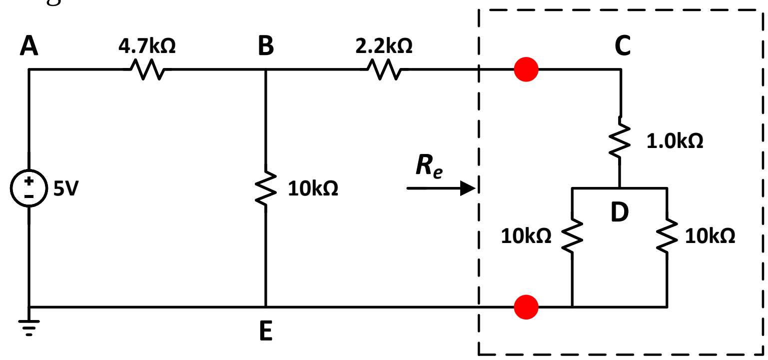
KNOWLEDGE INTEGRATION #1

PART I – BACKGROUND INFO

For this KI, we have decided to focus on a simple circuit from ECE202 Lab#3. Circuit with nominal values of resistors is given in the figure below.



KNOWLEDGE INTEGRATION #1 (KI_ 1) PREP

To prep data for KI #1, each ECE202 Lab team has filled-in the provided excel spreadsheet and emailed it to their TA.

During lab session, each team has picked ten 10-kΩ resistors and measured their values using a Hand-Held Digital Multi Meter (HH DMM) and using an HP Impedance Analyzer in C105 lab. Each team has recorded the following:

1. Ten measurements from HH DMM
2. Ten measurements from HP Impedance Analyzer

In the following step, teams have setup the circuit for measuring V_{Th} and R_{Th} four times, using different 10 kΩ resistor, and measured V_{Th} and R_{Th}. The following data that will be used in this KI was recorded:

3. Four measurement results for V_{Th}
4. Four measurement results for R_{Th}

As the final step, the TAs had taped one resistor on the whiteboard in C105 lab. We labeled this resistor as R_{202}. Each student measured the value of this resistor using HH DMM and an HP Impedance Analyzer and entered the measured values in the table. Measured data has been recorded in two additional columns:

5. Measured value of R_{202} using HH DMM

6. Measured value of R_{202} using HP Impedance Analyzer

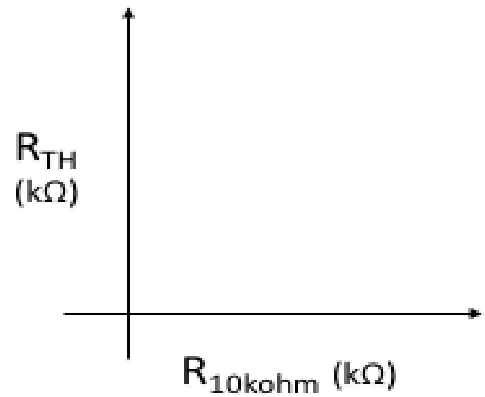
The purpose of (1) and (2) will be to analyze values of resistors, given manufacturing precision.
The purpose of (3) and (4) will be to analyze how actual values of circuit variables differ from the nominal (ideal / designed) values.
The purpose of (5) and (6) is to analyze whether there is experimental error involved, given that different people had measured the same resistor, using different HH DMM and the same HP Impedance Analyzer.

Lastly, one half of the students have worked with 1% precision resistors and the other half of the students have worked with 5% precision resistors.
The R_{202} resistor had 1% precision, and was the same resistor for everyone.

Your TAs have combined measurement results of all students and organized them in an Excel spreadsheet

PART II – CIRCUITS REVIEW, SIMULATIONS, AND FLUCTUATIONS (YOUR ASSIGNMENT)

1. Calculate Thevenin Voltage V_{Th} and Thevenin resistance R_{Th} for the given circuit, to the left of the two red dots.
2. Write a MATLAB script to read the values in the xlsx spreadsheet (you should use the MATLAB function xlsread) and compute the maximum and minimum values of all measured 10 kΩ resistors.
   Note: for a one-dimensional array A, you can get rid of all NaNs by using the MATLAB command `A(isnan(A))=[];`
3. Divide this segment [Rmin, Rmax] into 200 values and write MATLAB script that computes and plots R_{Th} as a function of the value of 10 kΩ resistor. Make sure to label your axes. You should have 201 values in your plot. What values of 10 kΩ resistor in this range result in min and max value of R_{Th}?
   Note: To answer this question, assume that the 10 kΩ resistor is the only one that changes value and keep the rest of the resistors at their nominal values.



4. Create a triple-nested loop in MATLAB that will vary each of the three resistors in the range +/-1% and compute every possible combination of the resistors. From these data, find the worst-case scenario (specifically, which resistance values yield the min and max values of R_{Th} and which set of resistor values produces the R_{Th} furthest away from the nominal value). Perform this check for 100 values of each resistor (Each loop will execute 100 times). This will result in 100^3 sets of resistors that should be evaluated.

5. Research and find on the internet the precision of the used HH DMM (Grey: HP E2373A, Flat: Mastech MS8216 DMM and Green: Mastech 8217) and HP Impedance Analyzer (HP 4192A), when measuring resistances and voltages.
6. Write a MATLAB script to extract the mean and standard deviation from each column in the xlsxs spreadsheet.
7. Plot six histograms of the measured resistor values (different histograms for 1%, 5%, HP, DMM, and 202).
8. Draw conclusions about different factors that contribute to fluctuations in the measured resistor values. Estimate to the best of your ability the standard deviations in the resistance of the 1% and the 5% resistors. Estimate the mean value of these resistances.
9. The manufacturer "guarantees" that the resistors will be within the given accuracy (1% or 5% in these cases). How many σ's are these reported accuracies?
10. Elaborate on why people are needed to perform data analysis instead of simply cranking the experimental data into a machine.