# ANALOG SYSTEMS : PROBLEM SET 5

**IN ALL PROBLEMS IN THIS TUTORIAL, THE OPAMP IS NONIDEAL IN THE SENSE THAT IT HAS FINITE BANDWIDTH. The transfer function of the opamp is given by** $A(s) = \frac{\omega_u}{s}$
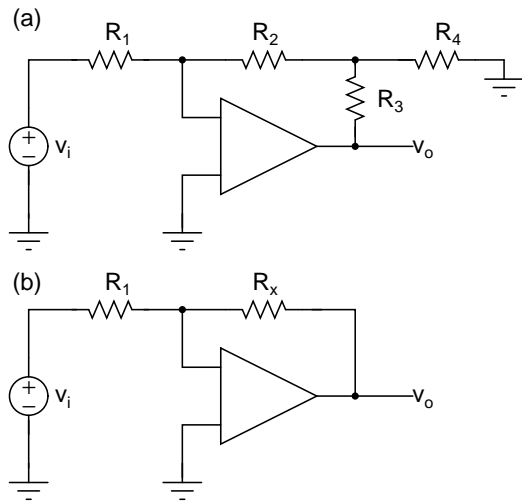
## Problem 1



Figure 1: Circuits for Problem 1.

In the circuits above, determine the signs on the opamps for negative feedback operation, and determine the transfer function $v_o/v_i$. Consider the case where $R_x = 100\,R_1$, $R_2 = R_1 = R_3$. Determine $R_4$ so that both circuits have the same gain. Compare the 3-dB bandwidths achieved for both circuits.
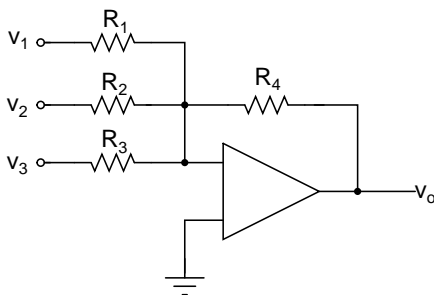
## Problem 2



Figure 2: Circuit for Problem 2.

Determine the transfer functions from $v_1$, $v_2$ and $v_3$ to $v_o$. What is the 3-dB bandwidth of each of these transfer functions?
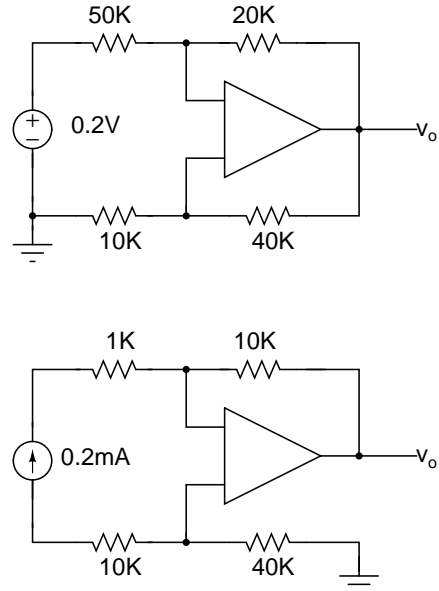
## Problem 3



Figure 3: Circuits for Problem 3.

In the circuits above, mark the signs on the opamp for negative feedback operation, and determine the transfer functions from the input sources to $v_o$.
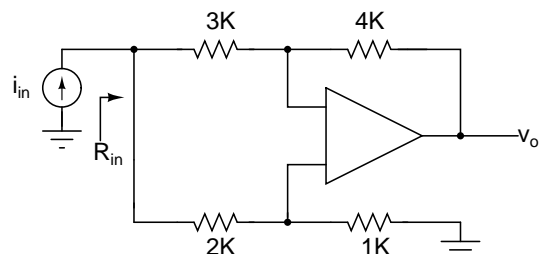
## Problem 4



Figure 4: Circuits for Problem 4.

In the circuit above, mark the signs on the opamp for negative feedback operation, and determine the transfer function from $i_{in}$ to $v_o$. Determine the input impedance (as a function of frequency) looking in, as denoted by $R_{in}$.
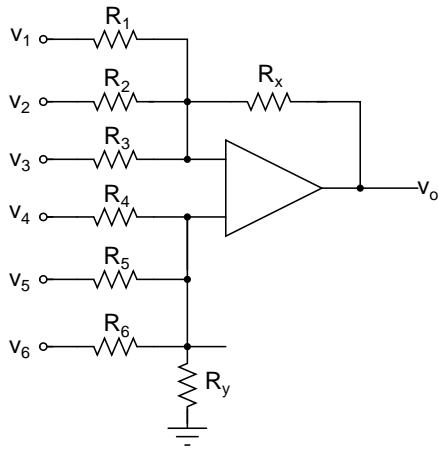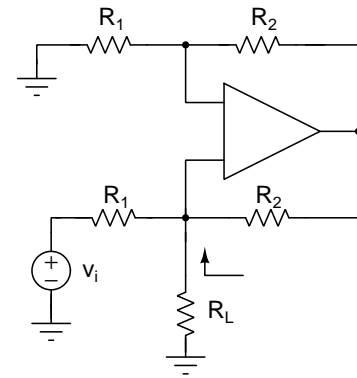
Figure 5: Circuit for Problem 5.

# Problem 5

In the circuit above, mark the signs on the opamp for negative feedback operation, and determine the transfer functions to $v_o$ from $v_1, \cdots, v_6$.
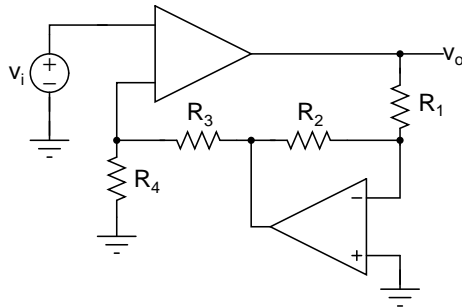
# Problem 6



Figure 6: Circuit for Problem 6.

In the circuit above, mark the signs on the opamp for negative feedback operation, and determine $V_o(s)/V_i(s)$.

# Problem 7

In the circuit above, mark the signs on the opamp for negative feedback operation, and determine the Norton equivalent for the circuit looking across the load resistor $R_L$. Remember, that the Norton equivalent will be frequency dependent.

# Problem 8

The figure above shows three different ways of achieving an amplifier with a gain of $n^2$, where $n^2 \gg 1$. If $v_{off,1,2} = 0$ and the opamps have infinite gain, all three are equivalent.
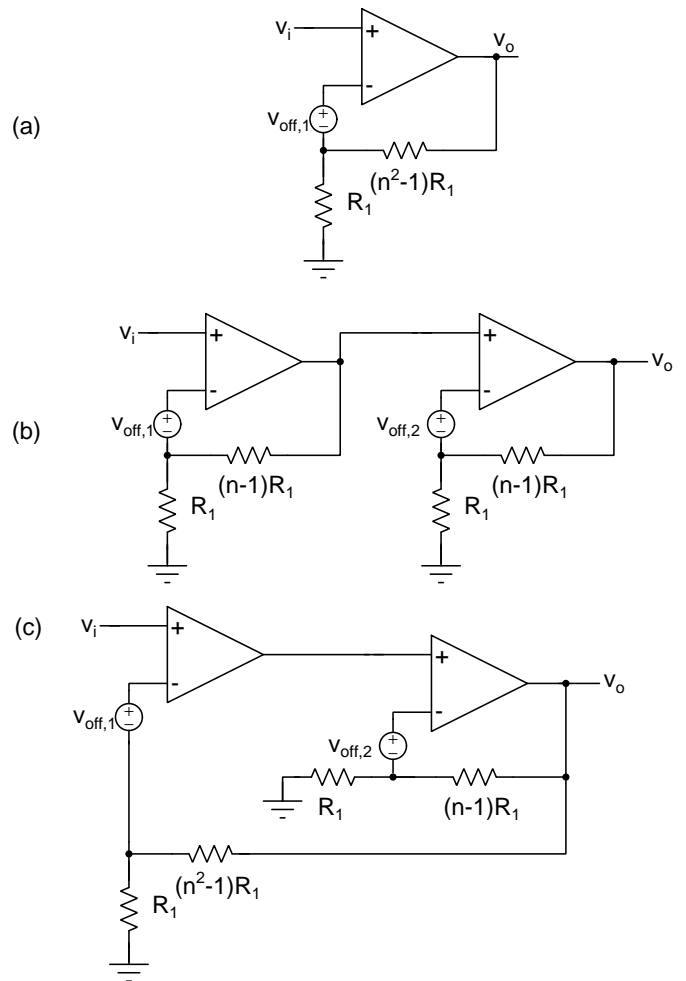


Figure 7: Circuit for Problem 7.



Figure 8: Circuit for Problem 8.

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Determine the transfer functions of each of these amplifiers. Assume that the offset voltages are all zero. WHich of them has the highest bandwidth?