Name: ______________________________
Partners: ______________________________
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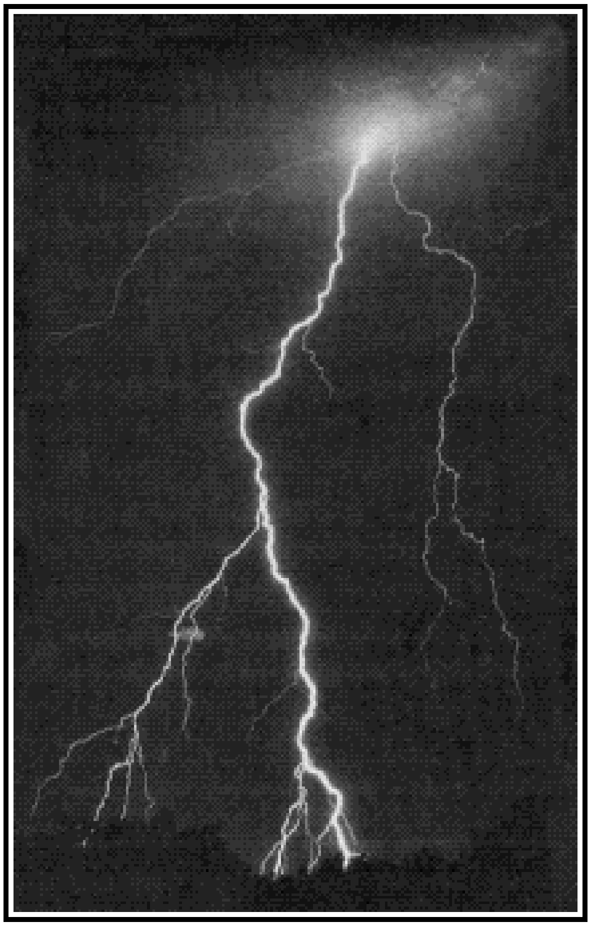
PHYSICS 221 LAB #4: DC CIRCUITS



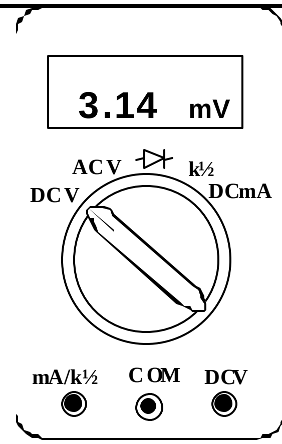
As a result of atmospheric processes, negative charges build up at the base of clouds causing a potential difference between them and the ground beneath the cloud. During lightning storms, this charge difference is dissipated by the flow of electrons downward and positive ions upward along a complex network of paths.

OBJECTIVES

1. To understand the voltages across different elements in series and parallel circuits.
2. To understand the flow of electric current through different elements in series and parallel circuits. Also, to understand the idea of equivalent resistance.
3. To understand and apply the relationship between potential difference across a resistor and the current through it (Ohm's law).
4. To gain experience using basic electronic equipment and constructing circuits while reviewing the application of Kirchhoff's Rules.

OVERVIEW

You will use a multimeter like the one pictured to the right in three modes: as an ohmmeter to measure resistance, as a voltmeter to measure electric potential differences (voltage), and as an ammeter to measure current. The ON/OFF switch is on the left side of the meter. For all uses, there should be one wire plugged into the COM socket. Be careful to watch the units because they are adjusted automatically as the readings change.



1. **Ohmmeter**: Turn the dial to "kΩ" and plug the second wire into "mA/kΩ". Only use the meter in this mode to find the resistance of an individual resistor, <u>not</u> on a circuit with current running through it.
2. **Voltmeter**: Turn the dial to "DCV" and plug the second wire into the "DC 1000V" socket to measure voltages in DC circuits. The leads from the voltmeter should be connected at the two points between which you want to know the potential difference. A positive voltage reading means that the wire connected to the "DC 1000V" socket is at a higher voltage than the wire connected to the "COM" socket and a negative reading means the reverse.
3. **Ammeter**: Turn the dial to "DCmA" and plug the second wire into the "mA/kΩ" socket. The ammeter must be inserted into a circuit so the current flows through it. A positive current reading means that the current is flowing into the wire connected to the "DCmA" socket and a negative reading means it is flowing in the opposite direction.

Ohm's Law, V=IR, tells how the voltage drop (V) across a resistor to the current (I) through the resistor are related to the resistance (R). There are two simple kinds of arrangements of resistors that are pictured below. For resistors in series, the current through the resistors is the same. For resistors in parallel, the voltage across the resistors is the same.

The equivalent resistances for resistors in series and in parallel are:

$$R_{\text{ser}} = R_1 + R_2 + \ldots \qquad \frac{1}{R_{\text{par}}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

Two other rules useful for making calculations for circuits are:

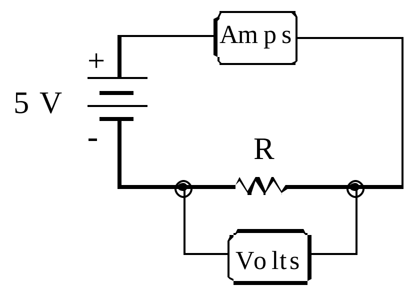
1. **Kirchhoff's Junction Rule:** The sum of all currents entering a junction must equal the sum of all currents leaving the junction.
2. **Kirchhoff's Loop Rule:** The sum of the voltage changes around any closed loop in a circuit must equal zero.

PART ONE: Ohm's Law

1. Set up a multimeter for use as an ohmmeter and measure the resistance of each of the four resistors on the board. Enter your measurements in the first column of the table below. (Don't forget to include units with every measurement made in this lab!)

	Measured Resistance	**Measured Current**	**Measured Voltage**	**Expected Voltage**
A				
B				
C				
D				

2. To practice using the multimeters with circuits and to verify Ohm's Law, set up the circuit picture below using the resistor marked "A" on the board and the power supply. The "+" in the diagram below indicates the higher voltage which will be "+5 V" on the power supply and the "-" indicates the lower voltage which will be "COM" on the power supply. One multimeter should be set up as an ammeter and the other as a voltmeter.

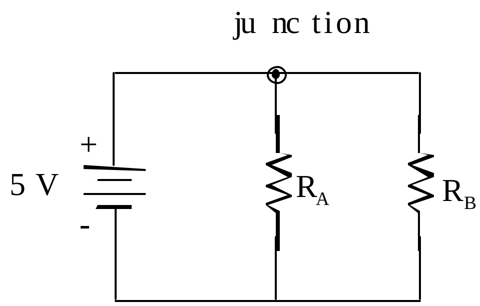


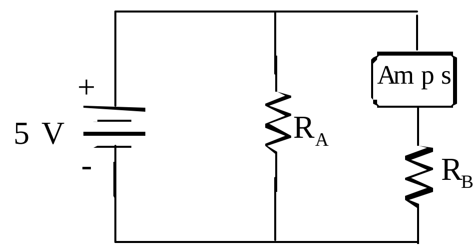
3. Turn on the multimeters and the power supply. Record the current through the resistor and voltage across it in the first line of the table. Use Ohm's law to calculate the expected voltage from the measured resistance and current.
4. For each of the other resistors, turn off the power supply, rebuild the circuit, and measure the current and voltage. Also calculate the expected voltages using the measured currents and resistances.

Question: Do your measured values of voltage agree well with the predicted values? (You do not have to calculate the percentage difference here.)

PART TWO: Currents and Kirchhoff's Junction Rule

1. Set up the circuit shown below to the left. You will measure the currents into and out of the junction indicated with a dot to test Kirchhoff's Junction Rule.





2. Use an ammeter to measure the sizes of the currents (<u>not</u> the signs) through the power supply (I_P) and the resistors (I_A and I_B). Wires must be disconnected so that the ammeter can be inserted into the circuit. The arrangement for measuring I_B is shown above to the right. Also use the sign shown by the ammeter to determine whether the current is entering or leaving the junction and circle the appropriate direction.

I_P = ______________ entering / leaving the junction

I_A = ______________ entering / leaving the junction

I_B = ______________ entering / leaving the junction

Question: Do you measurements confirm Kirchhoff's Junction Rule? Show your work.

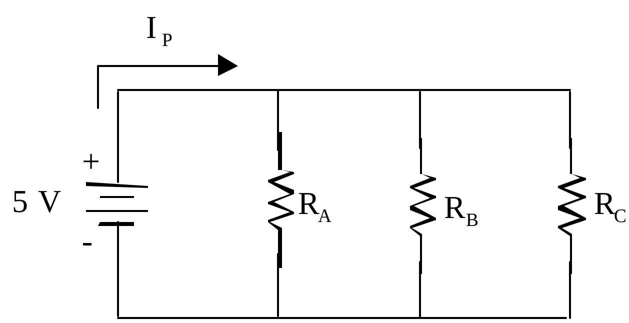
Question: Does the larger or smaller resistor in parallel have the larger current flowing through it? Explain why.

3. Measure the voltage of the power supply. (It is not exactly 5 V.)

ΔV_P = ____________

Question: Use the resistance addition rules to find what single (equivalent) resistor would result in the same amount of current (I_P) flowing from the power supply. How does that theoretical value compare with $\left|\frac{\Delta V_P}{I_P}\right|$?

4. Add a third resistor in parallel to the previous circuit to make the one shown below. Measure the current flowing from the power supply.

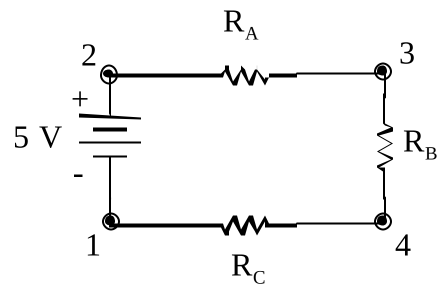


I_P =______________

Question: Is the current flowing from the power supply larger or smaller than in step 2 with two resistors in parallel? Explain why.

PART THREE: Voltages and Kirchhoff's Loop Rule

1. Set up the circuit shown below. You will measure the voltages between the points shown to test Kirchhoff's Loop Rule.



2. Measure the voltages between each pair of points with a voltmeter by attaching the lead from the "COM" socket on the voltmeter to the first point listed and the lead from the "DC 1000V" socket to the second point. Record your measurements below being sure to include the signs.

ΔV_{12} = ___________________ ΔV_{23} = ___________________

ΔV_{34} = ___________________ ΔV_{41} = ___________________

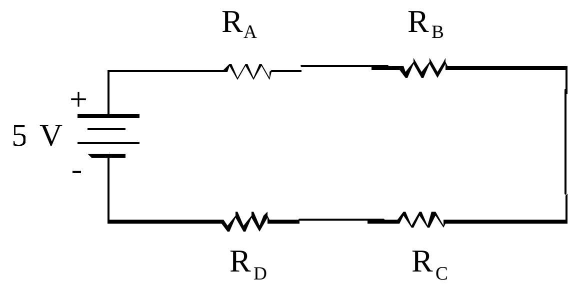
Question: Do you measurements confirm Kirchhoff's Loop Rule? Show your work.

3. Measure the current flowing from the power supply.

I_P =_______________

Question: Use the resistance addition rules to find what single (equivalent) resistor would result in the same amount of current (I_P) flowing from the power supply. How does that theoretical value compare with $\left|\frac{\Delta V_P}{I_P}\right|$?

4. Add a fourth resistor in series to make the circuit shown below.



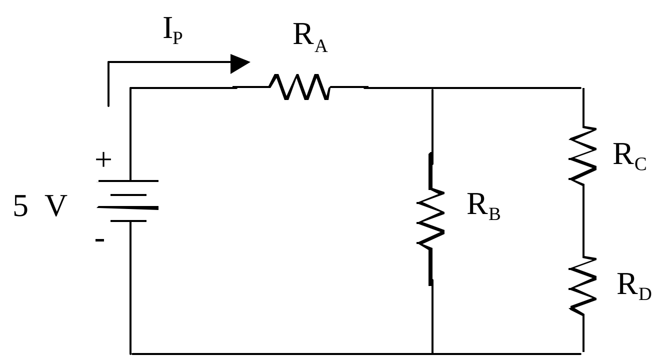
5. Measure the current now flowing from the power supply.

I_P =_______________

Question: Is the current flowing from the power supply larger of smaller than in step 3 with three resistors in series? Explain why.

PART FOUR: A More Complicated Circuit

1. Construct the circuit shown below.



2. Measure the current flowing from the power supply and the actual voltage across the power supply (it will not be exactly 5 V).

I_P = _______________ ΔV_P = _____________

Question: Calculate the expected current flowing from the power supply using equivalent resistances. Start with just the voltage of the power supply and the values of the resistors. Show your work. How does the expected value compare with your measurement?

3. Measure the current through R_B

I_B = ______________

Question: Calculate the expected value of this current. Use just measured values of the voltage of the power supply and of the resistances and the calculated value of the current flowing from the power supply (from the previous question). Show your work. How does the expected value compare with your measurement?