Homework Assignment #4 – due in BRKI 368 at 4 pm Friday, Oct. 11, 2013

***Instructions, notes, and hints*:**

You may make reasonable assumptions and approximations in order to compensate for missing information, if any. Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work.

All Problems: If only a single power supply voltage V_{CC} is specified in the problem statement, it implies that a bipolar power supply (with $\pm V_{CC}$ and a common, or reference, node) is applied to the op-amp. If no power supply is specified, you may assume that the circuit operates in the linear range at all times; that is, the output voltage is not constrained by the power supply limits.

Prob. 4.7: The op-amp in the circuit should be replaced with the equivalent circuit model given in Fig. 4-4.

Probs. 4.14 through 4.23: You do not have to use the op-amp equivalent circuit model as you did in Prob. 4.7. Instead, you may assume that a virtual short exists between the input terminals as long as there is negative feedback. Remember that you are not likely to gain much by writing a KCL equation for the output node of the op-amp, unless you are trying to find the op-amp's output current after the rest of the circuit's voltages and currents have been found. There is no way to relate the output current to any of the node voltages in the circuit because the output current is coming from a voltage-dependent voltage source (source $A(v_p - v_n)$ in the model given in Fig. 4-4).

Probs. 4.14, 4.15, and 4.23: The voltage or current gains in each of these problems should be a numerical value.

Probs. 4.15 and 4.20: The "linear range of v_s" is the range of voltage values of v_s such that v_o stays within the power supply limits ($\pm V_{CC}$). That is, when v_s is in its linear range, the output voltage is linearly related to v_s.

Probs. 4.22 and 1: A potentiometer is a resistor with a movable "tap" (usually called a "wiper," but referred to as a "stylus" in the problem statement here) that is connected to a third terminal. In this problem the wiper (stylus) breaks the 10-kΩ resistor into two parts, and the wiper serves as a connection point between the parts. The two parts each have resistances less than 10 kΩ, but they always add up to 10 kΩ. The quantity β in this problem is simply the fraction of the total 10-kΩ resistance that extends from the wiper to the upper end of the potentiometer. In general, β would range from 0 to 1, but in this particular case some mechanical constraint limits the range from 0 to 0.9. For more information on potentiometers, see pp. 43-44 in the textbook.

***Assignment*:**

Probs. 4.7, 4.14, 4.15, 4.20, 4.22, and 4.23 in the textbook plus the additional problem on the next page.

(*continued on next page*)

Prob. 1: [Adapted from Prob. 14.33 of A. R. Hambley, *Electrical Engineering: Principles and Applications*, 4th ed., Pearson Education, Inc., Upper Saddle River, NJ, 2008] Derive an expression for the voltage gain v_o/v_{in} of the circuit shown below as a function of the parameter β, assuming an ideal op-amp. Parameter β varies from 0 to 1, depending on the position of the wiper of the potentiometer. Note that the total resistance of the potentiometer is equal to the two fixed resistor values. *Hint*: Make sure your answer gives the correct result for the limiting cases of $\beta = 0$ (wiper at ground end of the potentiometer) and $\beta = 1$ (wiper at v_{in} node).