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LAB #2: Fun with DC Circuits

Physics 2020, Fall 2004

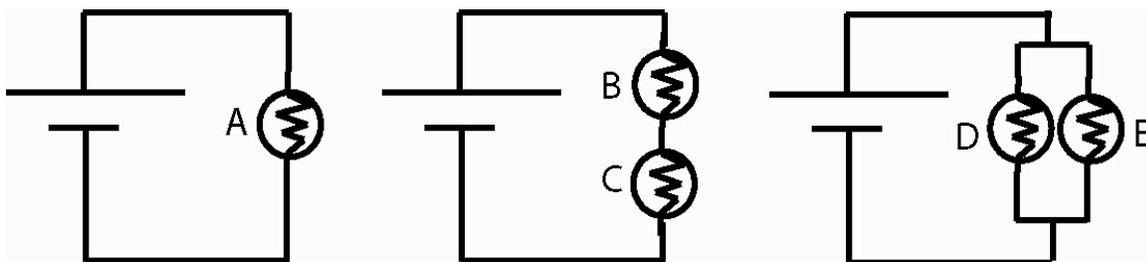
The field of electronics has revolutionized the way we live and what we do. We can find circuits everywhere—from our cell phones, digital watches, calculators, televisions, computers, etc. Understanding how these things work is interesting in their own right, but from this we can figure out how to do more practical things, like design and install our own car stereo system or make sure that we *do not* electrocute ourselves.

In this lab, we will first look at a few simple DC circuits that will give us an idea of how these things work in the first place. We will learn how to use a DC power supply and an electrician's best friend—a digital multimeter (DMM).

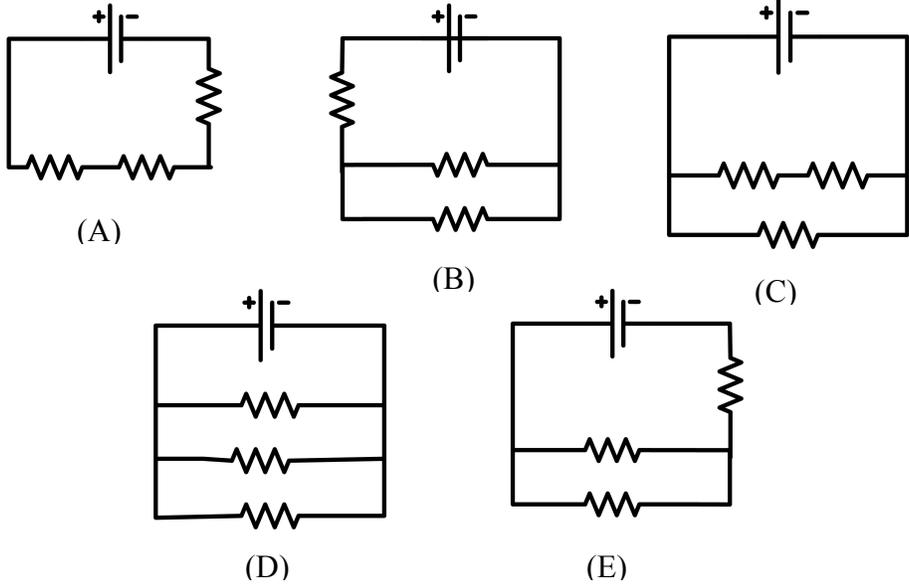
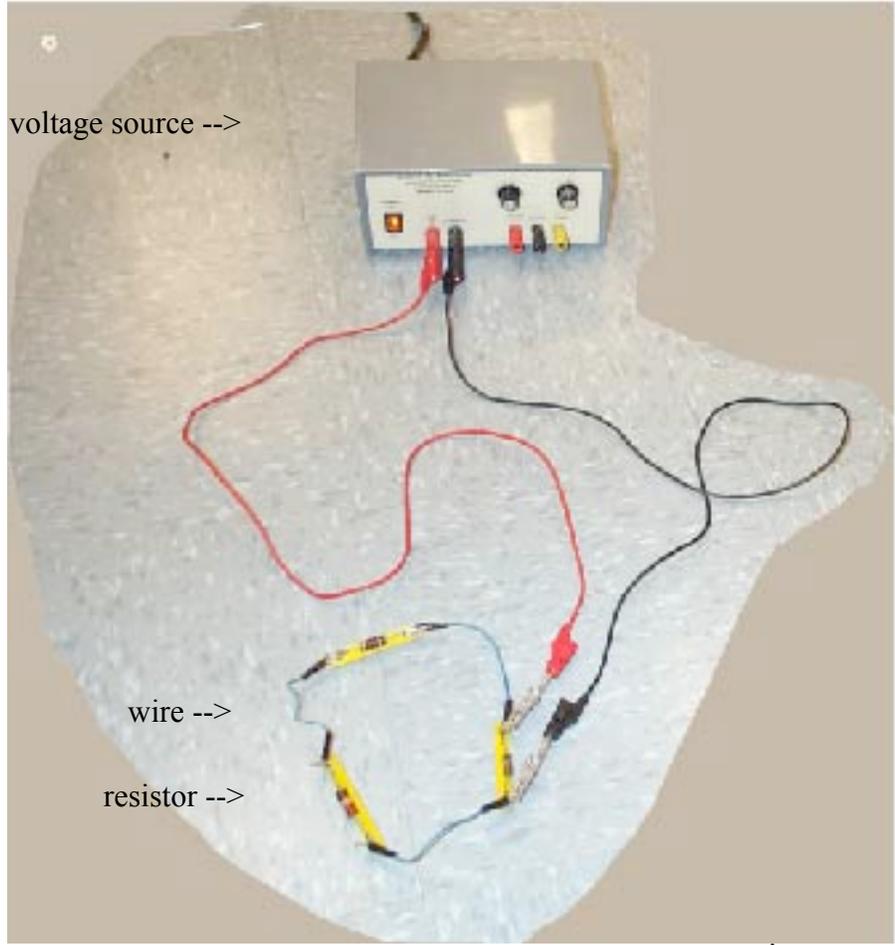
PRELAB QUESTIONS:

TURN THIS PRELAB IN ON A SEPARATE SHEET OF PAPER

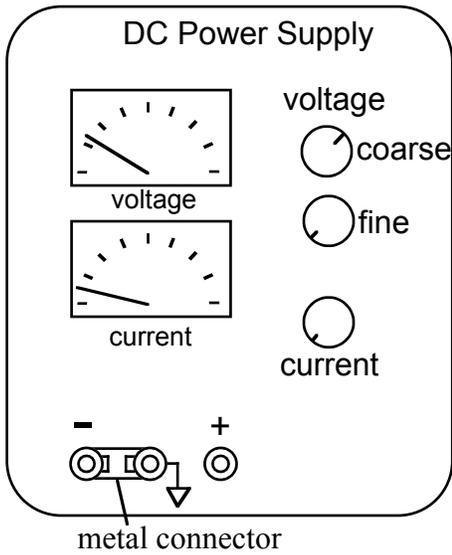
1. Read the lab thoroughly.
2. Familiarize yourself with circuits and circuit diagrams in your book. Chapter 19-1 to 19-5.
3. Thought experiment: Can you use a SINGLE lightbulb SINGLE battery and SINGLE wire, and can get the lightbulb to light? Answer this on a separate sheet and Draw a diagram
4. For the circuits below rank the relative bulb brightness from brightest to dimmest (use CCK if you like). Note all batteries are identical and ideal. All lightbulbs are identical and ideal. Note also that bulb brightness reflects the power dissipated in the bulb and that the bulb is a resistor.



5. In 50 words OR MORE describe WHY the bulbs are ranked as they are. Present your reasoning in every day language so that a friend who has never taken physics would understand your reasoning for why you ranked the bulbs as you did (you can use words like voltage difference, current, energy etc, but no explicit formulas).
6. Look at the picture on the following page. Select the schematic diagram for the resistors and power supply below the picture.



The Tools:



On your bench:

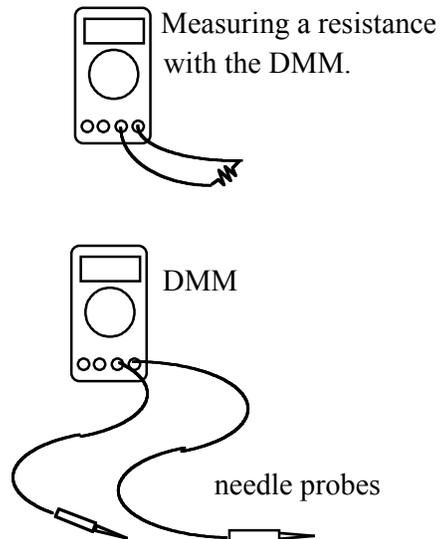
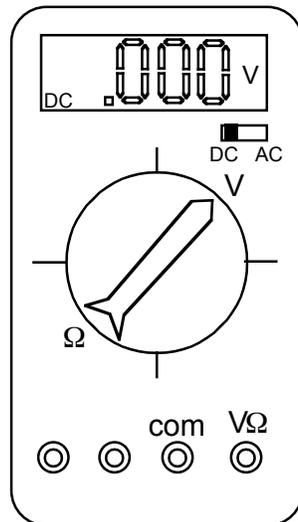
The two instruments you will use in this lab are a DC power supply and a digital multimeter. The DC power supply produces a constant voltage, which can be adjusted anywhere from zero to 30 volts with the voltage knobs (coarse and fine) on the front panel. The power supply has three output terminals: plus (red), minus (black), and ground (green). The ground terminal is always at zero volts. In this experiment, the ground and minus terminals are tied together by a metal connector so the minus terminal is also at zero volts. Both the current and voltage produced by the power supply can be read on meters on the front panel. Also on the front panel is a current-limit knob, which can be adjusted to limit the maximum output current, to prevent damage to sensitive circuit elements. In this lab, the current knob has been set and clamped in place so the power supply cannot produce more than about 0.6A current.

The hand-held digital multimeter (DMM) is a wonderful little device which can be used to measure the voltage difference between any two points in a circuit, the current, and the resistance or capacitance of any circuit component(s). In this lab, we will use the DMM to measure both resistances and DC voltage differences. There are 2 wires attached to the DMM. One of the two wires always goes to the COM (common) terminal. To measure either the voltage difference or the resistance, the second wire is attached to the "VΩ" input. In this lab, all our measurements will be DC, so the DC/AC switch (upper right) should always be in the DC position. The DMM has an alarm; it rings if you have wires plugged into positions which conflict with the central knob's position.

The 2 wires attached to the DMM are called "needle probes". You can quickly measure the change in voltage between any two points in a circuit by touching the points with the needle probes.

When measuring a resistance with a DMM, you must disconnect the source of the resistance from any other devices, such as power supplies. *Never try to measure the resistance of a resistor while it is still in a circuit.*

You will also be using
The Circuit



Construction Kit (CCK) Simulation:

With the CCK you can quickly build and explore any circuit you want!

You will be using laptop computers at your stations. When the simulation is started you are ready build your own circuits. Click and drag the icons (batteries, bulbs, resistors, etc) into the workspace. The wires are automatically soldered (connected) together by touching the round ends. To decouple them right click. To change the values of the components, right click. You can look at things in a schematic view or a life-like view

It comes with:

- batteries with adjustable voltages
- light bulbs with adjustable resistance
- resistors with adjustable resistance
- switches
- wires
- a volt meter which like the DMM can measure voltage differences between any two points in your circuit.
- and, a current meter

Helpful hints:

- right click on junctions to disconnect
- right click on components to view your options.
-

You cannot break the CCK, so go for it!

PART I: UNDERSTANDING RESISTANCE

Your goal of this part of the lab is the following: *Figure out how to measure the resistance of various things using the tools in the CCK.*

In your play area select 5 resistors and adjust their values to be: one 1Ω , one 4Ω , two 50Ω , and one 100Ω . Add two light bulbs to your play area and adjust their resistance to be 25Ω each.

It is up to your lab group to create 2 different resistor combinations using some of the 5 resistors and 2 light bulbs —both in series and in parallel. Draw a picture of each combo of resistors in your lab book, and *predict* the equivalent resistance of that combo. Build these resistor combinations in the CCK, and test your prediction by building another single-resistor circuit with the equivalent resistance (within 1Ω) and comparing the two. Do your two circuits have equivalent resistance? How can you tell?

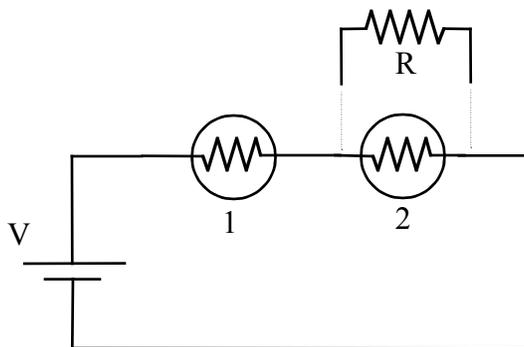
PART II: CIRCUIT BEHAVIOR

Now that you understand how to use the DMM, you will now use CCK to build a circuit and investigate its behavior.

Using CCK, construct the circuit shown below, consisting of two light bulbs in series with the power supply (battery). (The resistor R will be added later). Slowly increase the battery voltage until the bulbs are glowing, but not too bright. *Predict* what will happen to the brightness of the bulbs when you place a $R = 50\Omega$ resistor in parallel with bulb #2 as

shown in the schematic. Go ahead and add in the resistor, and describe in your own words what happened and why. Measure the voltage difference across the light bulbs and resistor and verify that they match your prediction (i.e., if you know the power supply voltage and all the resistances, do the other voltages make sense?).

Do the same thing for other resistor values and describe what happens in each case.



PART III: MEASURING RESISTANCE IN MULTIPLE WAYS

In Part I of this lab, you used CCK to test whether you had correctly predicted equivalent resistance. Go back to one of the circuits that you built in CCK in Part II. Using the tools available in CCK, measure the resistance of the resistor in parallel with bulb #2 *without* using the resistance readout setting in the program. Your group will have to figure out a clever way to do this using the tools available to you. Describe in detail how you were able to accomplish this.

Note: Besides not being able to use the resistance readout, make sure that the light bulbs are still glowing when you take any measurements.