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 7, 2009

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

PROBLEM 1 (10 points)
Describe four essential differences between the ideal operational amplifier and the realistic operational amplifier (there are at least six).

PROBLEM 2 (10 points)
Describe the operation of the electromagnetic isolation amplifier (how does it work?)

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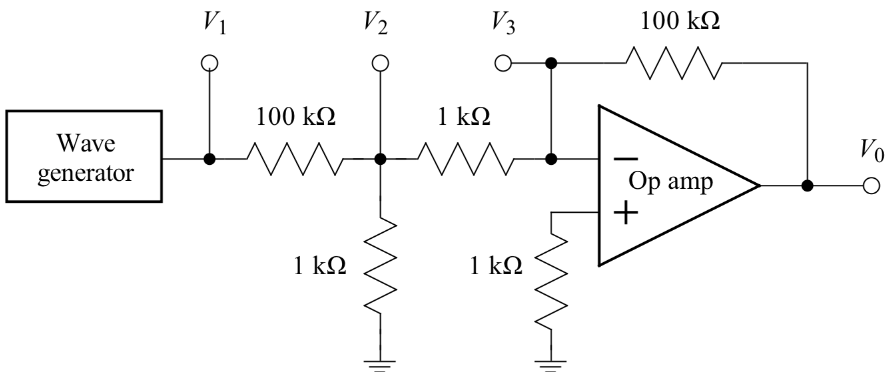
PROBLEM 3 (36 points)

In the circuit shown below, assume the following:

- The op-amp open-loop gain $A = 10^6$ Hz/f for $f > 10$ Hz.
- Op-amp input currents are zero
- Output offset can be neglected
- The wave generator produces a pure sinewave of frequency f and has zero output impedance



3.1 **(20 points)** Derive expressions for V_0, V_3, and V_2 as a function of input V_1, frequency f and open-loop gain A.

3.2 **(16 points)** Evaluate the above expressions at f =10 Hz and 1 MHz. Note: To simplify the calculation, you can neglect small terms that change the answer by less than a few percent.

PROBLEM 4 (20 points)

Design a circuit that uses two op-amps to combine four inputs as follows:

$$V_0(t) = V_1(t) + V_2(t) - V_3(t) - V_4(t)$$

Sketch your circuit below:

PROBLEM 5 (24 points)
Describe how you would measure the following characteristics of an instrumentation amplifier:

5.1 (6 points) Common-mode and differential-mode gains as a function of frequency.

5.2 (6 points) Output offset voltages relative to input (V_{RTI}) and relative to output (V_{RTO}) with both inputs grounded.

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5.3 (6 points) Input bias currents I_{B+} and I_{B-}

5.4 (6 points) Noise factors relative to input (D_I) and relative to output (D_O) $V_{rms} = \sqrt{\Delta f\left[(D_I G)^2 + (D_0)^2\right]}$ using a voltmeter that measures rms voltage in a 10 kHz bandwidth.