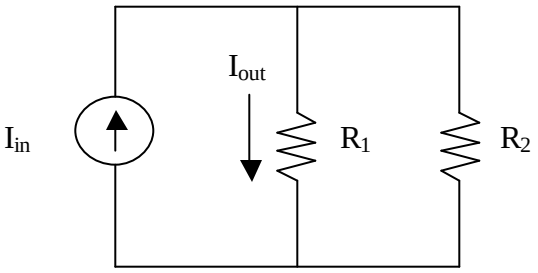
EE 70 Midterm #1
Closed Book, Closed Notes, Calculators Allowed
Tuesday, October 6th (2 pm – 3:45 pm)
17 problems, 34 total points

Please do all of your work on a separate sheet of paper
Final answers should be circled next to your work
To receive full (or partial) credit, you must show your work
Unless otherwise specified, each question is worth two points

Consider the current divider circuit shown below:



1a. How many branches are there in the circuit?

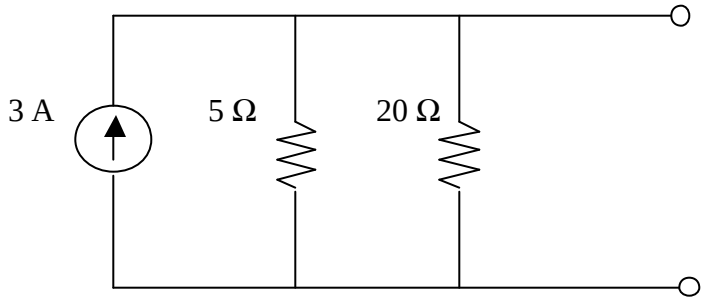
1b. How many nodes are there in the circuit?

2. Derive an expression for the output current (I_{out}, shown above) as a function of the input current (I_{in}) and the two resistors (R_1 and R_2). Use any technique you'd like.

3. How should the resistors be chosen such that twice as much current flows through R_1 compared to R_2?

4. *Using the equation you obtained in #2*, show what happens to I_{out} if R2 is replaced with a short circuit (i.e. $R_2 = 0$). Repeat if R_2 is replaced with an open circuit. (think about what R_2 should be replaced with here)

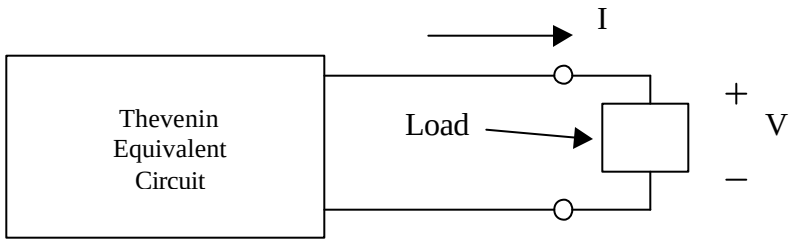
Now suppose the following values are used: $I_{in} = 3$ A, $R_1 = 5\ \Omega$, $R_2 = 20\ \Omega$, and we wish to find the Thevenin equivalent circuit across the two indicated terminals below:



5. Find V_{oc} and I_{sc} across the two terminals indicated on the circuit.

6. Draw the Thevenin equivalent circuit for the two terminals indicated above.

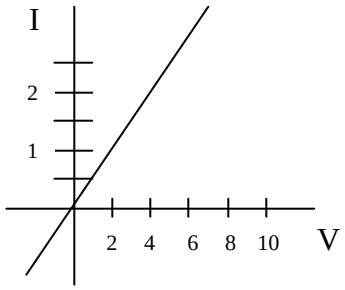
7. Suppose a load is now attached across the two terminals of the Thevenin equivalent circuit:



a. Write an equation for I in terms of V.

b. Sketch the IV characterstics. Use I as the "y-axis" and V as the "x-axis". Label all relevant points.

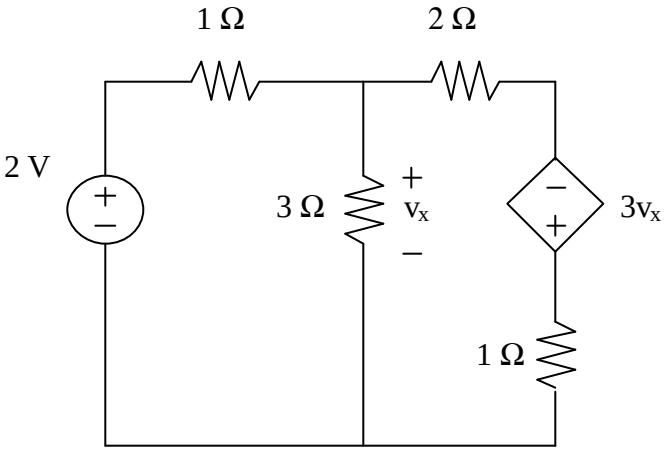
8. Suppose the load has an IV characteristic given as follows:



a. What are the values of I and V if the load is attached to the Thevenin equivalent circuit?

b. Looking at the IV characteristic, what is the load? (describe the load as much as you can)

For problems 9 through 12, consider the following circuit:



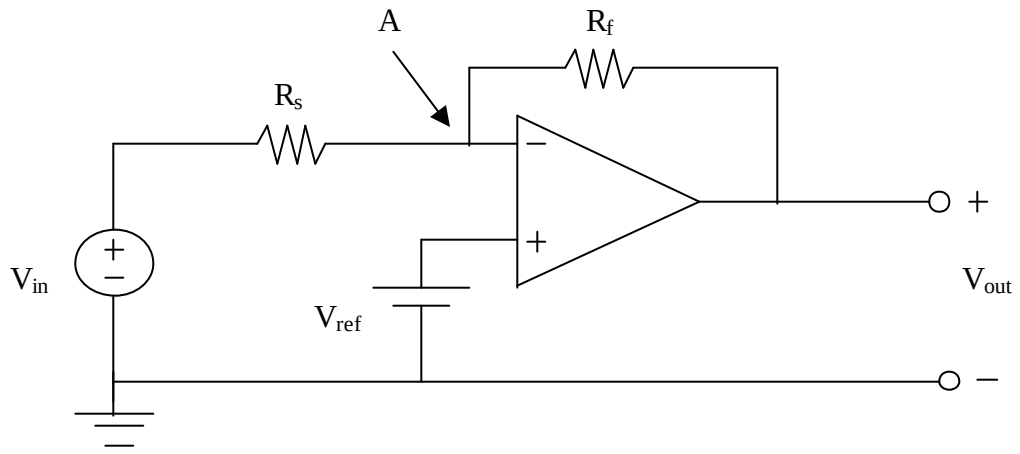
9. Using KVL and mesh analysis, write down the equations needed to solve the circuit. Convert the resistor voltages into currents.

10. The dependent source requires one additional equation to be generated. Write down that equation by looking at the 3 Ω resistor.

11. Solve the equations simultaneously to determine the two mesh currents.

12. To check your answer, confirm that power is conserved in the circuit. Find the power dissipated in each resistor. Find the power generated (or dissipated in each source). Be clear in your answers whether power is being generated or dissipated in each circuit element.

For problems 13 through 17, consider the following op-amp circuit:



Assume ideal op-amp conditions (i.e. summing-point constraint applies)

13. Write a KCL equation at node A. Convert the currents into voltages and solve for V_{out} (in terms of the resistors, V_{in}, and V_{ref}).

The purpose of this op-amp circuit is to remove any DC offset in the input signal. If the input signal has no DC offset, V_{ref} is set to 0.

14. Suppose the input voltage is $V_{in} = 0.1 \cos \omega t$. The desired output voltage is $V_{out} = -\cos \omega t$. Choose a value for R_f and R_s (in the kΩ range) so that this output is achived. (Hint: since there is no DC offset in the signal here, use $V_{ref} = 0$)

15. Now suppose the input voltage has been shifted by a 1.8 v DC component we wish to remove, i.e. $V_{in} = 0.1 \cos \omega t + 1.8$ What value of V_{ref} will ensure the same V_{out} in #14? (i.e. $V_{out} = -10 \cos \omega t$)

16. Redraw the circuit and replace the op-amp with an equivalent circuit model. Label values for all circuit elements. Assume the op-amp has an input resistance of 100 kΩ, an output resistance of 10 Ω, and a differential gain of 10000. Use the R_f and R_s values from #13 and assume $V_{ref} = 0$ and $V_{in} = 10$ v.

17. Test the validity of the summing point constraint. Find V_-, the current flow through the input resistance, and $V_+ - V_-$ Comment on the results you get.