ECE 301
Fall Semester, 2005
HW #5

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.](image)

(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.](image)
(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.](image)

(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.](image)

(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.](image)

(6) The circuit of problem (5) can be used as a low pass filter. If $R_1 = R_2 = 1 \, \text{k}\Omega$ and $C = 0.1 \, \mu\text{F}$ 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.
You are given the op amp circuit of Figure 8. This configuration can be used for a high-pass filter.

\[ \frac{V_o(s)}{V_in(s)} = \frac{-sR_2C_1}{1 + sR_1C_1} \]

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

(b) Determine the value of \( R_2 \) so that the gain of the filter as \( \omega \) 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 first 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)
grid

% This is the bode statement

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 first 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 = 0:1:5000;

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