Physics 215 - Experiment 11
Series and Parallel Circuits

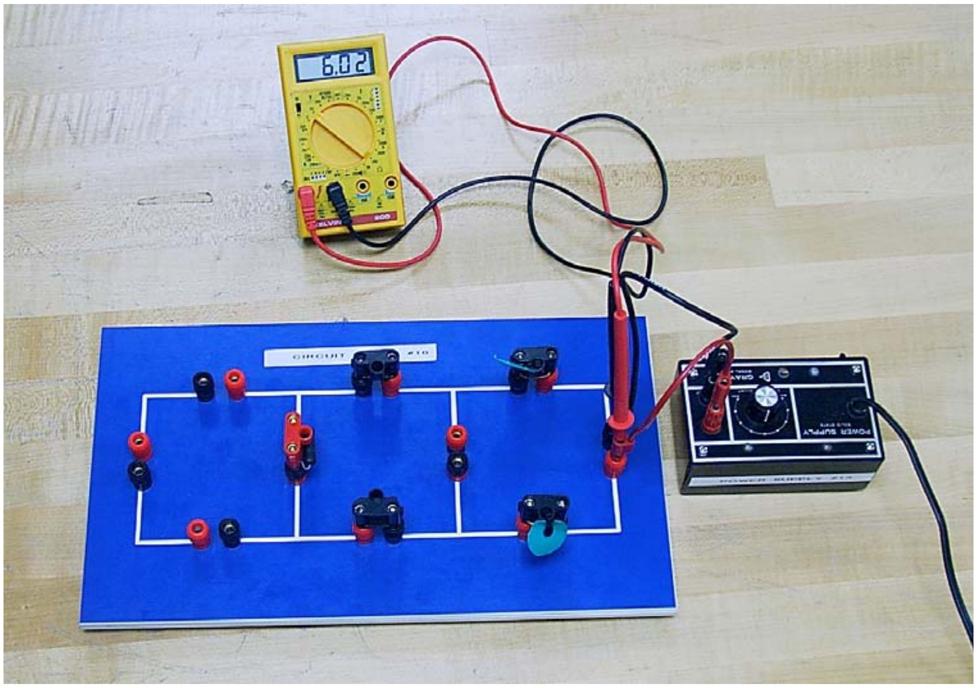

Fig. 11-1 Series Circuit

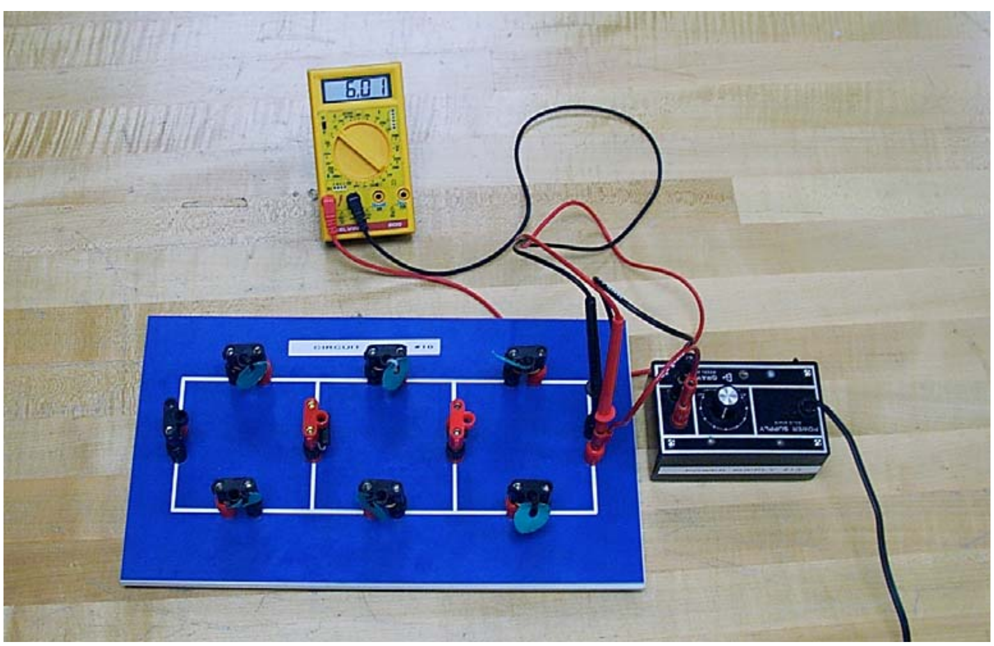

Fig. 11-2 Parallel Circuit

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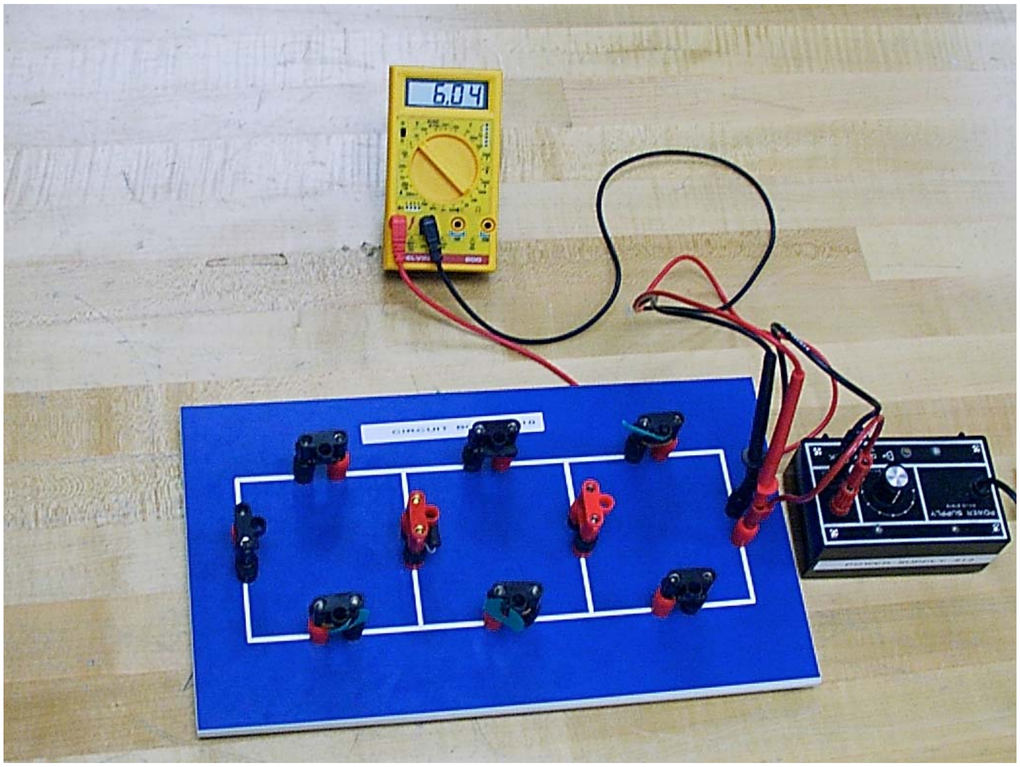

Fig. 11-3 Combination Circuit

Equipment

Universal circuit board
2 100-Ω Resistors
2 200-Ω Resistors
2 330-Ω Resistors
2 Digital Multi-Meters (DMM's)
Power Supply
5 Jumpers
Wire Leads

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Advance Reading
Urone, Chapter 20, sections 20-1 & 20-4.
Appendix B Computers and Software
Appendix C Equipment: DMM.

Objective: The objective of this lab is to study resistances connected in series, parallel, and combination circuits.

Theory: In the previous experiment you constructed a circuit that contained only one resistive element, a resistor or a light bulb. In this experiment you will construct circuits using multiple resistors.

The first type of circuit you will construct is a series circuit (Fig. 11-1 and Fig. 11-4). In a series circuit the resistors are connected end-to-end such that the current is the same through each resistor; *the current has only one path available*. The voltage drop across each resistor depends on the resistor value.
For a series circuit the total equivalent resistance, R_{eq}, is:

$$R_{eq} = R_1 + R_2 + R_3 + \ldots + R_N = \sum_{i=1}^{N} R_i$$

(Eq. 11-1: Resistors in Series)

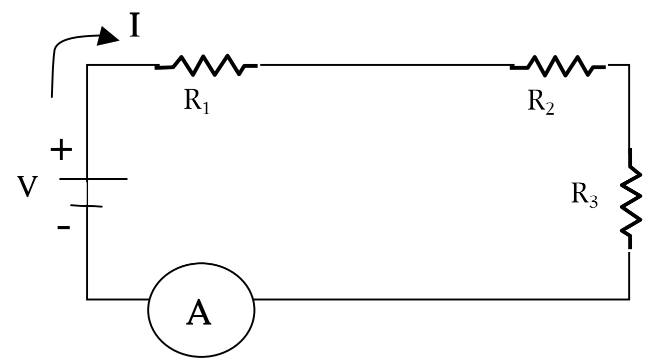

Fig. 11-4: Series Circuit Schematic

The second type of circuit you will construct is a **parallel circuit** (Fig. 11-2 and Fig. 11-5). Resistors are said to be in parallel when they are connected at both ends, such that the potential difference applied across the combination is the same as the potential difference applied across an individual resistor. The current through each resistor depends on the resistor value. *The current has more than one path available, and takes all available paths.*

For a parallel circuit the total equivalent resistance, R_{eq}, is:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \frac{1}{R_N} = \sum_{i=1}^{N} \frac{1}{R_i}$$

(Eq. 11-2: Resistors in Parallel)

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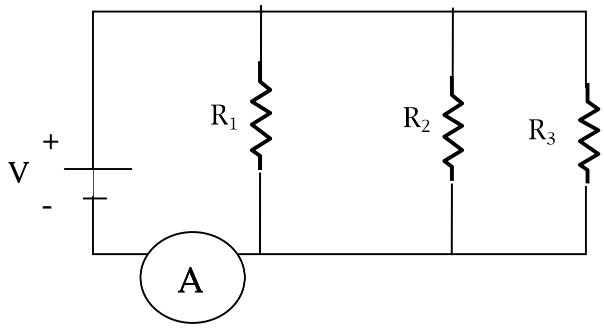

Fig. 11-5: Parallel Circuit Schematic

The third type of circuit you will construct is a **combination circuit** (Fig. 11-3 and Fig. 11-6). Resistive elements are not connected in series or parallel. To analyze this type of circuit, it should first be simplified (reduced to an equivalent resistor, R_{eq}).

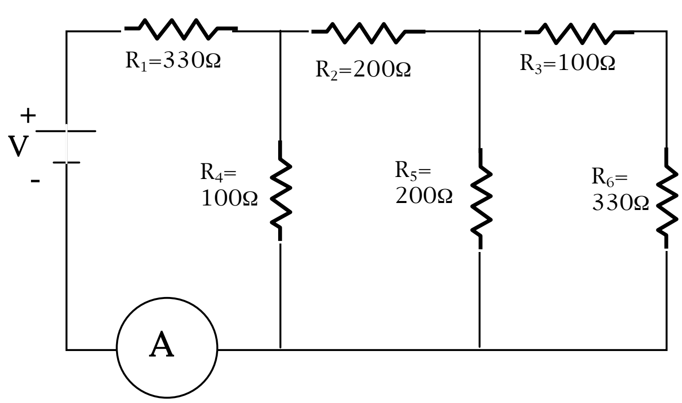

Fig. 11-6: Combination Circuit Schematic

WARNING!

Have your instructor approve *each* circuit before you plug in a power supply! Be sure the power supply is turned off before you plug it in.

Procedure

Series Circuit

1. Measure the resistance of each resistor, R_i, (Fig. C-14); record the values.
2. Construct a series circuit (Fig. 11-4) with the power supply (unplugged from outlet) and three resistors (one each: 100-Ω, 200-Ω, 330-Ω) connected in the appropriate places. (Note: There is more than one way to do this.)
3. Calculate the theoretical value of the equivalent resistance, R_{eq-T}, of the circuit. (Eq. 11-2. Use the measured values of R.) Record R_{eq-T}.
4. Select the voltmeter function of one DMM (Fig. C-9); connect it to your circuit so that it will measure the potential difference when a current is flowing (Fig. C-12). Select the ammeter function (Fig. C-11) on the second DMM; insert it into your circuit (Fig. C-15).

   Get instructor approval of your circuit!

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5. Plug in the power supply. Adjust the power supply until the potential difference across the resistors is 1.0V; this is the same as the potential difference across the power supply. Record the current (A) and the voltage (V). Repeat this process in 1.0V increments up to 6.0V.
6. With the voltage across the power supply set at 6.0V, disconnect the voltmeter. Maintaining the same orientation of the leads (black lead behind red lead), measure the potential difference across each resistor. Add these potential differences ($\sum_{i=1}^{N} V_i$).
7. Does $\sum_{i=1}^{N} V_i$ equal 6.0V?
8. Turn off, then disconnect, the power supply from the circuit. Measure and record the resistance of the circuit, R_{eq}, (Fig. C-10 and Fig. C-13) with the ohmmeter function of the DMM.

Determine Resistance of Ammeter

9. Leave the power supply disconnected. Set the ohmmeter scale to 2kΩ and the ammeter scale to 200μA. Measure and record R_{eq} of the circuit.
10. Measure and record R_{eq} for each of the following scale settings on the ammeter: "2m","20m","200m" and “20A”. (Note-you will have to change DMM positive lead to 20A hole for last measurement).

Parallel Circuit

11. Construct a parallel circuit (Fig. 11-5) with the power supply (unplugged from outlet) and three resistors (one each: 100Ω, 200Ω, 330Ω. There are a variety of ways to do this.
12. Calculate $R_{eq\text{-}T}$ of the circuit.
13. Connect the voltmeter and ammeter to the circuit. Plug in the power supply and increase the power until the potential difference is 1.0V. Record the voltage and current.
14. Measure and record the potential difference across each resistor.
15. As you increase the potential difference, in 1.0V increments, up to 6.0V, measure and record the voltage and current.
16. Turn off, then disconnect, the power supply from the circuit. Measure and record R_{eq} of the circuit.

Combination Circuit

17. Construct a combination circuit (Fig. 11-6).
18. Calculate $R_{eq\text{-}T}$.
19. Measure and record R_{eq} of the circuit.
20. Set the potential difference to 1.0V. As you increase the potential difference, in

1.0V increments, up to 6.0V, measure and record the voltage and current.

Test Circuit

21. Your TA will draw a schematic on the board. Construct this circuit. Set the voltage as specified by the TA.
22. Measure I, R_i, V_i, and R_{eq}.

Graphing

23. On one graph, graph I vs. V for each of the circuits. From this graph, determine R_{eq} for each circuit (use Linear Fit).

Questions

1. Draw an equivalent circuit for each of the three circuits you constructed for this experiment. Show each step in this process.
2. Why should the voltage drops (potential differences) across the resistors connected in parallel be the same? Were your values equal?
3. Are the circuits in houses wired in series and/or parallel? What evidence do you have for your answer?
4. Consider your data from *Determine Resistance of Ammeter*. Why does R_{eq} change when you change the scale of the ammeter?