

## Combination Circuits Lab

### Teacher's Guide

**Topic:**

Electric Circuits

**The following information is provided to the student:**

**Question:**

How do the voltage drops across the various resistors of a combination circuit compare to each other? Are these voltage drops different for different resistors? How do the branch voltage drops compare to each other? How do the voltage drops compare to the voltage gain in the battery? How do the current values in the individual branches compare to each other? Are these currents affected by the resistance of the resistors? How do the current values compare to the current at the battery location? How do the current values in the branches compare to those values outside of the branches? For any individual resistor, how are the voltage drop, current and resistance related? How can all these comparisons be expressed using mathematical equations?

**Purpose:**

To develop equations which compare the currents in the individual resistors of a combination circuit to the current in the battery AND which compare the voltage drops for the individual resistors to the voltage gain in the battery AND which compare the voltage drop across an individual resistor to the current in that resistor and the resistance of that resistor.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include the provided page - completed and taped in. Work is should be shown for each type of calculation. Other calculations should be performed and shown in an effort to establish equations which relate the data to each other. The Conclusion/Discussion should state several mathematical equations relating the data. Conceptual ideas should be extracted from the data and referenced to the data. An error analysis should be performed and percent difference values calculated.

**Materials Required:**

Four D-cells; battery holder; alligator leads; four resistors (with a different resistance); computer interfaced ammeter and voltage probes.

**Description of Procedure:**

A combination circuit is constructed by placing two resistors in series with one another and connecting to it two resistors in separate, isolated branches. See provided diagram. This combination of four resistors is connected to the ends of a battery pack consisting of four D-cells. The ammeter is wired in series so to collect the current at the battery location. Eventually the ammeter will be moved to other locations in order to determine the current in each of the four resistors. The voltage probes are used to determine the electric potential (i.e., voltage) at the six labeled positions relative to the negative terminal of the battery pack; this requires that one of the leads of the voltmeter is attached to the negative terminal. These values can be plotted in the provided chart and used to calculate the voltage drops for each resistor. The ammeter is placed at the various locations to determine the current at each resistor location. Resistance values are recorded and compared to the ratio of the voltage drop to current for each resistor location. Data is analyzed and mathematical relationships are determined.

## The Laboratory

### Alternative Materials and Procedure:

A couple of multimeters can be used in place of the computer interfaced ammeter and voltmeter.

### Safety Concern:

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

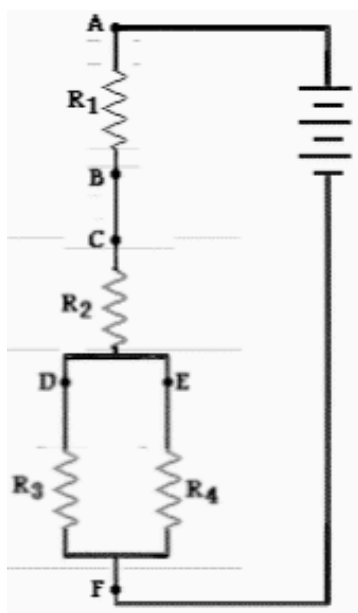
### Suggestions, Precautions, Notes:

1. Both the arrangement of resistors and the collection and analysis of data can be a difficult task for many students. This lab might be best suited for your most able students.
2. Demonstrate how to use the voltage probes to determine a voltage difference between two points. Make sure students are using the probes correctly and not *wiring* the voltage probes into the circuit.
3. Combining the lab with a reading assignment on the mathematics of combination circuits may make both the lab and the reading more enlightening.
4. This lab offers students a challenge at collecting quantitative data and making numerical sense of it. In their Conclusion/Discussion, students might simply state equations which they have read in some physics textbook. Emphasize that they are to provide evidence for such equations, making specific references to their data.
5. Many resistors utilize a color code to convey the theoretical resistance. Information about the interpretation of the colors is typically available online. Conducting a Google search for "Resistor Color Code Convention" will return a collection of web sites, such as

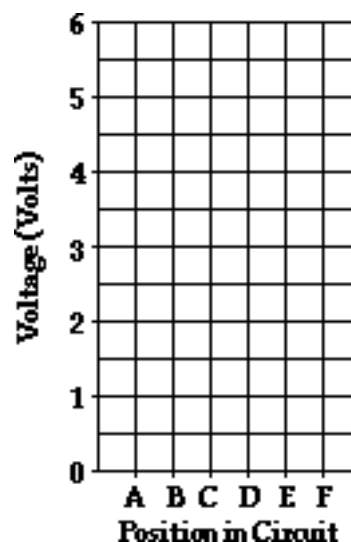
<http://www.diyaudioandvideo.com/Electronics/Color/>

### Auxiliary Materials:

The following page is provided to the student for completion and inclusion in the Data section of their lab notebook.



### Record voltmeter readings



## The Laboratory

	Measured Current (A)	Measured $\Delta V$ (V)	Calculated Resistance ( $\Omega$ )	Theoretical Resistance ( $\Omega$ ) -color bands-	Percent Error
R <sub>1</sub>			$\Delta\Delta V/I =$		
R <sub>2</sub>			$\Delta V/I =$		
R <sub>3</sub>			$\Delta V/I =$		
R <sub>4</sub>			$\Delta V/I =$		
Total (Battery)			$\Delta V_{tot}/I_{tot} =$	R <sub>eq</sub> = (use eq'n)	

Clearly show your calculations for the resistance (in cells) and the percent error (using calculated and theoretical resistance values) for each of the four resistors.

### Scoring Rubric:

C11. Combination Circuits Lab	Score
<ul style="list-style-type: none"> <li>— Included, labeled and organized all parts of the lab report.</li> <li>— Data section should include the provided sheet - completed and taped in. Work should be shown for the <math>\Delta V/I</math> calculations and the percent error calculations. Other calculations should be performed in an effort to generate equations from the data which respond to the Purpose of the lab; work is clearly shown and labeled so as to communicate the ideas. (Wrong turns, scribbles, and changes in the direction of one's thought should be documented and are always considered a sign of the scientific process.)</li> <li>— Conclusion/Discussion states several mathematical equations which related the quantities in the combination circuit. Customary symbols - <math>\Delta V_1</math>, <math>\Delta V_2</math>, <math>I_1</math>, etc. - are used in the equations. Equations are supported by the data and referenced to the data (or at least included in the Calculations part of the Data section). All questions are answered (see Questions section); data is used to support the answers. Discussion is complete and accurate; reveals understanding.</li> </ul>	___/___

### Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/circuits/u9l4e.cfm>

### Connections to Minds on Physics Internet Modules:

Sublevel 11 of the Electric Circuits module is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/mop/module.cfm>