NAME ______________________________

EET 1150 Lab 11
Thévenin's Theorem

OBJECTIVES:

- To measure the Thévenin voltage and Thévenin resistance of a circuit.
- To find out whether Thévenin's theorem lets us correctly predict currents and voltages.

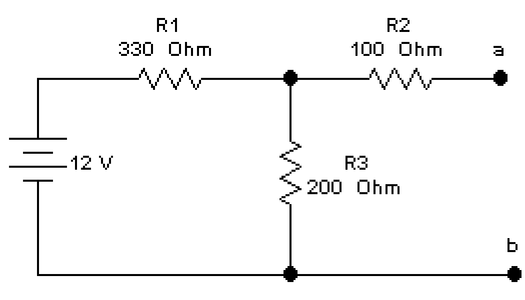
PROCEDURE:

1. Select the resistors shown in Table A. Measure and record their actual resistances. **Throughout this lab, round all values to three significant digits.**

TABLE A: **Resistor Values**

Resistor I.D.	Nominal Value	Actual Value
R_1	330 Ω	
R_2	100 Ω	
R_3	200 Ω	
R_4	470 Ω	
R_5	620 Ω	
R_6	560 Ω	

2. **Do not make any measurements until you read step 3 below.** Consider Circuit 1, shown in the schematic diagram. Notice that this circuit has two open terminals, labeled *a* and *b*. Use the procedure you learned in class to calculate the Thévenin voltage, E_{TH}, and the Thévenin resistance, R_{TH}, of this circuit. Record these values in the "Calculated Values" column of Table B. **Do not make any measurements until you read the next step.**



Circuit 1

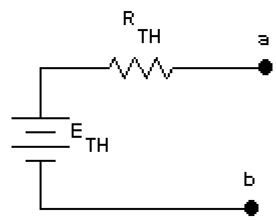
TABLE B: Thévenin Equivalent of Circuit 1

Quantity	Calculated Value	Measured Value	DMM Range Used	% Error
E_{TH}				
R_{TH}				

3. Now build Circuit 1 on the breadboard. To measure E_{TH}, simply measure the voltage between points *a* and *b*, with the red meter lead at point *a*. To measure R_{TH}, **first turn off**

and disconnect the power supply, and then replace it in the circuit with a short (in other words, with a wire). Then measure and record the resistance between points *a* and *b*. Record your measured values of E_{TH} and R_{TH} in Table B. Your measured values should be close to your calculation. Compute and record percentage errors.

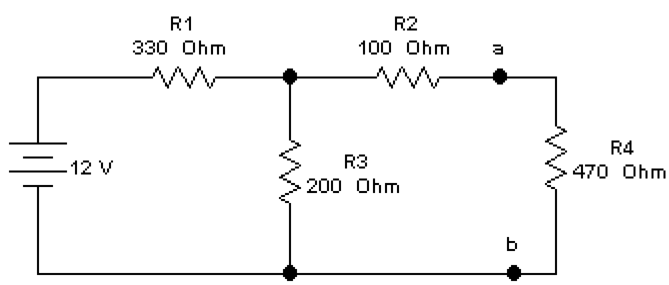
4. Here's what we've done so far in this lab: we've seen how to directly measure a circuit's Thévenin voltage, E_{TH}, and its Thévenin resistance, R_{TH}. Next, we want to verify that Thévenin's theorem is correct. This theorem says that our original Circuit 1 is equivalent to the simplified circuit shown below as Circuit 2.



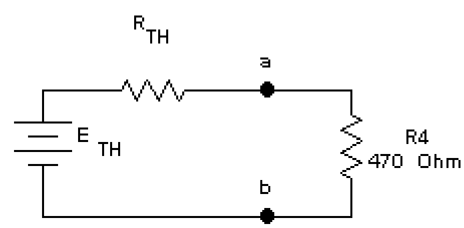
Circuit 2: Thevenin equivalent circuit of Circuit 1

What does it mean to say that the original circuit and this simplified circuit are equivalent? **It means that if we connect any additional components to Circuit 1, and connect the same additional components to Circuit 2, the resulting voltages and currents in those added components will be exactly the same in the two circuits. In other words, the added components will have no way of "knowing" whether they are connected to the original Circuit 1 or to the simpler Circuit 2.** If you think about this a bit and really understand it, you'll see that it's quite surprising and interesting.

5. For instance, suppose we just connect a single resistor to points *a* and *b* in the two circuits. By connecting a 470 Ω resistor across points *a* and *b* in Circuit 1, we'll end up with Circuit 3, shown on the left below. And by connecting the same 470 Ω resistor across points *a* and *b* in Circuit 2, we'll end up with Circuit 4, shown on the right below. Then, according to Thévenin's theorem, the resulting current and voltage for the 470 Ω resistor will have the same values in Circuit 4 that they have in Circuit 3.



Circuit 3



Circuit 4

6. Before building these circuits, let's see whether we would calculate the same values for V_4 and I_4 in the two circuits. Using your knowledge of series-parallel circuits, calculate values for V_4 and I_4 in Circuit 3. Record your calculations in Table C. Then, using the values that you measured above for E_{TH} and R_{TH}, calculate values for V_4 and I_4 in Circuit 4. Record these

calculations in Table D. Your calculated values for the two circuits should be very close to each other.

TABLE C: $\boldsymbol{V_4}$ and $\boldsymbol{I_4}$ in Circuit 3

Quantity	Calculated Value in Circuit 3	Measured Value in Circuit 3	DMM Range Used	% Error
V_4				
I_4				

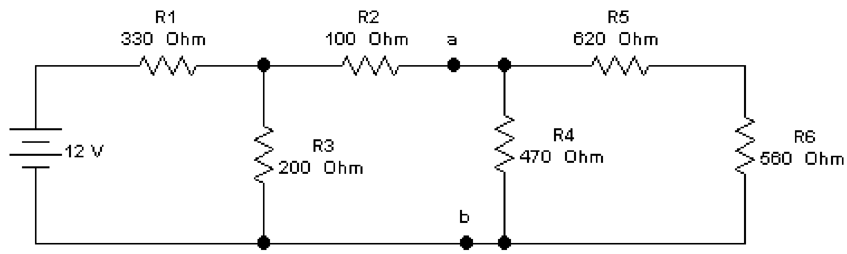
TABLE D: $\boldsymbol{V_4}$ and $\boldsymbol{I_4}$ in Circuit 4

Quantity	Calculated Value in Circuit 4	Measured Value in Circuit 4	DMM Range Used	% Error
V_4				
I_4				

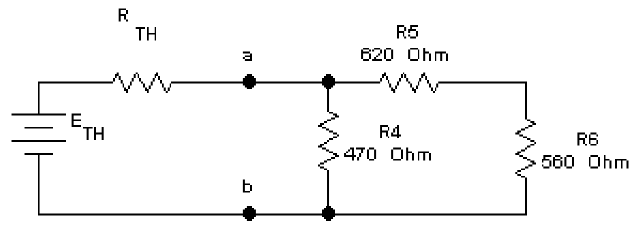
7. Now build Circuit 3. Then measure V_4 and I_4, and record their values in Table C. Your measured values should be close to your calculations.

8. Building Circuit 4 will be a bit trickier. Why? Because you probably will not find a resistor in the cabinet whose resistance is equal to the value of R_{TH} that you need. So how can you build Circuit 4? By using a potentiometer that is carefully adjusted so that its resistance is equal to the desired value of R_{TH}. Locate a potentiometer whose total resistance is greater than the R_{TH} that you need. Then, while using a DMM to monitor the resistance between the middle terminal and one end terminal of the potentiometer, adjust the potentiometer until you get the desired resistance. Now you can build Circuit 4, using the potentiometer as your R_{TH}. After building Circuit 4, measure V_4 and I_4, and record their values in Table D. Once again, your measured values should be close to your calculations.

9. Next, let's look at a more complicated case. Instead of just adding a single resistor to Circuits 1 and 2, let's add a more complex arrangement of resistors. By adding three resistors to our original Circuit 1, we end up with Circuit 5, shown on the next page. And by adding the same three resistors to our simplified Circuit 2, we end up with Circuit 6, also shown on the next page. As you probably realize by now, Thévenin's theorem predicts that the resulting currents and voltages for these three resistors will have the same values in Circuit 6 that they have in Circuit 5.



Circuit 5



Circuit 6

10. Build Circuits 5 and 6, then measure the quantities listed in Table E. (Predict at least one of these values to check yourself.) **Don't take your circuits apart until I have checked one of your measurements.** Your measured values from the two circuits should be very close. In computing percentage errors, use the equation

$$\text{Percentage error} = \frac{|\text{Circuit 5 value} - \text{Circuit 6 value}|}{\text{Circuit 5 value}} \times 100$$

TABLE E: Comparing Circuits 5 and 6

Quantity	Measured Value in Circuit 5	Measured Value in Circuit 6	% Error
V_4			
I_4			
V_5			
I_5			
V_6			
I_6			

Before taking your circuits apart, call me over to check one of your measurements. ________________

TECHNICAL CONCLUSION: Re-read the objectives at the beginning of this lab. For each objective, briefly state what you've learned from the lab. Include some discussion of how far off (percentage errors) your measured values were from your predicted values.