ELEC 225 Circuit Theory I Fall 2013

Homework Assignment #5 – due in BRKI 368 at 4 pm Friday, Oct. 25, 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.

Prob. 4.27: The output voltage should be equal to $(v_1 + v_2 + \cdots + v_5)/5$. More than one op-amp may be used in the circuit, but all should operate from the same power supply(ies). There is a lot of flexibility in the design. You may specify resistor ratios instead of specific resistor values, if appropriate.

Probs. 4.29, 4.30, 4.31: The power supply label $V_{CC} = 16$ V implies that a bipolar power supply set to ±16 V and that includes a common reference node is applied to the op-amp.

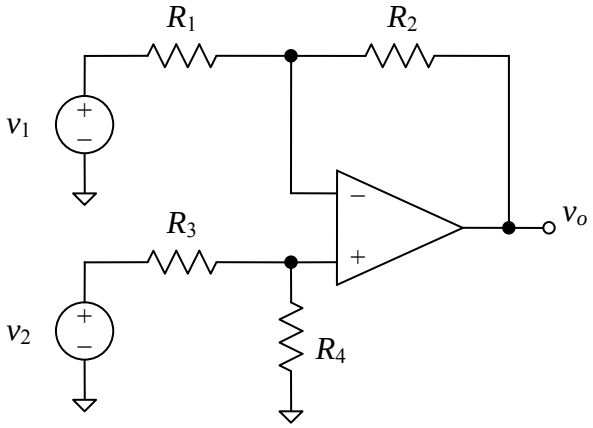
Probs. 4.29 and 4.30: You may assume that the op-amp is ideal and can produce output voltages all the way to the power supply "rails." Note that fixed input voltage source V_0 is different from the output voltage v_o (one is upper case).

***Assignment*:**

Probs. 4.27, 4.29, 4.30, and 4.31 in the textbook plus the following additional problems:

1. Consider the difference amplifier (diff amp) circuit shown below. The resistor pairs R_1-R_3 and R_2-R_4 are not perfectly matched in value. Show that the total output voltage v_o as a function of the input voltages v_1 and v_2 is given by the expression below. You may analyze the circuit with both inputs active, or you may apply the superposition principle.

$$v_o = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right)v_2 - \frac{R_2}{R_1}v_1 .$$



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2. Show that the output voltage expression given in Prob. 1 for the diff amp circuit reduces to

$$v_o = \frac{R_2}{R_1}(v_2 - v_1) \quad \text{if} \quad \frac{R_4}{R_3} = \frac{R_2}{R_1} \text{ exactly.}$$

3. The circuit shown below will be used to indicate on a voltmeter the number of spaces that are occupied in a parking lot. A sensor located at each of the 24 spaces produces a 2-V DC signal that appears at one of the 24 inputs labeled v_1 through v_{24}. If no car is parked in the space, the sensor produces a 0-V signal. The labeled circles indicate that the input is connected to a sensor not shown; thus, current can flow in and out of the terminal. For example, current can flow through R_1 into/out of the sensor connected to the circle labeled v_1; the left end of R_1 does not end in an open circuit. Find the required values for R_f and R_1 through R_{24} to produce an output voltage v_o with a scale of 1 V/occupied space. For example, if 14 spaces were occupied then v_o should be 14 V. An additional constraint is that the output current i_{o1} of the first op-amp (IC_1) must be less than 5 mA in magnitude at all times. (Don't forget to include the current that flows into the circuit built around IC_2.)