Name: Cayce Beames
Date: September 30, 2019
Professor Steven Gillette

Abstract
In this lab, I used 4 resistors, a breadboard and a DC power supply to simulate workloads in three parallel different parallel circuits. Using Ohm's and Kirchhoff's laws, I calculated voltage, current, and resistance values as well as % error rates between calculated and measured within the circuits.

Because I missed this lab in-class, I substituted resources from my home lab including an 830 connection-point breadboard, a UNI-T UTP3315TFL-II regulated DC power supply and a UNI-T UT89XD digital multimeter.

Learning Objectives

- Build parallel circuits as per a schematic diagram
- Measure electrical values using a digital voltmeter
- Use Ohm's Law to validate field measurements
- Use Kirchhoff's Current Law to calculate total circuit current
- Use a data table and schematic diagrams to capture field measurements

Notes:
1. Take all voltage measurements relative to ground (unless otherwise stated)
2. Record relevant measurements and calculation results in data tables
3. **Record all expected resistor values on the circuit schematics**
4. Use all available precision in calculations, round off answers to 3 significant figures

Materials

Quantity	Description
1	DC Power Supply
1	Digital multimeter (DMM)
1	Breadboard
	Circuit 1, 2 & 3
1ea	R1 - 750Ω resistor, R2 - 1kΩ resistor, R3 – 2kΩ resistor, R4 – 2.7kΩ resistor.

Procedure – Parallel Circuits
Circuit 1
1. Selected resistors for circuit 1, 2 and 3 according to the materials chart above. ***Recorded*** the resistor values for each circuit on the schematic diagram.
2. Built Circuit 1 ***without the voltage source connected*** (i.e. left the circuit power supply leads disconnected)

3. **Total Resistance (expected) -** *Calculated and recorded R_{Texp}*, the total circuit resistance using expected resistor values and one of the R_{equiv} formulas.

	Expected Resistor Value (Ω)	Conductance (g)	Expected Equivalent Resistance (Ω)
R1	750.00E+00	1.33E-03	545.45E+00
R2	2.00E+03	500.00E-06	
V_{source}	10.00E+00		

4. **Total Resistance (measured) –** *Measured and recorded R_{Tmeas}* and compared the measured value to the expected value using the % Error formula.

Expected Equivalent Resistance (Ω)	Measured Equivalent Resistance	% Error
545.45E+00	542.0	-0.63%

5. Set the power supply to 10V ±0.2V. Recorded this value as V_{Source} to three significant figures.

6. **Circuit Currents (expected) *Calculated and recorded*** total circuit current (I_{Total}), branch 1 and 2 currents (I_{R1}, & I_{R2}) – using Ohm's Law, the supply voltage (V_S), and resistor expected values.

	Expected Current (Amp)
I_{R1}	13.33E-03
I_{R2}	5.00E-03
I_T	18.33E-03

7. Used Kirchhoff's Current Law to show that total circuit current equals the sum of the branch currents. $I_{R1} + I_{R2} = I_{Total}$

$$I_T = 13.33mA + 5mA$$
$$= \boxed{18.33mA}$$

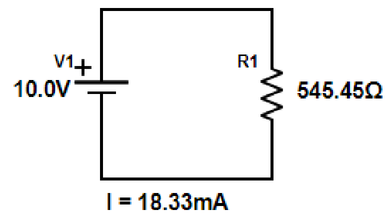
8. **Circuit Currents (measured) *Measured and recorded*** total circuit current (I_{Total}), branch 1 and 2 currents (I_{R1}, & I_{R2}).

Measured Current (Amp)
13.51E-03
4.86E-03
18.37E-03

9. ***Compared expected and measured*** circuit currents using the percent error formula.

	Expected Current (Amp)	Measured Current (Amp)	% Error
I_{R1}	13.33E-03	13.51E-03	1.32%
I_{R2}	5.00E-03	4.86E-03	-2.80%
I_T	18.33E-03	18.37E-03	0.20%

10. Drew a circuit reduction diagram showing total equivalent resistance and total circuit current.



Circuit 2

11. **Built circuit 2.**
12. **Calculated and recorded expected total resistance.**

	Expected Resistor Value (Ω)	Conductance (g)	Expected Equivalent Resistance (Ω)
R1	750.00E+00	1.33E-03	352.94E+00
R2	2.00E+03	500.00E-06	
R3	1.00E+03	1.00E-03	
V_{source}	10.00E+00		

13. **Measured and recorded total resistance.**

Measured Equivalent Resistance
351.1

14. **Compared measured with expected.**

Expected Equivalent Resistance (Ω)	Measured Equivalent Resistance	% Error
352.94E+00	351.1	-0.52%

15. **Calculated and recorded expected total and branch currents.**

	Expected Current (Amp)
I_{R1}	13.33E-03
I_{R2}	5.00E-03
I_{R3}	10.00E-03
I_T	28.33E-03

16. **Measured and recorded total current.**

Measured Current (Amp)
28.35E-03

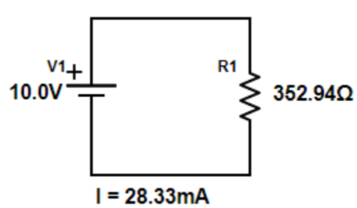
17. **Compared measured and expected total currents using the percent error formula.**

Expected Current (Amp)	Measured Current (Amp)	% Error
28.33E-03	28.35E-03	0.06%

18. **Used Kirchhoff's Current Law to prove that expected total current equals the sum of the expected branch currents.** $I_{R1} + I_{R2} + I_{R3} = I_{Total}$

$$I_T = 13.33\text{mA} + 5\text{mA} + 10\text{mA}$$
$$= \boxed{28.33\text{mA}}$$

19. **Drew a circuit reduction schematic for Circuit 2**



Circuit 3

20. **Built circuit 3.**
21. **Calculated and recorded expected total resistance.**

	Expected Resistor Value (Ω)	Conductance (g)	Expected Equivalent Resistance (Ω)
R1	750.00E+00	**1.33E-03**	**312.14E+00**
R2	2.00E+03	**500.00E-06**	
R3	1.00E+03	**1.00E-03**	
R4	2.70E+03	**370.37E-06**	
V_{source}	10.00E+00		

22. **Measured and recorded total resistance.**

Measured Equivalent Resistance
310.4

23. **Compared measured with expected.**

Expected Equivalent Resistance (Ω)	Measured Equivalent Resistance	% Error
312.14E+00	310.4	**-0.56%**

24. **Calculated and recorded expected total and branch currents.**

	Expected Current (Amp)
I_{R1}	**13.33E-03**
I_{R2}	**5.00E-03**
I_{R3}	**10.00E-03**
I_{R4}	**3.70E-03**
I_T	**32.03E-03**

25. **Measured and recorded total current.**

Measured Current (Amp)
32.02E-03

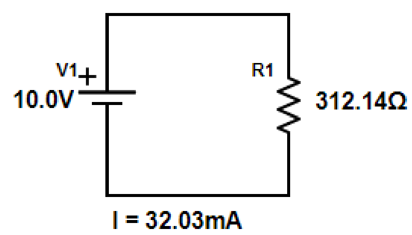
26. **Compared measured and expected total currents using the percent error formula.**

Expected Current (Amp)	Measured Current (Amp)	% Error
32.04E-03	32.02E-03	-0.05%

27. **Used Kirchhoff's Current Law to prove that expected total current equals the sum of the expected branch currents.** $I_{R1} + I_{R2} + I_{R3} + I_{R4} = I_{Total}$

$$I_T = 13.33mA + 5mA + 10mA + 3.7mA$$
$$= \boxed{32.03mA}$$

28. **Drew a circuit reduction schematic for Circuit 3.**



Formulas

$$E = IR, I = \frac{E}{R}, R = \frac{E}{I}$$

Where;
E = voltage (Volts)
I = current (Amperes)
R = circuit resistance (Ohms)

$$\%Error = \frac{measured - \exp ected}{\exp ected} x100\%$$

Where;
%Error = % change between measured and expected values
measured = a value taken from direct measurement
expected = a value taken from component or process specifications

Parallel Resistance – Conductance Method

$$R_{equiv} = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R_n}}$$

Where;
R_{equiv} = circuit total resistance
R = resistance
1/R = conductance in mho's

Parallel Resistance – Product over Sum Method

$$R_{equiv} = \frac{R1 \times R2}{R1 + R2}$$

Note; Product Over Sum may only be used when there are only 2 parallel loads.

Parallel Resistance – Equal Value Resistance

$$R_{equiv} = \frac{R_{all}}{n}$$

Note; Equal Value Resistance may only be used when there are identical resistance paths through *n* parallel loads.

Critical Thinking

1. What are the primary characteristics of a parallel circuit?

A parallel circuit includes components connected between the same set of common connectivity points. In this case, the applied voltage will be equal across all parallel components. Additionally, there is more than one continuous path for current to flow where the current in these paths are inversely proportional to the resistance of the path.

2. Describe two ways to find the total circuit current for a parallel circuit?

Kirchhoff's Current Law states that the total circuit current is equal to the sum of the currents in the branches. According to Ohm's Law, the total current is directly proportional to the source voltage and inversely proportional to the total equivalent resistance.

3. Calculate the Circuit 3 total circuit resistance if all the resistors were changed to 10K Ω? Show your work.

$$R_T = \frac{R_{all}}{N}$$

$$R_T = \frac{10K\Omega}{4}$$

$$\boxed{R_T = 2.5K\Omega}$$

4. Calculate the Circuit 3 total circuit resistance if two resistors are 10KΩ and two resistors are 5KΩ ? Show your work.

$$R_T = \frac{1}{\frac{1}{10K\Omega} + \frac{1}{10K\Omega} + \frac{1}{5K\Omega} + \frac{1}{5K\Omega}}$$

$$R_T = \frac{1}{\frac{1}{10K\Omega} + \frac{1}{10K\Omega} + \frac{2}{10K\Omega} + \frac{2}{10K\Omega}}$$

$$R_T = \frac{1}{\frac{6}{10K\Omega}}$$

$$R_T = \frac{1}{1} \bullet \frac{10K\Omega}{6}$$

$$R_T = \frac{10K\Omega}{6}$$

$$\boxed{R_T = 1.667K\Omega}$$

Appendix A –Lab Notes

SIERRA COLLEGE	MECH 10 - Lab 07 Parallel Circuits	Mechatronics Real Skills Real Jobs
Name Cayce Brames		9/29/19

Learning Objectives

- Build parallel circuits as per a schematic diagram
- Measure electrical values using a digital voltmeter
- Use Ohm's Law to validate field measurements
- Use Kirchhoff's Current Law to calculate total circuit current
- Use a data table and schematic diagrams to capture field measurements

Notes:

1. Take all voltage measurements relative to ground (unless otherwise stated)
2. Record relevant measurements and calculation results in data tables
3. **Record all expected resistor values on the circuit schematics**
4. Use all available precision in calculations, round off answers to 3 significant figures

Materials

Quantity	Description
1	Global Specialties Circuit Trainer
1	Digital multimeter (DMM)
	Circuit 1, 2 & 3
1	R1, R2, R3, R4 – choose any four resistors between 750 and 4.7K Ω, each of different value

Procedure – Parallel Circuits

Circuit 1

1. Select resistors for circuit 1, 2 and 3 according to the materials chart above. ***Record*** the resistor values for each circuit on the schematic diagram.
2. Build Circuit 1 ***without the voltage source connected*** (i.e. leave the circuit power supply leads disconnected)
3. **Total Resistance (expected) -** *Calculate and record* R_{Texp}, the total circuit resistance using expected resistor values and one of the R_{equiv} formulas.
4. **Total Resistance (measured) –** *Measure and record* R_{Tmeas} and compare the measured value to the expected value using the % Error formula.
5. Set the trainer power supply to 10V ±0.2V. Record this value as V_{Source} to three significant figures.
6. **Circuit Currents (expected)** ***Calculate and record*** total circuit current (I_{Total}), branch 1 and 2 currents (I_{R1}, & I_{R2}) – using Ohm's Law, the supply voltage (V_S), and resistor expected values.
7. Use Kirchhoff's Current Law to show that total circuit current equals the sum of the branch currents. $I_{R1} + I_{R2} = I_{Total}$

I_T = 13.33mA + 5 mA
= $\boxed{18.33mA}$

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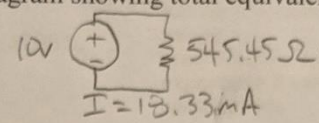
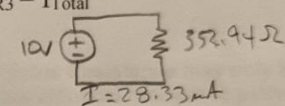
8. **Circuit Currents (measured)** ***Measure and record*** total circuit current (I_{Total}), branch 1 and 2 currents (I_{R1}, & I_{R2}).
9. ***Compare expected and measured*** circuit currents using the percent error formula.
10. Draw a circuit reduction diagram showing total equivalent resistance and total circuit current.



Circuit 2

11. **Build circuit 2.**
12. **Calculate and record expected total resistance.**
13. **Measure and record total resistance.**
14. **Compare measured with expected.**

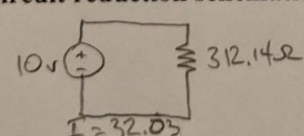
15. **Calculate and record expected total and branch currents.**
16. **Measure and record total current.**
17. **Compare measured and expected total currents using the percent error formula.**
18. **Use Kirchhoff's Current Law to prove that expected total current equals the sum of the expected branch currents.** $I_{R1} + I_{R2} + I_{R3} = I_{Total}$
    13.33mA + 5mA + 10mA = 28.33mA
19. **Draw a circuit reduction schematic for Circuit 2**



Circuit 3

20. **Build circuit 3.**
21. **Calculate and record expected total resistance.**
22. **Measure and record total resistance.**
23. **Compare measured with expected.**

24. **Calculate and record expected total and branch currents.**
25. **Measure and record total current.**
26. **Compare measured and expected total currents using the percent error formula.**
27. **Use Kirchhoff's Current Law to prove that expected total current equals the sum of the expected branch currents.** $I_{R1} + I_{R2} + I_{R3} + I_{R4} = I_{Total}$
    13.33mA + 5mA + 10mA + 3.7mA = 32.03mA
28. **Draw a circuit reduction schematic for Circuit 3.**



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Parallel Circuits

A parallel circuit has two or more current paths with equal voltage distribution across all parallel connected loads. The current that travels down each path is controlled by the branch resistance with the total current flow equal to the sum of the branches. Total circuit current is found by adding individual branch currents (see Circuit 2), or by calculating equivalent circuit resistance for the parallel combination of loads.

$I_T = V_S / R_{equiv} = I_{B1} + I_{B2} + I_{bn+1}$

Where;

I_T	= total circuit current
V_S	= source voltage
R_{equiv}	= circuit equivalent resistance
I_{B1}	= branch 1 current
I_{B2}	= branch 2 current
I_{Bn+1}	= branch n current

Kirchoff's Current Law

The amount of current entering a circuit node must be equal to current leaving that circuit node.

In a parallel circuit, Kirchoff's Law dictates that the total circuit current must be equal to the sum of the branch currents. A simple Ohm's Law analysis of a parallel circuit provides insight into parallel resistance.

Branch Currents

Using Circuit 1 as a reference, assume that R1 is a 100 Ohm resistor, and R2 is a 500 Ohm resistor. The branch currents are;

$I_{B1} = 10V / 100\ \Omega = 100mA$
$I_{B2} = 10V / 500\ \Omega = 20mA$
$I_T = I_1 + I_2 = 120mA$

The branch current is inversely proportional resistance. In other words, branch current is voltage divided by branch resistance. Having resistance in the denominator of the fraction makes it "inversely proportional."

Equivalent Resistance

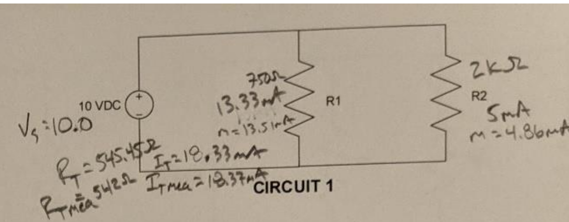
From the previous example, total circuit equivalent resistance must equal;

$R_T = V_S / I_T = 10.0V / 120mA = 83.3\ \Omega$

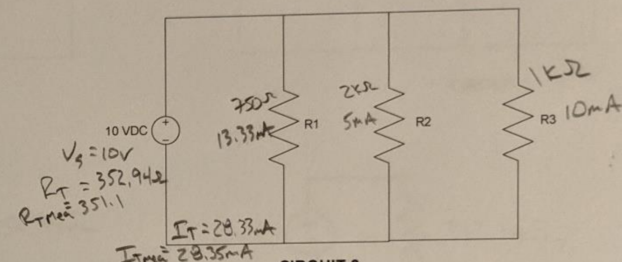
Note that this circuit equivalent resistance is less than the lowest value resistor in the parallel circuit. This behavior is not like series resistance where resistance values simply add. The inverse relationship resistance plays in branch currents requires special treatment when calculating total circuit resistance.

One way of looking at the equivalent resistance formula is that equivalent resistance equals the inverse of the sum of the conductance (or 1 divided by the sum of the conductance). Resistance and conductance are inverse of each other. The sum of circuit load conductance is shown in the denominator of the R_{equiv} equation as inverted resistance.

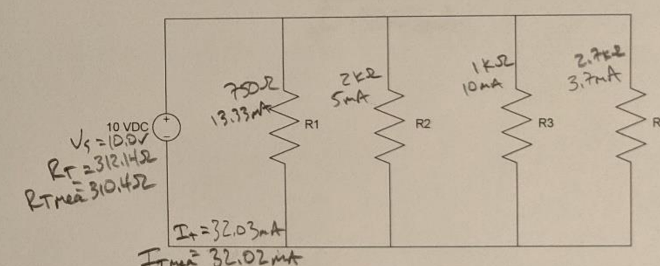
$$R_{equiv} = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R_n}}$$



CIRCUIT 1



CIRCUIT 2



CIRCUIT 3

SIERRA COLLEGE Mechatronics Real Skills Real Jobs	MECH 10 – FUNDAMENTALS OF ELECTRONICS				
	LAB 07 – PARALLEL CIRCUITS				
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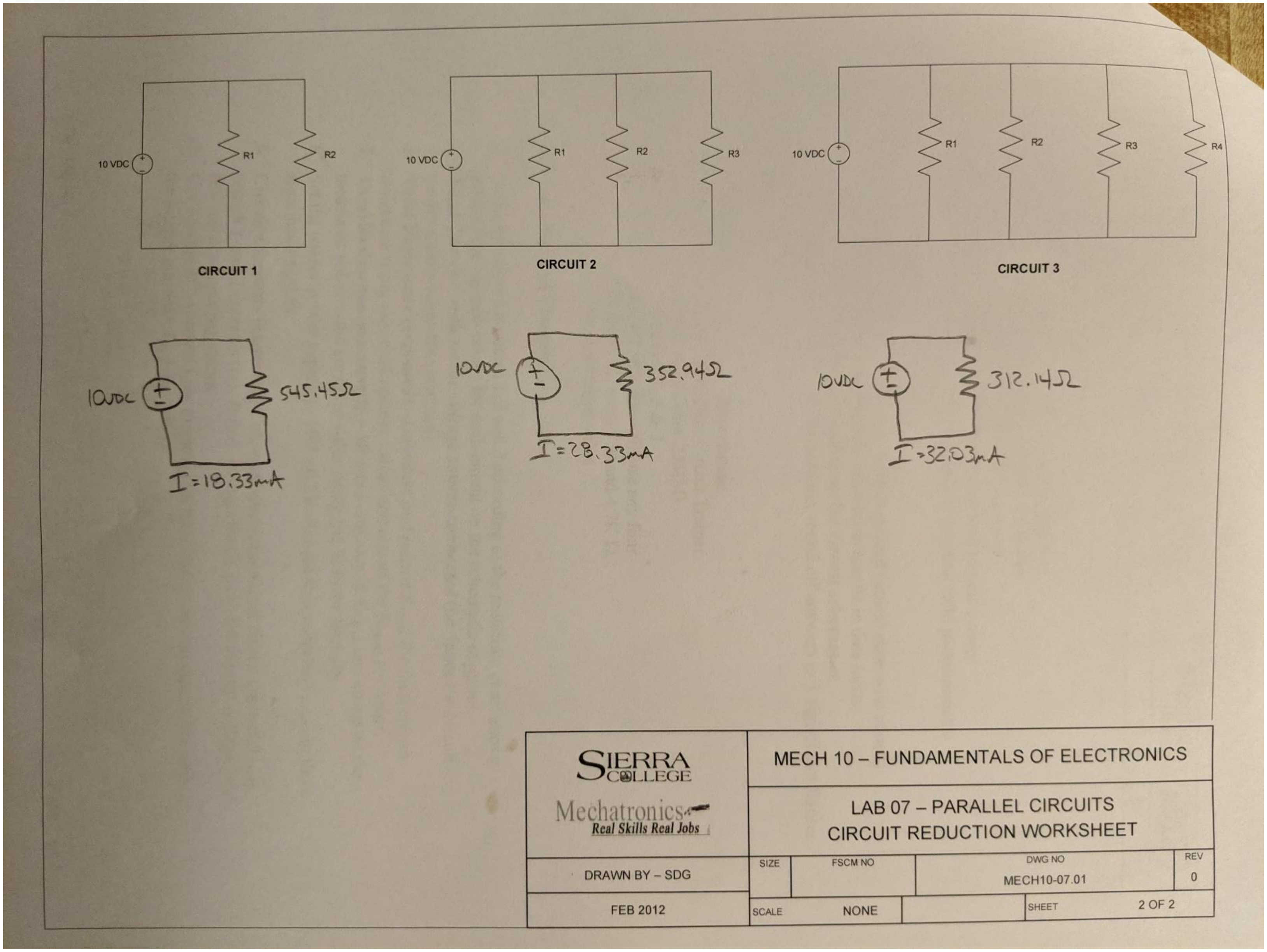
10 VDC
R1
R2
CIRCUIT 1
10 VDC
R1
R2
R3
CIRCUIT 2
10 VDC
R1
R2
R3
R4
CIRCUIT 3
10VDC
545.45Ω
I=18.33mA
10VDC
352.94Ω
I=28.33mA
10VDC
312.14Ω
I=32.03mA
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CIRCUIT REDUCTION WORKSHEET
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2 OF 2

Grading Criteria

		Points Possible	Points Earned
Documentation	Abstract, introduction, experiment, data results, conclusions, attachments, clarity, spelling, grammar	**10**	
Circuit 1	Measured and expected total resistance values recorded and compared	**5**	
	Expected and measured branch and total currents recorded in data table with percent error; circuit reduction diagram complete & accurate	**5**	
Circuit 2	Measured and expected total resistance values recorded and compared;	**5**	
	Expected and measured total current compared; expected branch currents recorded in data table; circuit reduction diagram complete & accurate	**5**	
Circuit 3	Measured and expected total resistance values recorded and compared;	**5**	
	Expected and measured total current compared; expected branch currents recorded in data table; circuit reduction diagram complete & accurate	**5**	
Conclusions	Questions answered completely & accurately. State conclusions drawn and lessons learned from the lab	**10**	
On-time submittal	Lab report is submitted in accordance with the assignment due date as posted on Canvas	**5**	
	Total	**55**	

Lab Report Format

Abstract - a summary and high-level overview of the lab and its results
Introduction - State the objectives of the laboratory and list the equipment required
Experiment - Describe the procedure used to carry out the lab
Data Results - list data taken in table or graphical format where appropriate
Conclusion - State the conclusions drawn and lessons learned from the laboratory activities. Answer any questions found within the lab procedure.
Attachments – grading criteria, verification signatures, circuit diagrams, lab procedures & notes