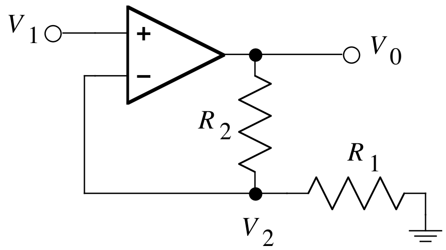
NAME (please print) ______________________________ SID __________________

UNIVERSITY OF CALIFORNIA, BERKELEY
Electrical Engineering and Computer Sciences Department
EECS 145L Electronic Transducer Lab
MIDTERM #1 (100 points maximum)
October 6, 2010

(closed book, calculators OK, equation sheet provided)
(You will not receive full credit if you do not show your work)

PROBLEM 1 (25 points)

Consider the noninverting op-amp circuit shown below:



The op-amp has open loop gain $A = k/f$, $k = 10^6$ Hz and the input impedances are infinite.

1.1 (15 points) ***Derive*** the equation for the voltage gain V_0/V_1 as a function of the resistor values R_1, R_2, and the frequency f.

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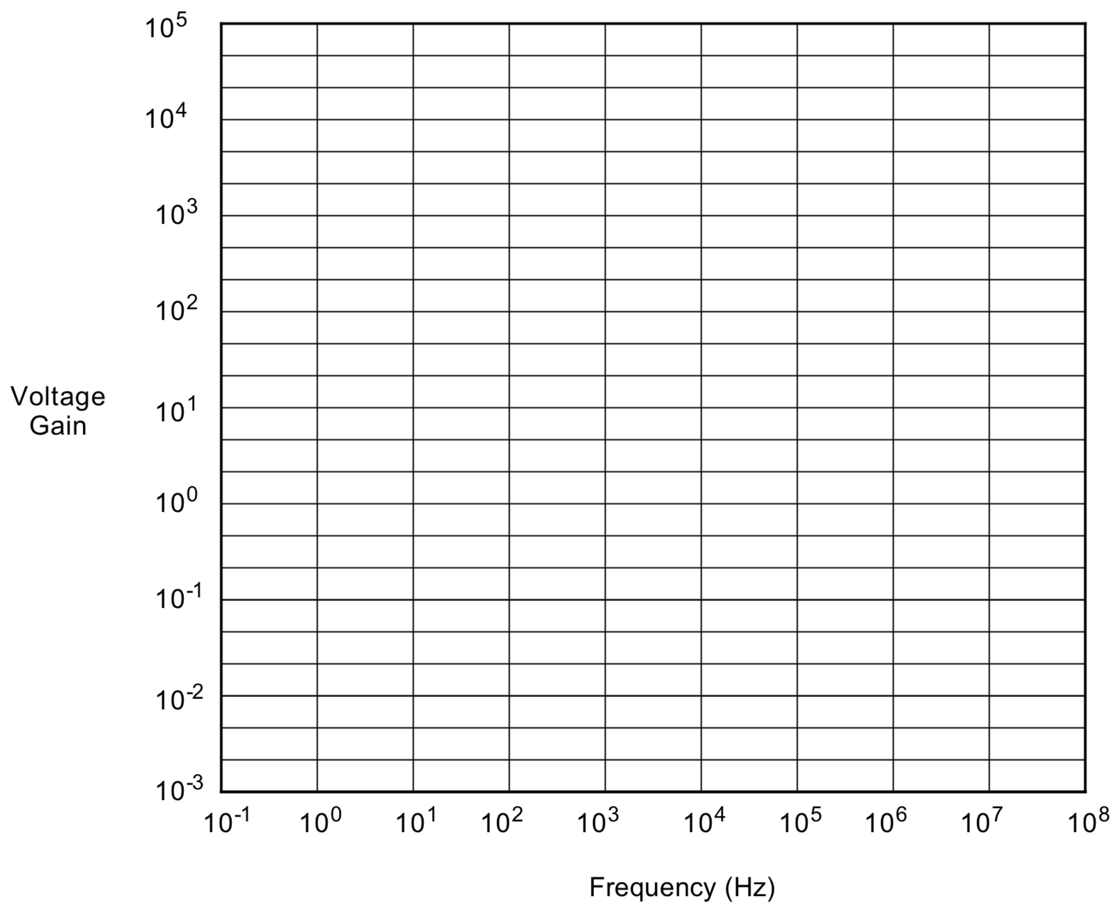
1.2 (10 points) Write the gain equation for R_1 = 1 kΩ and R_2 = 999 kΩ and sketch the gain from f = 0.1 Hz to 100 MHz in the figure that follows.



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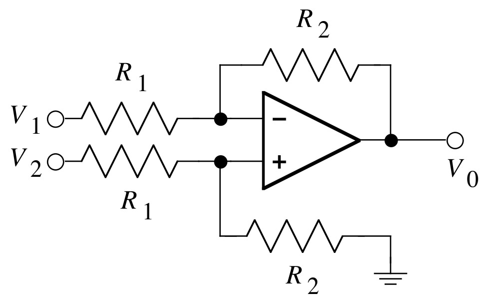
PROBLEM 2 (25 points)

2.1 (15 points) Derive an equation for the output V_0 of the op-amp circuit shown below as a function of the input voltages V_1 and V_2 and the resistors R_1 and R_2. Assume that the op-amp has infinite open loop gain and infinite input impedances.



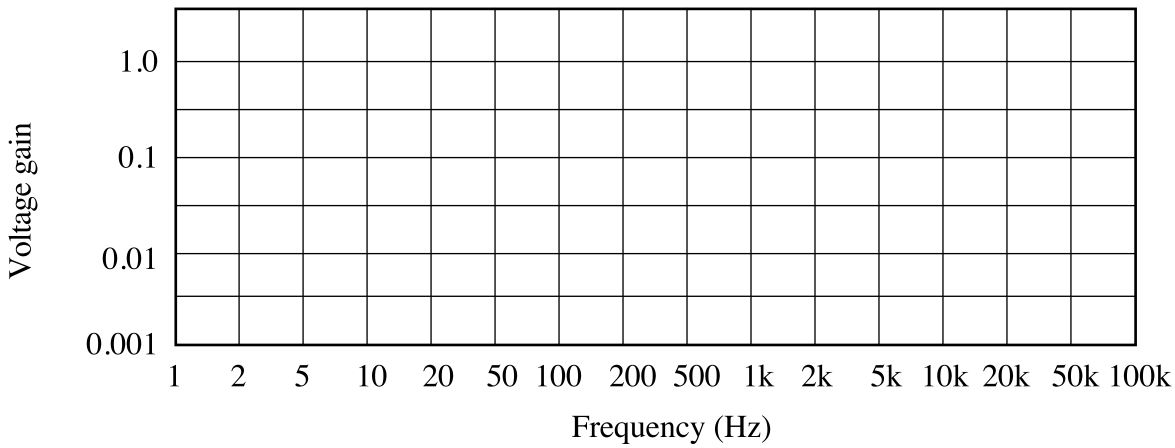
2.2 (10 points) Using the equation derived in part 2.1, write an equation for the differential and common-mode gains as functions of the resistors R_1 and R_2.

PROBLEM 3 (30 points)

Design an analog filter circuit that has the following properties

- Gain between 0.9 and 1.0 for frequencies between 100 Hz and 20 kHz
- Gain less than 0.001 for frequencies above 52 kHz
- Gain less than 0.01 at 60 Hz
- Gain less than 0.001 for frequencies below 2 Hz

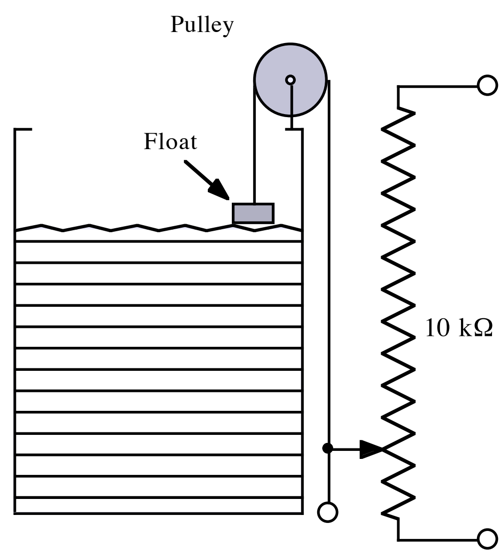
3.1 (10 points) Sketch the required gain vs. frequency below



3.2 (20 points) Design a filtering circuit that meets the requirements above with the minimum complexity and cost. **For each filtering element, give type, corner frequency, and order number.** (Hint: see equation sheet for a table of f/f_C vs. gain and order.) Do not give resistor and capacitor values.

PROBLEM 4 (20 points)

You are asked to design a system for measuring the height of a liquid in a tank 10 m high. As the water level changes, the float rises and falls, and the cable winds on the pulley and raises and lowers the contact point on the resistor. Assume that the contact is at the bottom end of the resistor when the tank is full and at the top end of the resistor when the tank is empty.



4.1 (10 points) Design a circuit that produces a 10 V output when the tank is full and 0V when the tank is empty. The output must drive the recording circuit which acts as an approximate 10 kΩ load.

4.2 (3 points) You perform repeated measurements of the output of your circuit when the height of the liquid is constant and find that the measured output voltages have a standard deviation of 1 mV. How accurately can a single measurement determine the height of the liquid?

4.3 (7 points) If a measurement is taken every minute with precise timing, how accurately could you determine the change in the liquid level per minute?