**Lab 1: Equivalent Resistance Lab (Introduction to MATLAB) - Part the First**

Resistors are one of the simple components of the Linear Circuits that are being used as an application of engineering mathematics in this course. Consistent with their name resistors “resist” the flow of electrons (current), lowering the current and increasing the loss of energy (voltage).

In this lab, different configurations of resistors are examined. Experimental data is available for three resistors and several different networks (wiring arrangements of these resistors). The required task is to compare the measured network resistances to calculated resistances using provided network equations.

The primary goal is to get introduced to using MATLAB as a calculation and programming tool. You will also become familiar with calculating equivalent resistances for different configurations using MATLAB to complete the calculations.

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1. **Resistors in Series**

Figure 1 shows a schematic diagram of two resistors in “series”. Resistors are called in series when the current passes through resistors one after another (i.e., when they are connected end to end). It is often helpful to know the total equivalent resistance of the resistors take together

Equation 1 shows how the equivalent network resistance is calculated when resistors are connected in series. Notice the resistances simply add up. For two resistance all that is needed to add the resistances together. Note: resistance is measured in Ohms (or the metric multiples such as kOhms). Ohms can be abbreviated with the Greek letter capital omega (Ω).

**Figure 1:** This schematic shows the configuration a for series network of two resistors. RE represents the equivalent resistance of the network.

 $R\_{e}= \sum\_{i=1}^{n}R\_{i}=R\_{1}+ R\_{2}+…+ R\_{n}$ (1)

 where: Re = the equivalent resistance of the network (Ohms)
 R1 = the resistance of each resistor 1, etc. (Ohms)
 n = the total number of resistors

**Activity 1 – Hand Calculation of Resistors in Series:** Remove the worksheet attached to the end of this part of the lab. Notice that Table W-1 gives the measured values of three resistors (R1 through R3). Using these values determine the equivalent resistance for a series configuration each resistor set shown in table W-2. Write the results in the “Calculated” column under “Series configuration”. For one of the two resistor cases show your calculation in detail at the appropriate point at the bottom of the sheet. Include clear statement of the two input values used, the formula used and the calculation with answer.

**To be continued ….**

1. **Resistors in Parallel**



**Figure 2:** This schematic shows the configuration a for parallel network of two resistors.

Resistors in parallel are shown in Figure 2. In this configuration the both ends of the two resistors are connected causing them to be literally parallel in the figure. For this arrangement current splits between the two resistors. Equation 2 shows the formula for this case. It is a bit more complicated than equation 1. In this case the inverse of the individual resistances are added together and then the resulting sum is inverted. Equation 3 shows the form of this equation for two resistors in parallel.

 $R\_{e}= \frac{1}{\sum\_{i=1}^{n}\frac{1}{R\_{i}}}$ (2)

**Activity 2 – Hand Calculation of Resistors in Parallel:** Now determine the equivalent resistance for the parallel configuration each resistor set shown in Table W-2. Write the results in the “Calculated” column under “Parallel configuration”.

For one of the two resistor cases and for the three resistor case show your calculation in detail at the appropriate point at the bottom of the sheet. Include clear statement of the input values used, the formula used and the calculation with answer.

Compare your resulting table with a neighboring student. Note who you consulted with on the line at the top of the worksheet.

$R\_{e}= \frac{1}{\frac{1}{R\_{1}} +\frac{1}{R\_{2}} }$ (3)

1. **Calculations in MATLAB**The example calculations completed as part of Activities 1 & 2 are to be converted to calculations in the MATLAB command window. Activity 3 outlines the steps required. Instructor will provide background on using MATLAB.

**Activity 3: Example calculations in MATLAB**

* 1. Setup: Clear the command window, clear the workspace, and reduce the spacing in the workspace. This can be done with the following commands (respectively)

>> clc

>> clear

>> format compact

* 1. Enter the three input resistances into the workspace. For example for R1 use:
	>> R1 = 487;
	2. Complete MATLAB calculations matching the three example hand calculations used in Activities 1 & 2.
	3. Copy command window results to word, delete unnecessary lines (e.g., mistakes)
* **Print out to ET315 printer, attach to the completed worksheet, and turn in.**

What patterns do you notice in the network resistances? (Discuss with a neighbor.)

**ENGR 128 Lab 1 – Part the First Worksheet**

**Student \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Due Date: \_\_\_\_\_\_\_\_\_\_\_\_ \_\_ Section #\_\_\_\_\_**

**Consulted with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Table W-1:** Measured Resistances in Ohms

|  |  |  |
| --- | --- | --- |
| **R1** | **R2** | **R3** |
| 487 | 996 | 12,900 |

**Table W-2:** Equivalent Resistance of Series and Parallel Networks (Ohms)

|  |  |  |
| --- | --- | --- |
| **Resistors** | **Series Configuration** | **Parallel Configuration** |
|  | **Measured** | **Calculated** | **Measured** | **Calculated** |
| **R1 + R2** | 1,478 |  | 332 |  |
| **R1 + R3** | 13,400 |  | 463 |  |
| **R2 + R3** | 13,800 |  | 921 |  |
| **R1 + R2 + R3** | 14,400 |  | 323 |  |

**Sample hand calculations:** for one example of each case below show:
 1) ***Inputs:*** (i.e. the starting resistances values to be used in the calculation),
 2) ***Formula(s) used:*** (the equations in algebraic variable form, no numbers here) and
 3) ***Calculation:*** (plug the numbers into 2, show any steps and the final answer with units)

1. Network equivalent resistance for two resistors in series (pick any pair as an example)

***Inputs:***

***Formula(s) used:***

***Calculation:***

Network equivalent resistance for two resistors in parallel (again any pair as an example)

***Inputs:***

***Formula(s) used:***

***Calculation:***

1. Network equivalent resistance for three resistors in parallel

***Inputs:***

***Formula(s) used:***

***Calculation:***

Attach a copy of MATLAB **Command Window** calculations needed to complete the above three cases. (i.e. use the same values as in 1 – 3 above, copy the command window with the inputs and calculations into Word, print out and attach to this worksheet). Turn in before leaving.

**Lab 1: Equivalent Resistance Lab (Introduction to MATLAB) - Part the Second**

**Script Problem Instructions**

1. Combined Series and Parallel Network
2. Design an arrangement of the three resistors where some resistors are in series and some in parallel.
3. Draw hand schematic diagram of your network (similar to those in Figures 1 & 2) showing where the equivalent resistance is measured.

Check: Have the instructor check your circuit and diagram.

1. Develop a formula to calculate the equivalent resistance of this network.
Use to hand calculate the resistance.
2. MATLAB:
Use the comment template provided on the lab website ([www.etcs.pfw.edu/~moor/128Lab](http://www.etcs.pfw.edu/~moor/128Lab)). Calculate the equivalent resistance of your network with a MATLAB script (see example script).
3. Determining area and perimeter for a shape (another script problem)
Figure 3 shows an area consisting of a rectangle and a semicircle (i.e. a perfect half circle). It is desired to determine the area and the perimeter of this shape
	1. Develop equations for the area and for the perimeter of the shape as a function of W and L.
	2. Calculate these values for the case where W = 2, and L = 6 with a well presented hand calculation (i.e., including input values, formula used, and the calculation).
	3. Develop a script, using the script template file, to carry out these calculations. Use hard coded inputs, set to the values from part b. Execute the script. Copy the code and the execution to a word document for printing. Include a note describing how well the hand and MATLAB results compare.

**Figure 3:** This area consists of a standard rectangle and an exact half circle. The variables to be used in the script problem are shown.

Notes:

* **Pi:** The exact value of pi (π) is available in MATLAB by using the internal variable pi. For example, to calculate the circumference of a circle, 2 units in diameter, the MATLAB code could be:

>> radius = 1;

>> circumference = 2\*pi\*radius

* **Script Example:** On the back of the “MATLAB Introduction – Summary Page” there is an example of a MATLAB script that is likely to be helpful with problem 2.
* **Tutorial Worksheets:** Before Next week, some tutorial problems will be posted on the website to keep you building some comfort with MATLAB. They will be due in your lab the week of January 27th. The Tuesday labs on the 21st will be a chance to work on these problems with help. Monday lab students are welcome to attend one of the Tuesday labs on the 21st.

**Summary of Lab Deliverables: Due:** Tuesday, January 21st to lab instructor

1. Series-Parallel Equivalent Resistance Problem: Include the following elements:
	1. **Hand Calculation:**  Determine the formula and calculate the network resistance for your series & parallel network by hand. Present the hand calculation as a well-documented sample calculation including: 1) the input values, 2) the formula(s) used, and 3) the calculation with answer.
	2. **Network Schematic Diagram:** A computer drawn network schematic (e.g. drawn in Multisim) showing this network. Properly format as a figure with a caption.
	3. **Equivalent Resistance Script:** A script and its execution to calculate the equivalent resistance of the network. Use the script template. Compare to the hand calculation. Include a note describing how well the hand and MATLAB results compare.
2. Area and Parameter of a Compound Shape: the additional script problem should include:
	1. **Equations:** include clear presentations of the two equations (for area and for parameter)
	2. **Hand Calculation**: clearly present the calculation of area and parameter for W = 2 and L = 6. Present this calculation as in 1a above.
	3. **Script & its Execution:** Include a printout of the script and a copy of its execution in the command window. This print out must include the call to the script, the result of execution, and a note of its correspondence to the hand calculation.