Student's Name: ______________________ Student's Name: ______________________

Lab day & time: ________________ Date: ________________

Ohm's Law and Resistance (E3) - Data Sheets

Write all results on the data sheets in ink. Complete all steps, prepare required graphs, and answer all questions on the data sheets before you leave.

Activity 1: Ohm's Law *(1 p.)*

Before doing any calculations read the file "E3 – Theory and Procedure".

What is the function describing the dependence between voltage and current on the graph?

____

Is this the dependence you expect from Ohm's Law? ______________________

What are the values for the slope *m* and the y-intercept *b* in the equation of the line (i.e., $y = m*x + b$) for the best-fit data?

m = ______________ b = ________________

The resistance R of the rheostat = _____________ (Ω)

Print this graph for the lab report.

Do not use the nominal resistance of the rheostat (45 Ω) - it is not accurate!

Now you need to compute the resistivity ρ for the rheostat coil. Use the following data for this calculation.

radius of the coil $r = 0.0215$ (m)

number of turns of the wire in the coil = 220

length of wire l = ___________________ (   )

diameter of the wire $d = 0.86$ mm = ______________ (m)

cross-sectional area of the wire A = ____________________ (   )

Use the length and the cross-section of the wire to calculate the resistivity ρ of the wire.

ρ = ______________ (   )

What material is your rheostat made of? (<u>*Hint*</u>: look at the table in the E3 - Theory and Procedure file)

____

Lab Challenge 3.1. (*Estimate the number of electrons*) *(0.5 p.)*

Do not ask your TA for help with the lab challenge activity! You may consult with other students or use other available sources of information like textbook, online resources, etc.

A relatively small current I = 1.00 mA is running through a cross section of a copper wire. Calculate the number of electrons running through the wire cross section per second.

Number of electrons per second = __________________

Activity 2: Resistors in Series *(0.5 p.)*

Before doing any calculations read the file "E3 – Theory and Procedure". Pay special attention to the electrical circuit for this Activity.

What is the shape of your voltage vs. current graph? ________________________________

What is the slope of this graph? m = ____________________

From this information, what is the total resistance of your circuit?

R_{T1} = ______________ (   )

Now calculate the resistance R_A of the unknown resistor "A":

R_A = ________________ (   )

Activity 3: Resistors in Parallel *(0.5 p.)*

What is the slope of the voltage vs. current graph? m = _________________

From this slope, determine the total resistance of your circuit.

R_{T2} = _______________ (   )

Now calculate the resistance of the unknown resistor "B".

R_B = ______________________ (   )

Activity 4: Resistance vs. Temperature for Metals *(1.5 p.)*

What is the initial temperature (after 3-5 min. waiting to equalize the temperature of the coil and water)?

T_0 = _____________ (˚C) (it should be close to the room temperature)

Press the "Record" button. The computer will now plot the resistance and temperature points on the graph in front of you. This part of the experiment takes approximately 20-25 minutes to complete.

What is the shape of the graph you obtained?

____

What is the slope of this graph? m = __________________________

What is the y-intercept of this graph? b = __________________________

From Print/Printing preferences, select landscape orientation and **print a copy of your graph**.

Using the <u>slope</u> (m) and the <u>y-intercept</u> (b), determine the temperature coefficient of resistance α. Note that the y-intercept b is not the same as R_0. The y-intercept on your graph is equal to the resistance at temperature equal to 0 ˚C, whereas R_0 is the resistance at the temperature T_0 which is close to the room temperature ≅ 20 ˚C. Therefore,

$$R(T) = R_0 + R_0\alpha(T - T_0) = R_0 + R_0\alpha T - R_0\alpha T_0 = R_0\alpha T + R_0(1 - \alpha T_0) = mT + b$$

$$m = R_0\alpha\,,\quad b = R_0(1 - \alpha T_0) \quad\Rightarrow\quad \frac{m}{b} = \frac{R_0\alpha}{R_0(1 - \alpha T_0)} = \frac{\alpha}{1 - \alpha T_0}$$

$$b\alpha = m - m\alpha T_0 \quad\Rightarrow\quad \alpha(b + mT_0) = m \quad\Rightarrow\quad \alpha = \frac{m}{b + mT_0}$$

α = ______________________ (   )

What is the percent difference between your result above and the temperature coefficient of resistivity for copper given in the Table with ρ and α values (in the *Theory and Procedure* file)?

Percent difference = ______________ (%)

Activity 5: Temperature of the Bulb's Filament *(1 p.)*

5a. The initial temperature of the bulb's filament is equal to the room temperature:

T_0 = ______________ (ºC).

The initial resistance of the bulb's filament at temperature T_0:

R_0 = ______________ (Ω)

5b. Resistance of the **hot** bulb's filament:

R(T) = _______________ (Ω).

NOTE: **The resistance changes with the applied current!** The hot bulb is an example of a **non-linear resistor**. Most of the semiconductor devices like diodes and transistors are also non-linear resistors. In this case the increase of current in the bulb increases the temperature of the filament. The warmer filament gets larger resistance resulting in a non-linear response to the current. **Print** this graph.

Use the thermal resistance equation, $R(T) = R_0[1 + \alpha(T-T_0)]$, and the resistance R_0 at the room temperature T_0, to calculate the maximum temperature of the hot bulb filament. Remember that the bulb's filament is made from Tungsten with the temperature coefficient of resistivity $\alpha = 0.0045/^\circ C$.

The numerical value of the maximum temperature the filament reaches is equal to:

T = ______________ (ºC).

Use the voltage versus current graph to calculate what is the electrical power dissipated in the bulb when it is brightest, i.e., when the maximum value of the voltage (= 5V) is applied.

Power P = _________________ (W)

Complete the Data Sheets and return the completed lab report to your TA.