PHY338K Electronic Techniques

Fall 2025

Homework 1

Due: Sept. 3, 2025

1. (30 points) DC Circuit, analytical calculation

a) R2 and R3 in parallel are equivalent to a single resistor $R_{\|} = \frac{R2 \times R3}{R2 + R3} = \frac{740 \times 510}{740 + 510} = 302\ \Omega$.

$R_{\|}$ and R1 then appear in series across the voltage source with total resistance

$R_T = R_{\|} + R_1 = 302 + 215 = 517\ \Omega$.

The current through R1 is just the total current which is $\boxed{I_1 = I_T = \frac{V_1}{R_T} = \frac{5.40}{517} = 0.01045\,\mathrm{A}}$

R2 and R3 then form a current divider.

The current through R2 is $\boxed{I_2 = I_T \frac{R_3}{R_2 + R_3} = 0.01045 \frac{510}{740 + 510} = 0.00426\,\mathrm{A}}$

The current through R3 is $\boxed{I_3 = I_T \frac{R_2}{R_2 + R_3} = 0.01045 \frac{740}{740 + 510} = 0.00619\,\mathrm{A}}$

b) $R_{\|}$ and R1 form a voltage divider across voltage source V1.

The voltage across R1 is $\boxed{V_{R1} = V_1 \frac{R_1}{R_{\|} + R_1} = 5.40 \frac{215}{302 + 215} = 2.25\ \mathrm{V}}$

The voltage across $R_{\|}$ is $V_{\|} = V_1 \frac{R_{\|}}{R_{\|} + R_1} = 5.40 \frac{302}{302 + 215} = 3.15\,\mathrm{V}$.

This is the same as the voltages across R2 and R2, so those voltages are $\boxed{V_{R2} = V_{R3} = V_{\|} = 3.15\,\mathrm{V}}$

c) The power dissipated in the three resistors is

$\boxed{P_1 = I_1^2 R_1 = (0.01045)^2 \times 215 = 0.0235\ \mathrm{W}}$

$\boxed{P_2 = I_2^2 R_2 = (0.00426)^2 \times 740 = 0.0134\ \mathrm{W}}$

$\boxed{P_3 = I_3^2 R_3 = (0.00619)^2 \times 510 = 0.0195\ \mathrm{W}}$

d) The sum of the powers dissipated in the resistors is

$P = P_1 + P_2 + P_3 = 0.0235 + 0.0134 + 0.0195 = 0.0564$ W.

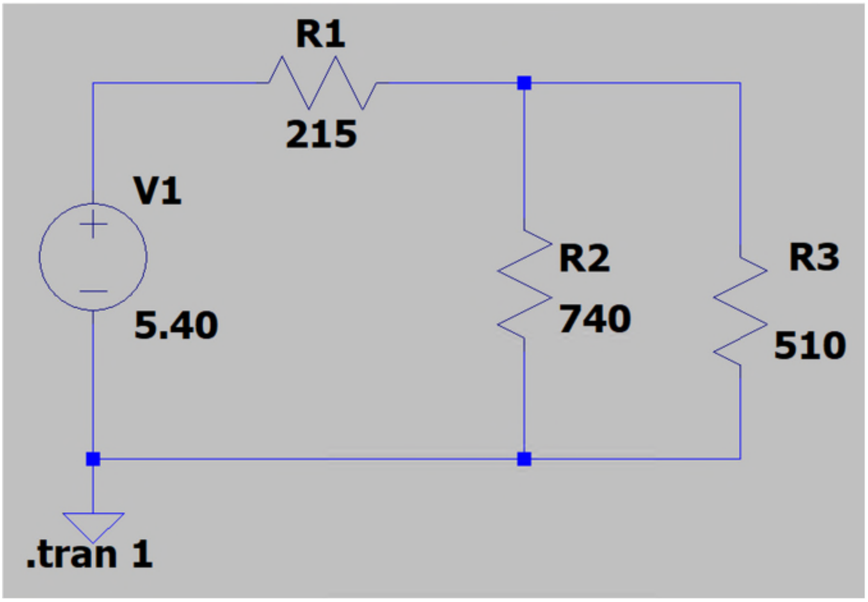
The power supplied by the voltage source is $P = I_T V_1 = 0.01045 \times 5.40 = 0.0564$ W.

The powers match as they should.

2. (30 points) DC circuit, LTSpice calculation

a) No need to show work.

b) Here is a copy of the circuit in LTSpice:



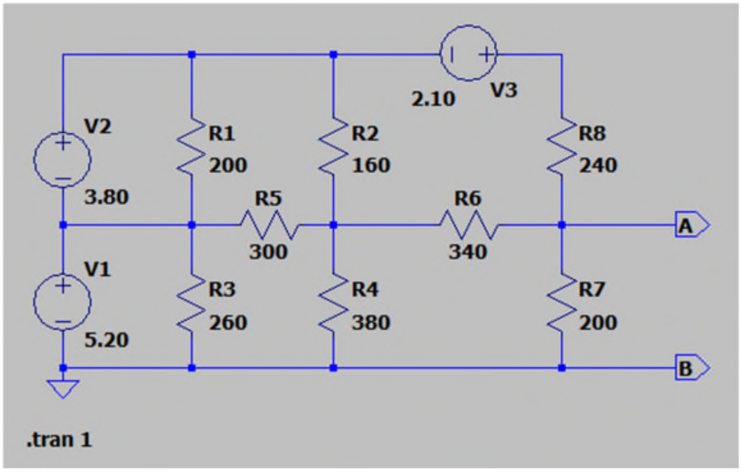
By making measurements from a simulation run for 1 second, I find that

$I_1 = 0.01045$ A, $I_2 = 0.00426$ A, $I_3 = 0.00618$ A, $V_{R1} = 2.246$ V, and $V_{R2} = V_{R3} = 3.154$ V.

These are the same values I obtained by analytical calculation in Problem 1.

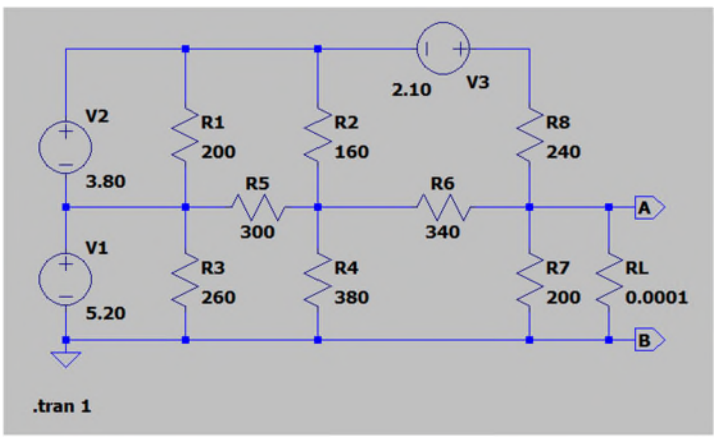
3. (40 points) <u>Thevenin equivalent</u>

a) Here is a copy of my circuit from LTSpice:



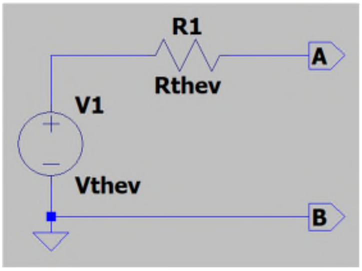
b) By running the simulation for 1 second and measuring the voltage at points A and B, I determined that the open circuit voltage (potential difference between A and B) is $V_{open} = 5.426$ V.

Here is a copy of the circuit modified with a load resistor $R_L = 0.0001\,\Omega$ connecting points A and B:



Since RL is so small compared to all other resistances in the circuit, the current through R1 is a good approximation to the short-circuit current. By running the simulation and measuring the current through RL, I find that the short-circuit current is $I_{short} = 60.53$ mA.

The Thevenin equivalent circuit is



From this circuit, it is apparent that $\boxed{V_{thev} = V_{open} = 5.246 \text{ V}}$

The short circuit current must be $I_{short} = \dfrac{V_{thev}}{R_{thev}}$.

So it follows that $\boxed{R_{thev} = \dfrac{V_{thev}}{I_{short}} = \dfrac{5.246}{0.06053} = 86.67\ \Omega}$

c) I modified the load resistor R_L in the simulation in part (b) to have the requested values, and obtained the following voltages at point A of the circuit

R_L	V_A	Expected voltage $V_{thev}\dfrac{R_L}{R_L + R_{thev}}$
$0.5R_{thev} = 43.34\ \Omega$	1.749 V	1.749 V
$R_{thev} = 86.67\ \Omega$	2.623 V	2.623 V
$2.0R_{thev} = 173.34\ \Omega$	3.498 V	3.497 V

If Thevenin's theorem is correct, the voltage output by the actual circuit should be the same as the voltage output by the Thevenin equivalent circuit with the same load. That is just a voltage divider with voltage V_{thev} and resistors R_L and R_{thev}. In the third column above, I've entered the voltage that should be produced by this voltage divider. The results are identical, which shows the actual circuit behaves the same as its Thevenin equivalent.