EECS 211 Circuits I
Fall Semester 2018
Assignment #6 Due 2 October 2018 Yes, this is the day after Exam 1!

Reading: Sections 6.1, 6.5 (through p. 195 only), 6.2, 6.3 (other parts of chapter 6 are interesting and useful, but they are supplemental for this course), 5.1 in Hayt/Kemmerly/Durbin

Do all of the Practice problems in the Reading assignment (but do not hand them in).

NOTE1: Some of the problems below have an indicated method (e.g., ideal op-amp model). For those problems, you must use the indicated method to solve the problem, but you may check your answers using any method. NOTE2: Some of the problems direct you to perform some sort of a check on your work. This check must be done to receive full credit for the problem.

1. Design Problem. The schematic below is a simplified representation of a rear window defroster for a car.

![Schematic](image)

The 12 V source represents a typical car battery. Current runs through the resistive defroster wires, and the power is dissipated as heat, heating the glass and melting the frost. The discrete resistors are representations of distributed resistance in the defroster wires. Resistors $R_1$, $R_2$, and $R_3$ represent resistance that is actually distributed over 1.5 meters (the length of the horizontal wires). Resistors $R_a$ and $R_b$ represent resistance that is actually distributed over 0.25 meter (the length of the vertical wires). Each of the wires can be made of different resistive material.

We want to design the defroster so that the glass heats up as uniformly as possible. Specifically, the design specification is to have a uniform power dissipation of 10 W/meter along all of the defroster wires. That is, resistors $R_1$ through $R_3$ should each dissipate $10\text{W/m} \cdot 1.5\text{m} = 15\text{W}$ and resistors $R_a$ and $R_b$ should each dissipate $10\text{W/m} \cdot 0.25\text{m} = 2.5\text{W}$. Note that the symmetry of the circuit ensures that the top two vertical resistors will have the same value ($R_a$) and similarly for the two resistors $R_b$. Determine all of the resistance values that will satisfy this design specification. Use whatever technique (or combination of techniques) you choose.
2. Use Figure 6.39 on p. 208 for this problem. Note that this is exactly the same basic inverting amplifier configuration as we examined in the lecture. Use the ideal op-amp model and the following values to find the voltage gain $v_{\text{out}}/v_{\text{in}}$ and the current leaving through the op-amp output terminal: $v_{\text{in}} = 3 \text{ V}$, $R_1 = 4.7 \text{ k}\Omega$, $R_2 = 10 \text{ k}\Omega$. Note that the voltage shown ($v_{\text{out}}$) is a node voltage with respect to ground (the reference node).

3. Re-work problem the previous problem using the detailed op-amp model given in class and in Section 6.5. Use nodal analysis with the following (typical) parameter values: $R_i = 1 \text{ M}\Omega$, $R_o = 50\Omega$, and $A = 10^6$. Check your work using mesh analysis. After working the problem this way, do you see the advantages of using the ideal op-amp model?

4. Problem 6.4, part (a) only, p. 209. Use the ideal op-amp model.

5. Problem 6.18, p. 210, but change the value of the first feedback resistor from 5 $\Omega$ to 2 $\Omega$ and change the value of the second feedback resistor from 2 k$\Omega$ to 5 k$\Omega$. Cascaded op-amps. Use the ideal op-amp model.