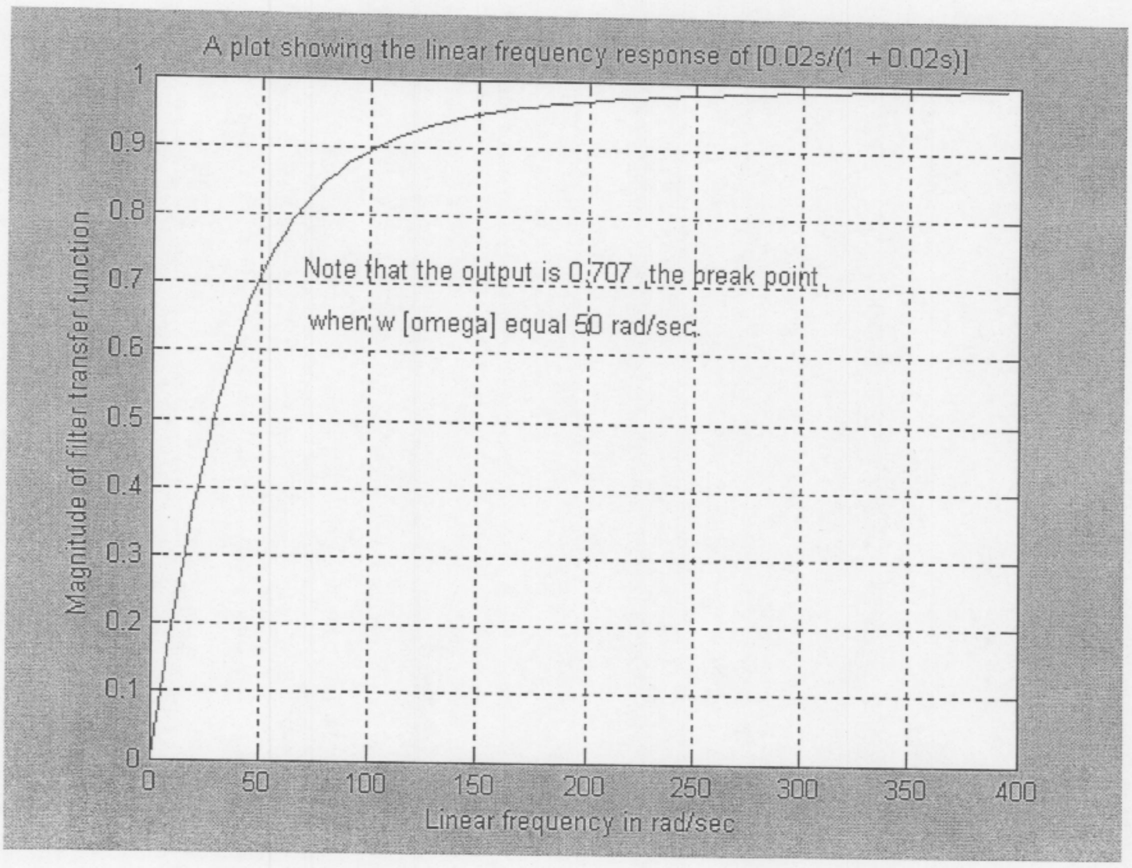


The Bode Plot

```
% program to show  students how to use the bode statement to obtain a linear frequency response.
% This program is written for G(s) = 0.02s/(1+0.02s)
% This is a frist order high pass filter.
% On office computer: October 25,2005, wlg. Program name is:  simple_linear_freq.m

num = [0.02 0];
den = [0.02 1];
w = 0.1:5:400;

G = freqs(num,den,w);   % This is the freqs statement
magG = abs(G);
plot(w,magG)
ylabel('Magnitude of filter transfer function')
xlabel('Linear frequency in rad/sec')
title('A plot showing the linear frequency response of [0.02s/(1 + 0.02s)]')
gtext('Note that the output is 0.707 ,the break point,')
gtext('when w [omega] equal 50 rad/sec.')
grid
```



The Linear Frequency Response