MARINE INSTITUTE

Electrotechnology 1100

Experiment 3
Series Circuits - Kirchhoff's Voltage Law

SAMPLE CALCULATIONS:

Using your own data, provide one worked sample of each formula used in this Lab.

$R_T = R_1 + R_2 + R_3 + ...$ Table 3-2, Step A2

$R_T = \frac{V_T}{I}$ Table 3-2, Step A8

$V_T = V_1 + V_2 + V_3 + V_4$ Table 3-3, Step B10

BASIC INFORMATION

A series circuit is a circuit where components are connected so that there is only one path for current to flow. Since there is only one path, current is the same through each component. As resistors are connected in series, the resistance increases, which means the current decreases.

The rules for series circuits gives the formula for total resistance in a series circuit as:

$$R_T = R_1 + R_2 + R_3 + ...$$

Kirchhoff's Voltage Law (KVL) states the algebraic sum of the applied voltage and voltage drops around any closed loop is zero. For a series circuit, this means:

$$V_T = V_1 + V_2 + V_3 + ...$$

This Experiment will attempt to prove these relationships.

OBJECTIVES:

When you have completed this experiment, you should be able to:

- Measure the total resistance of a series circuit.
- Measure the total voltage of a series circuit.
- Measure the total current of a series circuit.
- Verify the total resistance of a series circuit by Ohm's law.
- Measure the voltage drops of a series circuit.
- Verify Kirchhoff's Voltage Law.

EQUIPMENT & MATERIALS REQUIRED:

Power Supply:	0-60/70V dc.
Instruments:	Analog Ohmmeter.
	Analog Voltmeter.
	Analog Milliammeter.
Resistors:	330Ω.
	470Ω.
	1000Ω.
	1200Ω.
Miscellaneous:	Orange board.
	3 Black Alligator Clip to Banana Plug test leads.
	3 Red Alligator Clip to Banana Plug test leads.
	Quick clips.

PROCEDURE:

PART A: Total Resistance of Series Resistors.

A1. Measure the actual resistance of your resistors with your analog ohmmeter and record the results in Table 3-1.

A2. Calculate the total resistance, using the **MEASURED** values of resistance from Table 3-1 and Formula 1, and enter the value in Table 3-2.

> TIP
> Remember to zero your ohmmeter if you change scales.

$$R_T = R_1 + R_2 + R_3 + ...$$ *Formula 1.*

> TIP
> If you have 800Ω (2000Ω, 3000Ω, etc.) for your calculated R_T, odds are that you did not follow Step A2.

A3. Connect R_1 and R_2 in series as shown in the Figure 3-1 below. Measure the total resistance of the series resistors and record in Table 3-2.

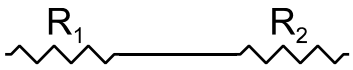

Figure 3-1

A4. Connect the circuit shown in Figures 3-2 and 3-3.

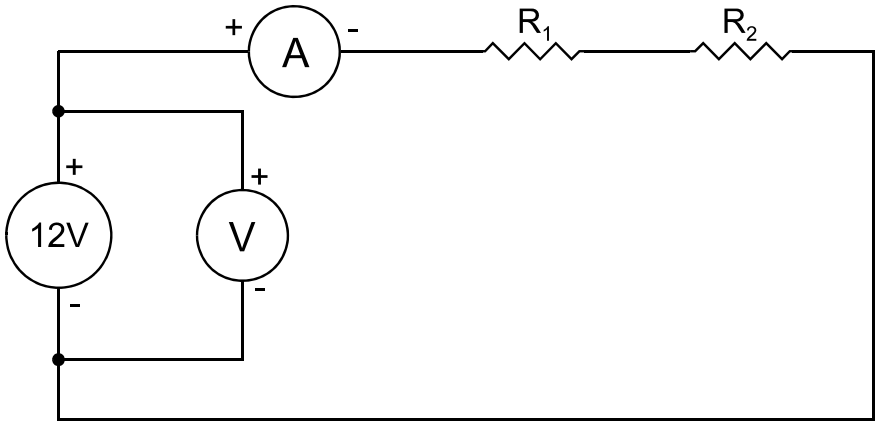

Figure 3-2

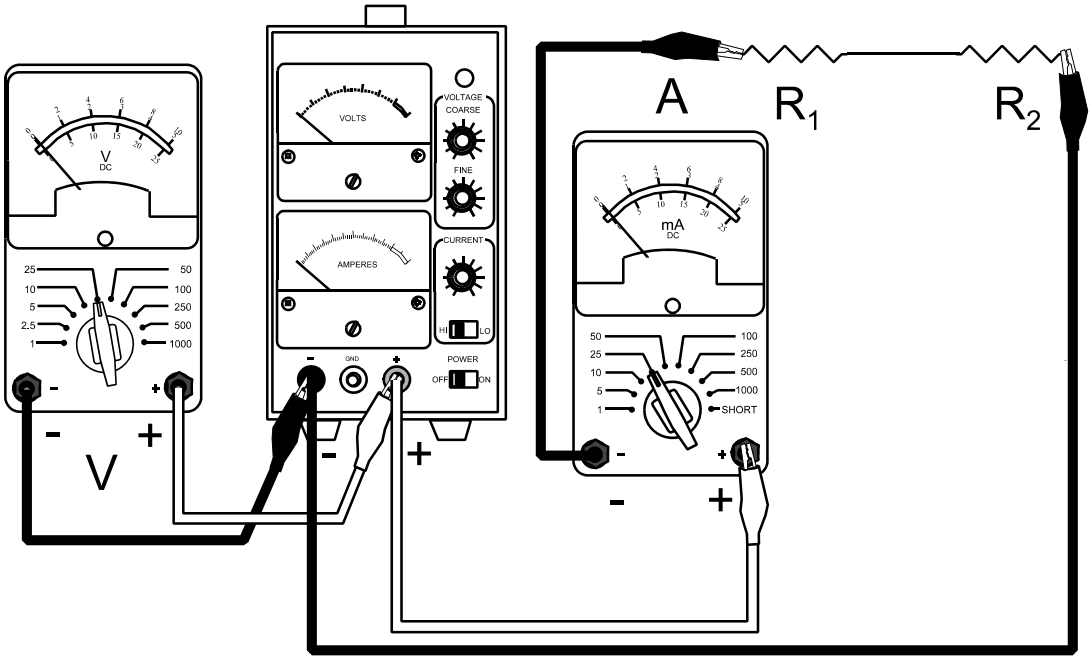

Figure 3-3

A5. Turn on the power supply.

A6. Adjust the voltage to 12V using the voltmeter. Record the value in Table 3-2.

A7. Measure the current using the ammeter. Record the value in Table 3-2.

> TIP
> Do not read voltage and current off of the power supply (≈20% error).
>
> Use Voltmeter and Ammeter.

A8. Use Ohm's Law (Formula 2) and calculate the total resistance of the series circuit from the measured values of voltage and current and record in Table 3-2.

$$R_T = \frac{V_T}{I}$$ *Formula 2.*

A9. Turn off the power supply.

A10. Repeat Steps A2-A9 for the other series combinations of Table 3-2.

A11. **Have a demonstrator check your results before disconnecting the circuit.**

PART B: Kirchhoff's Voltage Law.

B1. Connect the circuit shown in Figure 3-4.

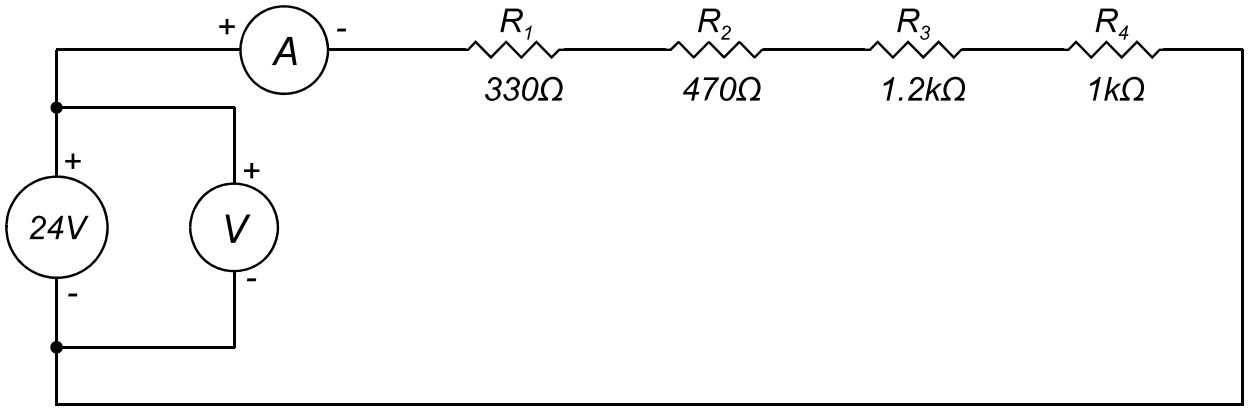

Figure 3-4

B2. Using the total resistance from Table 3-2 for Combination 3, calculate the current using Ohm's Law and record the value in Table 3-3.

B3. Calculate the voltage drop for each resistor using the **MEASURED** values from Table 3-1 and record the values in Table 3-3.

B4. Turn on the power supply.

B5. Adjust the voltage to 24V using the voltmeter. Record the value in Table 3-3.

B6. Measure the current using the ammeter. Record the value in Table 3-3.

B7. Turn off the power supply and move the voltmeter to measure the voltage drop of each of the resistors. Figures 3-5 and 3-6, show you how to connect the voltmeter to measure V_1.

B8. Turn on the power supply and measure the voltage drop of each of the resistors using the voltmeter. Record the values in Table 3-3.

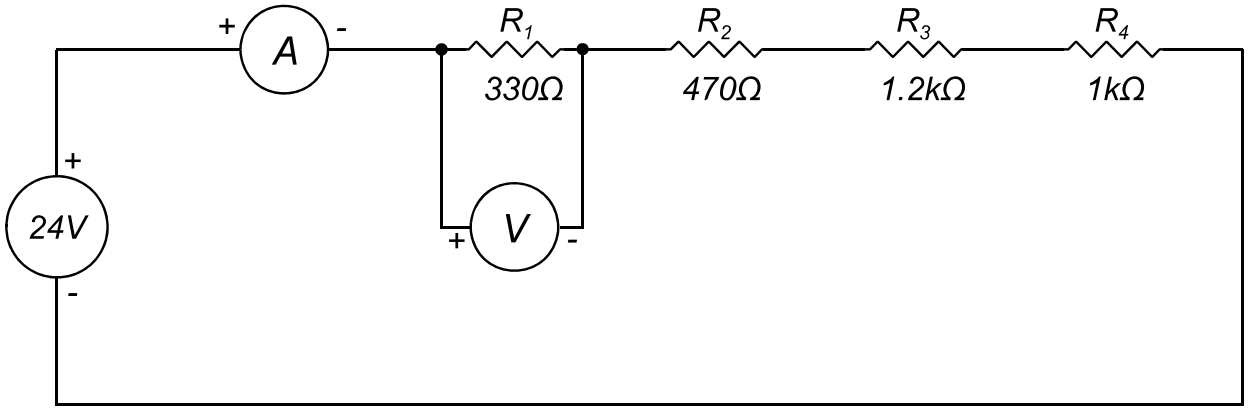

Figure 3-5

Use your calculations in Step B3 to select the appropriate range for the voltmeter. Between 5V-10V, use 10V scale. Between 2.5V-5V, use 5V scale. More deflection equals greater accuracy on an analog meter.

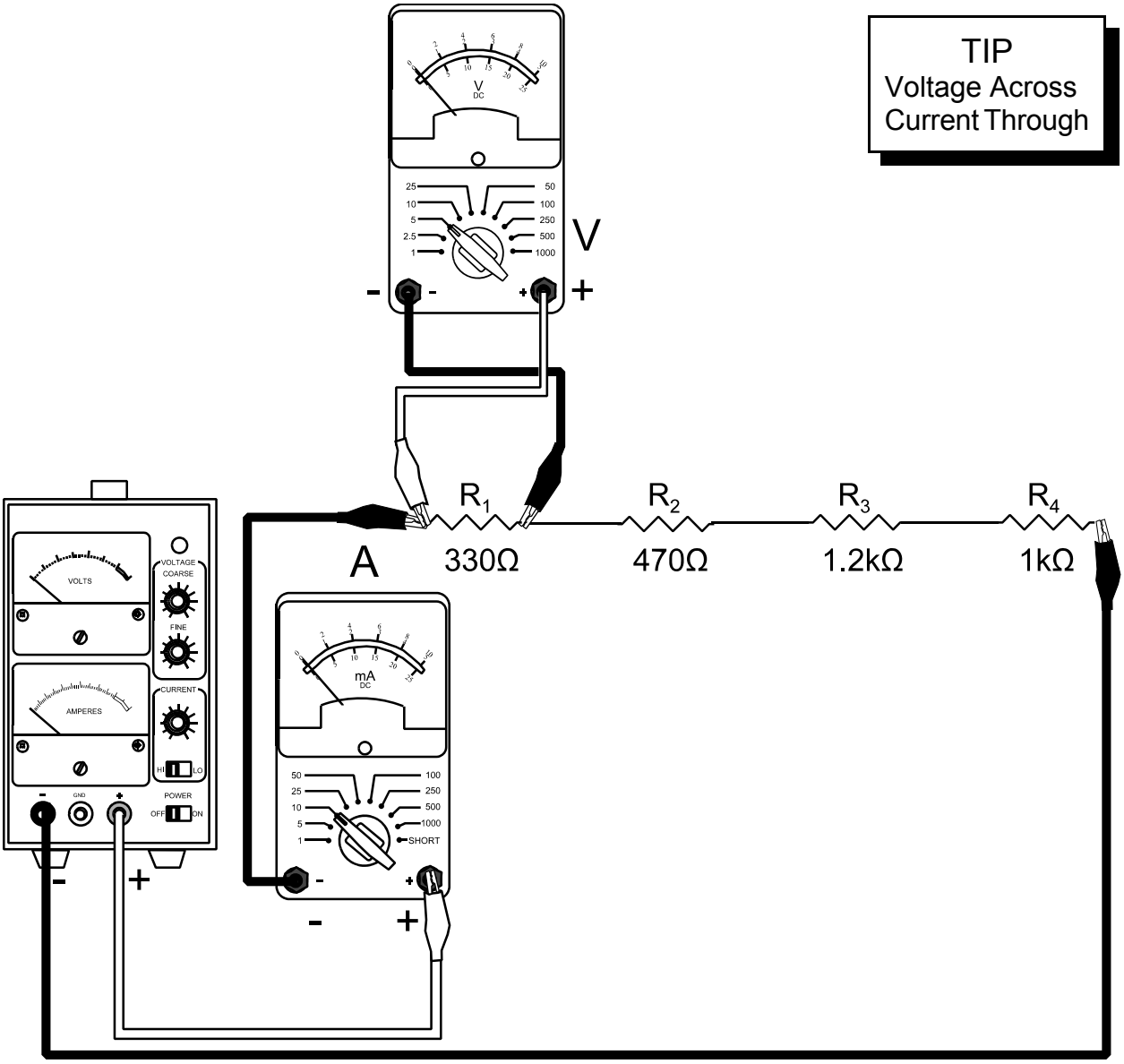

Figure 3-6

B9. Turn the power off.

B10. Calculate Kirchhoff's Voltage Law for the series circuit using Formula 3 and your measurements and record this data in Table 3-3.

$$V_T = V_1 + V_2 + V_3 + V_4$$ *Formula 3.*

B11. **Have a demonstrator check your results before disconnecting the circuit.**

B12. Disconnect your circuit and return all equipment to it's proper place.

RESULTS:

Table 3-1 Measured Resistances

Coded Value	330Ω	470Ω	1kΩ	1.2kΩ
Measured Value				

Table 3-2 Total Resistance of Series Circuits

	R_1	R_2	R_3	R_4	R_T (Ω) calc	R_T (Ω) meas	V_T (V) meas	I (mA) meas	R_T (Ω) calc
1	330Ω	470Ω							
2	330Ω	470Ω	1.2kΩ						
3	330Ω	470Ω	1.2kΩ	1kΩ					
4	470Ω	1.2kΩ	1kΩ						
5	1.2kΩ	1kΩ							
Step					A2	A3	A6	A7	A8

Table 3-3 Kirchhoff's Voltage Law

	V_T (V)	I (mA)	V_1 (V)	V_2 (V)	V_3 (V)	V_4 (V)	V_T (V)
calc	24						
Step		B2	B3				
meas							
Step	B5	B6	B8				B10

QUESTIONS:

1. Describe three methods used in this experiment to find the total resistance of series resistors.

2. Why was the **MEASURED** resistance of each resistor used in calculations?

Hint: The 4th band of the resistor color code represents tolerance, the worst case error for the resistor.

3. What effect does increasing the number of resistors in series have on the total resistance? Refer to your measurements to support your answer.

TIP

Be sure to quote your **ACTUAL** data in your answers.
Demonstrate you understand the learning objective!

4. What effect does increasing the number of resistors in series have on the total current? Refer to your measurements to support your answer.

5. What is the relationship between voltage drops in a closed circuit and the applied voltage? Express this relationship as a mathematical expression.

6. Does your results from Steps B6 and B10 confirm the relationship stated in Question 5? Explain any discrepancies.