

NAME _____

LAB PARTNERS _____

Station Number _____

Electric Circuits: Part II

Experiment 8

INTRODUCTION

In part I of your studies on electric circuits, you learned about conductors, insulators, and Ohm's law. In this part, you will continue the study of Ohm's law and learn how some complex arrangements of resistors may be reduced to simpler, equivalent forms.

THEORY

Recall that Ohm's law relates the potential difference V between the ends of a conductor to its resistance R and the current I in it; specifically, $V = IR$. The potential difference is sometimes called the voltage and the two terms are used interchangeably. Current is usually measured in amperes (A), resistance in ohms (Ω), and voltage in volts (V).

Whenever resistors (devices specifically designed to offer resistance to current) are connected as shown in Figure 8.1, they are said to be connected in series. In a series connection, each resistance carries the same current. The equivalent resistance R_s for n resistors connected in series is given by

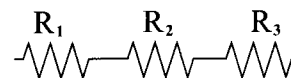


Figure 8.1

$$R_s = R_1 + R_2 + \dots + R_n. \quad (1)$$

Since the current in each resistor is the same, we may also write

$$I = I_1 = I_2 = \dots = I_n, \quad (2)$$

where I is the total current in that part of the circuit.

Resistors may also be connected in parallel as shown in Figure 8.2. For a parallel connection of resistors, the potential difference across each resistor is the same. The equivalent resistance R_p is given by

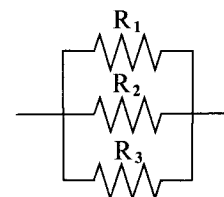
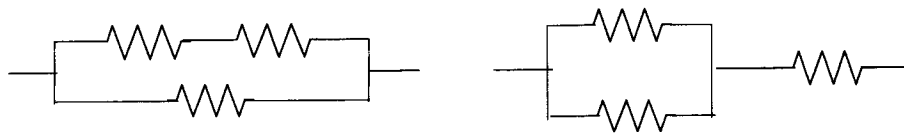
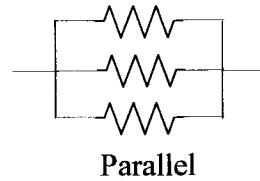
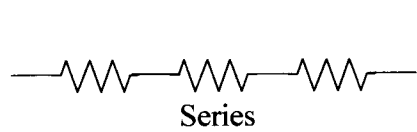


Figure 8.2

$$(1/R_p) = (1/R_1) + (1/R_2) + \dots (1/R_n) \quad (3)$$

EXPERIMENT NO. 8

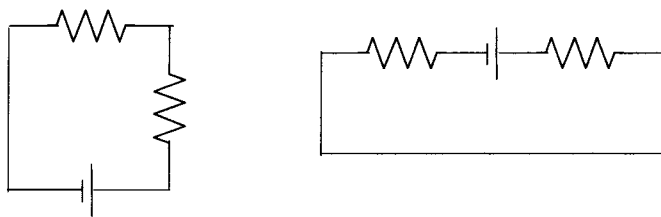
Before you begin to connect the circuits to do the experiment, let's get a better idea of some more complicated circuits. We'll show the 4 ways of connecting three resistors in series and parallel combinations.



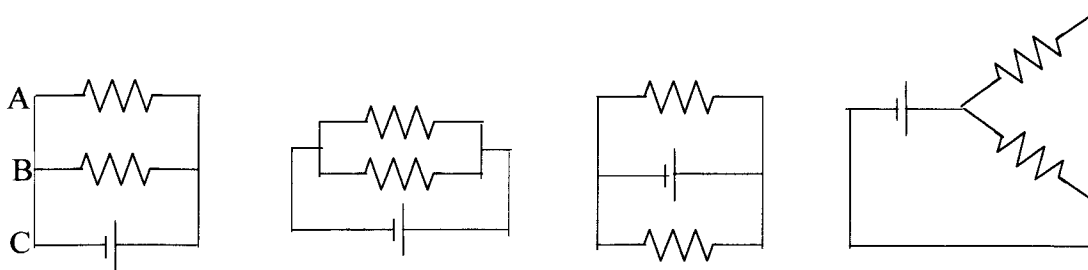
Parallel and series combinations

1. How many ways can you think of to connect four resistors using series and parallel combinations? Draw at least five of the connections.

2. The following two circuits are the same even though they have a different appearance. You may use the concept of common points discussed in the Introduction (p. x) to see that this is true.

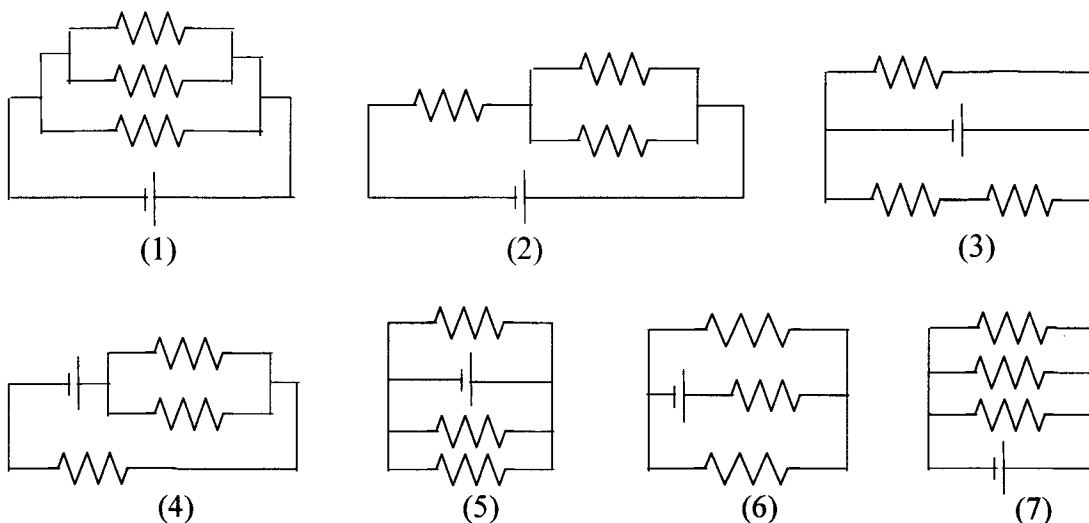


Likewise the four circuits below are the same.



To help compare circuits, consider the three points labeled A, B, and C in the leftmost circuit. If you trace the circuit between any two points and there is no other circuit element (resistor or battery) between the two points, then the two points are electrically equivalent. This means that points A, B, and C are electrically equivalent; they could all be connected directly together without changing the circuit. For practice, convince yourself that all of these four circuits are the same.

3. In the seven circuits shown below there are two sets of three identical circuits and one "oddball". Identify the "oddball" and state which of the remaining circuits are electrically equivalent to each other. Explain, using the concept of common points, why the circuits you identify are equivalent.



4. Set the power supply to 5 volts before making the following circuit. Connect the three resistors in series with the power supply as shown below. Connect the voltmeter in each of the positions indicated by the dashed lines meters. Dashed-line around meters mean that the meter is moved from connection to connection; not all connections are made at the same time. Record the potential differences on the diagram; record the resistances in the spaces indicated. Calculate the total potential difference V_T using the potential difference across each resistor. Find the percent difference between V_T and V_m , the reading on the meter connected directly across the power supply.

$R_1 =$ _____

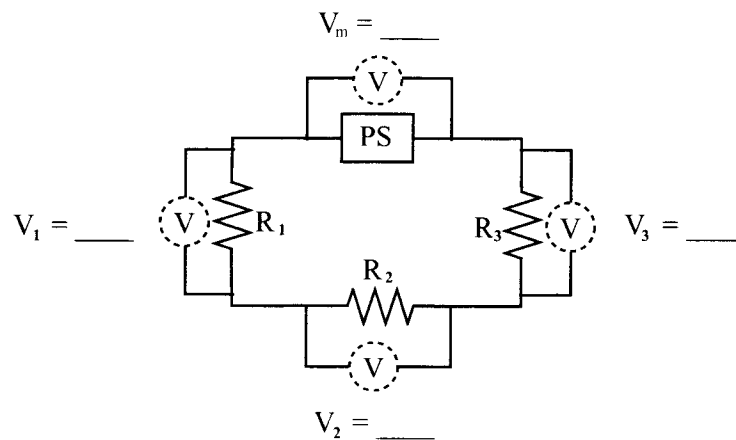
$R_2 =$ _____

$R_3 =$ _____

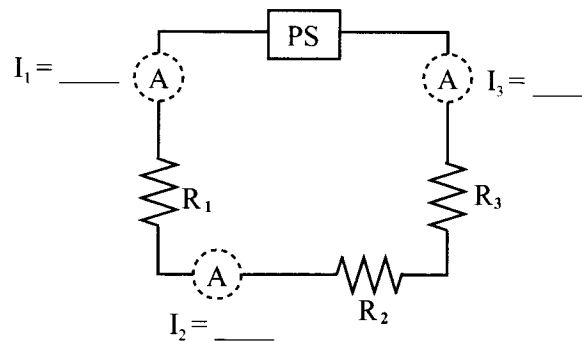
$V_T =$ _____

$V_m =$ _____

percent difference = _____



5. With the resistors still connected in series, connect the digital multimeter (in ammeter mode) in each of the positions shown below. Record the values of the current in the spaces on the diagram.



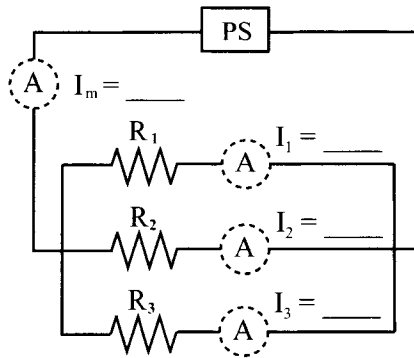
Using the values of V_1 , V_2 , and V_3 obtained in Part 4, calculate the current through each resistor.

$I_{1\text{calculated}} = \underline{\hspace{2cm}}$ $I_{2\text{calculated}} = \underline{\hspace{2cm}}$ $I_{3\text{calculated}} = \underline{\hspace{2cm}}$

Calculate the percent difference between the calculated and measured values in the current for I_1 , I_2 , and I_3 .

% difference $I_1 = \underline{\hspace{2cm}}$ % difference $I_2 = \underline{\hspace{2cm}}$ % difference $I_3 = \underline{\hspace{2cm}}$

6. Connect the three resistors in parallel and measure the current as indicated by the diagram.

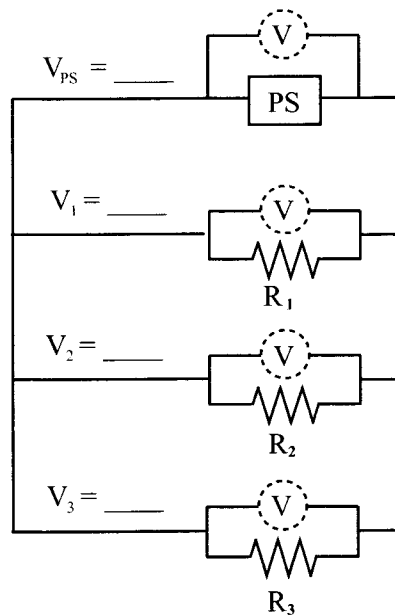


Calculate the total current I_T by adding I_1 , I_2 , and I_3 . Then compute the percent difference between I_T and I_m .

$I_T = \underline{\hspace{2cm}}$ percent difference = $\underline{\hspace{2cm}}$

7. With the resistors still connected in parallel as in Part 6, connect the voltmeter in the positions shown on the diagram. Record the values for the potential differences in the spaces on the drawing. Calculate the values for I_1 , I_2 , and I_3 using the corresponding values for the potential differences and resistances.

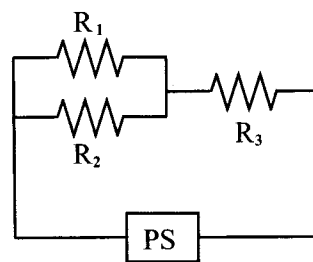
$I_1 =$ _____ $I_2 =$ _____ $I_3 =$ _____



Calculate the percent differences between these calculated values and those measured in Part 6.

% difference in $I_1 =$ _____ % difference in $I_2 =$ _____ % difference in $I_3 =$ _____

8. Connect the two resistors with the largest values in parallel. Then connect this parallel combination in series with the resistor having the smallest value. Be sure the power supply is still set to 5.0 volts. The circuit diagram is shown to the right. Measure and record the potential differences across R_1 , R_2 , and R_3 and label these as V_1 , V_2 , and V_3 , respectively. Remember that the voltmeter is connected in parallel with the element.



$V_1 =$ _____ $V_2 =$ _____ $V_3 =$ _____

Which of these should be equal, and which should sum to 5.0 volts? Explain.

Now measure and record the currents through R_1 , R_2 , and R_3 by using the multimeter as an ammeter. Label these currents as I_1 , I_2 , and I_3 , respectively. *BE SURE THAT THE AMMETER IS CONNECTED IN SERIES WITH THE ELEMENT, THAT THE "AMP" FUNCTION IS SELECTED, AND THAT YOU CONNECT ONE LEAD TO THE 10A INPUT AND THE OTHER TO THE COMMON INPUT.*

$$I_1 = \underline{\hspace{2cm}} \quad I_2 = \underline{\hspace{2cm}} \quad I_3 = \underline{\hspace{2cm}}$$

What relationship between I_1 , I_2 , and I_3 should you find? Explain.

Use values for I_1 , I_2 , I_3 , V_1 , V_2 , and V_3 to calculate values for R_1 , R_2 , and R_3 .

$$R_1 = \underline{\hspace{2cm}} \quad R_2 = \underline{\hspace{2cm}} \quad R_3 = \underline{\hspace{2cm}}$$

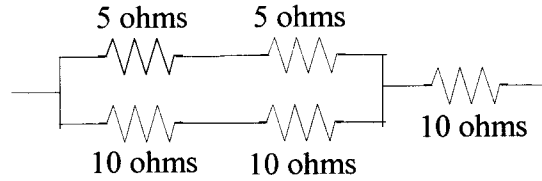
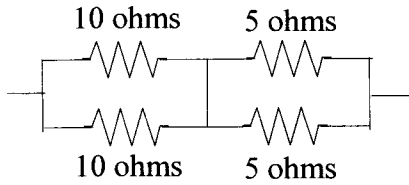
Calculate the percent error, using the value printed on the resistor as the standard value.

$$\% \text{ error for } R_1 = \underline{\hspace{2cm}} \quad \% \text{ error for } R_2 = \underline{\hspace{2cm}}$$

$$\% \text{ error for } R_3 = \underline{\hspace{2cm}}$$

QUESTIONS

1. Find the equivalent resistance for each of the resistor configurations shown.



2. Digital multimeters used as voltmeters or ammeters have a certain resistance. A voltmeter should have a small current through it and an ammeter should have a small potential drop across it. (a) Knowing how each of these is connected in a circuit, justify this statement. (b) Should the resistance of a voltmeter be large or small? Explain. (c) Should the resistance of an ammeter be large or small? Explain.

3. Find the current through each resistor for the circuit shown.

