Introduction:
The first lab experiment is intended to serve two purposes. First, you will learn how to use the parts of your lab kit, the proto board, and some of the equipment of your lab station including the power source and the digital multimeter (DMM). Make sure you read chapter I of the introductory handout and the first section of chapter II. The first chapter gives you guidelines for carrying out the lab experiments and can serve as a useful reference throughout the quarter. Second, you will carry out the first experiment, which deals with circuits that contain only resistors. The goals for this experiment are:

- Familiarize yourself with the lab equipment
- Build and analyze simple resistive circuits; measure circuit properties (voltage, current, power) of various elements in the circuit
- Build a voltage divider
- Design and build a resistance meter that allows you to determine unknown resistances

Topics from the lecture you need to be familiar with:

- Voltage and current, Ohm’s law
- Resistive circuits
- Kirchhoff’s laws
- Node/mesh analysis
- Power

Pre-lab questions (hand in before lab starts):
1. What is the power dissipated in a resistor? Does it depend on the polarity of the source?
2. State KCL and KVL in your own words.
3. What is a voltage divider?
4. Explain intuitively why the equivalent resistance of two resistors in series/parallel is always larger/smaller than the individual resistors. Use water analogies.
Part 1: DC circuit basics

1. Resistive circuits
   a) Build the following circuit on your circuit board using the power supply and the 5% tolerance resistors.

   ![Resistive Circuit Diagram]

   b) Measure the resistance values of the resistors. By how much do they differ from the nominal value (absolute difference in Ohms and relative difference in percent)?
   c) Measure voltage drops $V_{AB}$, $V_{AC}$, and $V_{BC}$.
   d) Measure all currents flowing into node B and verify KCL.

2. Light bulb circuits
   a) Measure the resistances of your 2 light bulbs when they are cold (off).
   b) According to their rating, what is the highest voltage that can be applied?
   c) Connect the light bulbs to a voltage source in series and in parallel. Draw the circuit diagram for each case. Compare the brightness and explain your result.
   d) Measure the resistance again while the bulbs are on. Do your results differ from your initial measurement? Is there a difference between the parallel and series circuit? Explain.
   e) Determine the power dissipated in each light bulb for each circuit.

3. Voltage divider
   a) Design a voltage divider which gives you a ratio of $V_1/V_2 = 1:3$. Use the 1k resistor, the 10k resistor and a variable resistor (trimpot). Draw a diagram for your circuit. Verify your design experimentally. Measure $R_{pot}$, $V_1$, and $V_2$. 
Part 2: Design of a resistance meter

The Wheatstone bridge is a circuit that is used to measure unknown resistances, see Hambley, chapter 2.8. It works by balancing a resistor ratio until the current between two nodes is zero.

a) Build the following circuit using the precision resistors (1%): $R_1=1k\,\Omega$, $R_2=1k\,\Omega$, $R_3=\text{pot}$, $R_x=5k\,\Omega$, $V_r=5V$

![Wheatstone Bridge Diagram]

The bridge is balanced when $i=0$. Then $R_x=R_2R_3/R_1$. What value for $R_3$ do you need to choose?

Balance the bridge by tuning $R_3$ until $i=0$. Measure $R_3$ and verify your calculation. What is the deviation (absolute and relative) from your expected result?

b) Free design: Your precision pot varies from 0-10k. Using the other precision resistors design a Wheatstone bridge, which can measure unknown values $R_x$ between 0 and 100k. Identify your resistor values for $R_1$ and $R_2$. You want the currents flowing through the resistors to have reasonable values. Pick your resistor values such that all currents stay between 0.1 and 10 mA for all $R_x$ values. Build the bridge and measure several of the low precision resistors and a light bulb by balancing the bridge and measuring your pot value $R_3$. Measure the current through each resistor and verify that you are within the limits. Compare your results with the DMM multimeter readings. How accurate are your measurements? What happens if you try to measure a 1M Ω resistor?