EE 42

Midterm #1 Review Material

Tips on solving for voltages and currents in general:

- Start by looking at what you are asked to find. Ask the following questions:
  - Is it a current or a voltage?
  - What other quantity might help you find that voltage?
  - Is it a resistor current or voltage? If so, can Ohm's law help?
  - If looking for a voltage, can you find other voltages in a closed loop (KVL)?
  - If looking for current, can you find other currents and use KCL?
- Writing seemingly random KVL and KCL equations never hurts.
- You can always resort to nodal analysis. Nodal analysis works best when you are looking for a voltage, and place ground at the – end of the desired voltage.
- If dependent sources are in the circuit, try to solve for the controlling voltage or current. Or, write an equation for it using Ohm's law, KVL or KCL.
- Look for short circuits and holes in the circuit.
- Remember that 0 V over a resistor implies 0 A current, and vice-versa.
- Remember that current sources can have nonzero voltage. Their voltage adapts to satisfy KVL in the circuit.
- Remember that voltage sources can have nonzero current. Their current adapts to satisfy KCL in the circuit.

Tips on finding Thevenin/Norton Equivalents:

- Remember that we are trying to identify the I-V line for the circuit. We usually find two specific points on the line (the x and y intercepts) but any two points will do.
- We match up the I-V line for the Thevenin/Norton circuit with that of our more complex circuit. We do this when we set:
  - V_{TH} = x-intercept
  - I_N = negative of y-intercept
  - $R_{TH} = R_N = 1/\text{slope} = V_{TH} / I_N$
- To find the x-intercept, set the y value to zero. That means set the current to zero. That's why V_{TH} is the voltage drop from a to b when no current flows (open circuit).
- To find the y-intercept, set the x value to zero. That means set the voltage to zero. That's why I_N is the negative of the current from a to b when no voltage drop is present (short circuit).
- The values of V_{TH} and I_N depend on the values of the independent sources. The value of R_{TH} (R_N) depends on the values of resistors and dependent sources. This means:
  - R_{TH} remains the same even if you set voltage and current sources to 0 V (wire) and 0 A (air) respectively. This can simplify R_{TH} calculation.

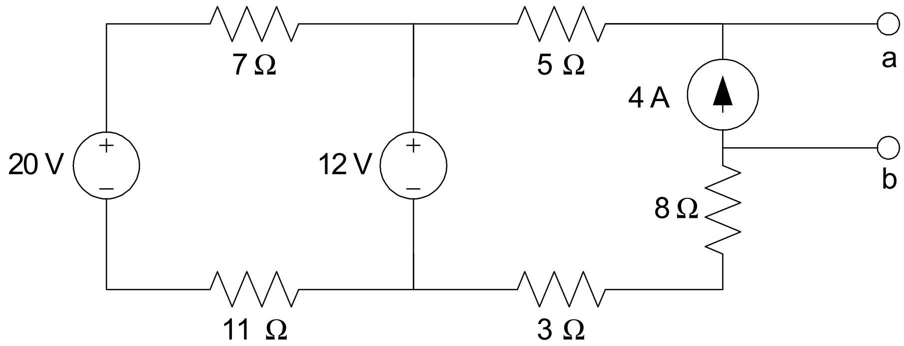
- If there are no independent sources in the circuit, V_{TH} and I_N are 0 V and 0 A respectively. Then you cannot find R_{TH} using V_{TH} / I_N since 0 / 0 is undefined. In this case, you need to treat the circuit like an unknown resistance:
    - Apply a test voltage across the terminals.
    - Measure the current that flows through the circuit from + to -.
    - Divide voltage by current to get R_{TH}.
    - You could also do this by applying a test current into the device and finding the resulting voltage drop.

Tips on solving op-amp circuits:

- We will look at two types of op-amp circuits:
    - Op-amp circuits with a feedback resistance
        - These circuits perform linear operations on input voltages.
        - We use the **ideal op-amp model** to analyze them:
            - Assume there is zero voltage drop across input terminals
            - Assume there is zero current into input terminals
        - The value of the output voltage is a linear function of the input voltages, and the coefficients depend on resistor values and the circuit configuration.
        - The output voltage does **not** depend on what is attached to the output. The op-amp provides current to whatever is attached to the output, to ensure that it carries the proper voltage.
        - You can design an op-amp circuit to perform a particular task by piecing together known designs and adjusting resistor values.
        - You can analyze an op-amp circuit by
            - Apply KVL in a loop containing input voltage source and op-amp input terminals (remember this drop is zero). Find voltage across resistors in loop.
            - Use this info to find current through resistors, and then current through the feedback resistor via KCL.
            - Use this info to find voltage over feedback resistor, and then output voltage via KVL (loop includes output to ground, 0 V across inputs, and feedback resistor voltage)
    - Op-amp used as comparator
        - Threshold voltage and input voltage are attached to input terminals.
        - We use the **op-amp circuit model** to see that the op-amp will be in the linear region only when the input voltage is very close to the threshold voltage.
        - If the difference between the input voltage and the threshold voltage is not very small, the output $A(V_+ - V_-)$ will be large in magnitude since A is large. The op-amp will hit a rail.

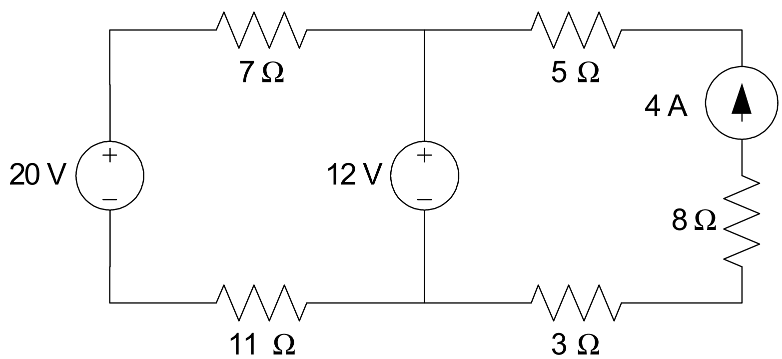
Problem 1:

Find the Thevenin and Norton equivalents for the following circuit:



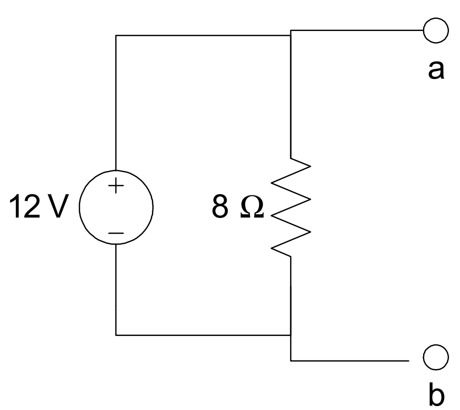
Problem 2:

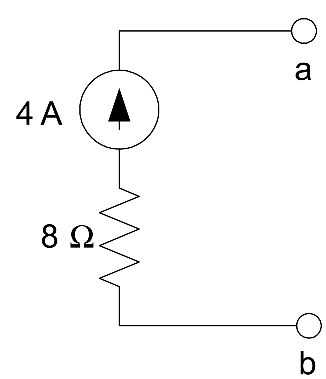
Find the power generated by each independent source in the following circuit:



Problem 3:

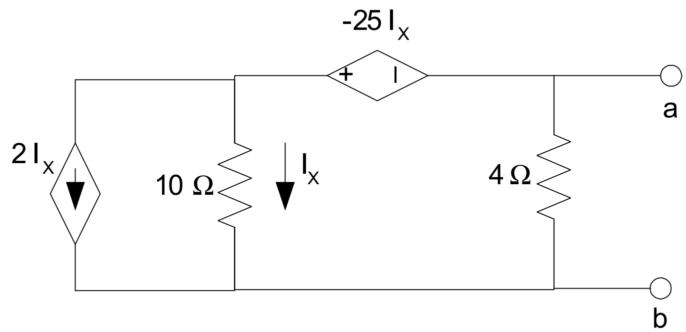
Find the Thevenin and Norton equivalents for each circuit below.
Hint: In some cases, a Thevenin or Norton equivalent may not exist.





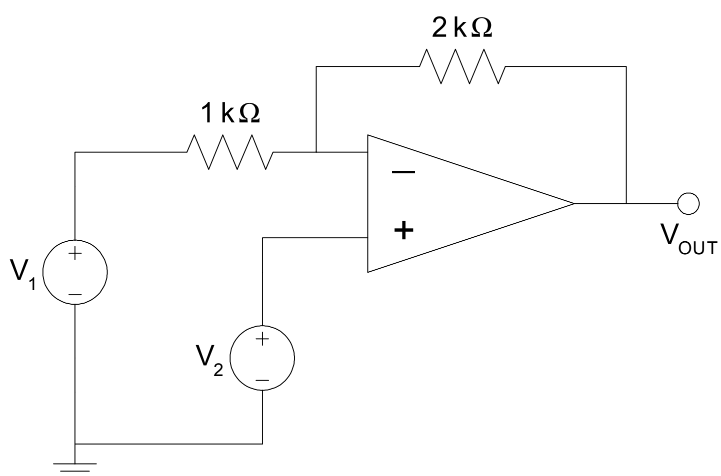
Problem 4:

Find the Thevenin and Norton equivalents for the circuit below.



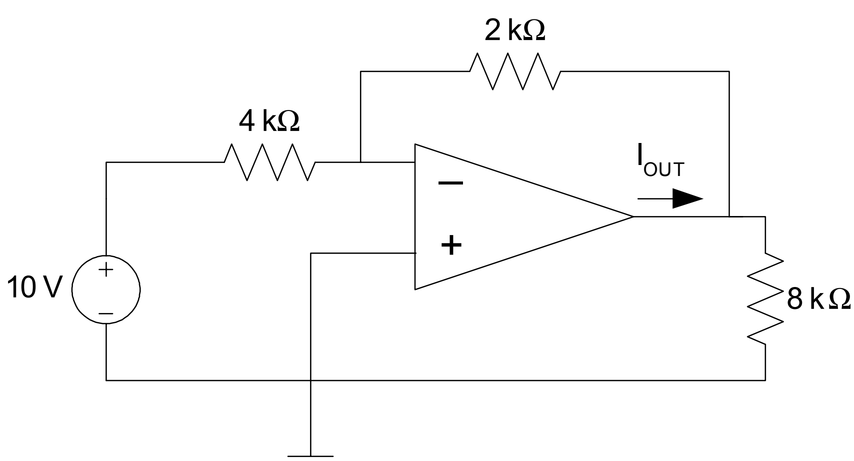
Problem 5:

Find V_{OUT} in terms of V_1 and V_2.



Problem 6:

Find I_{OUT}.



Problem 7:

Consider a comparator with:

- Threshold voltage 2 V
- Logic 1 voltage 5 V
- Logic 0 voltage 0 V
- $R_i = \infty$, $R_O = 0\ \Omega$
- A = 1000

Consider an input voltage to the comparator with the value

$V_{IN}(t) = 5\ e^{-4000\ t}$

valid for $t \geq 0$ s.

a) Sketch the comparator output voltage for t = 0 ms to t = 1 ms.

b) For what time interval is the op-amp in the linear region?