Carleton UNIVERSITY

Department of Electronics

ELEC 4700
Assignment 2
Finite Difference Method

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1. <u>Introduction</u>

The second assignment of the semester involves the application of principles and concepts associated with Finite Difference Method to solve Laplace's Equation and perform atomistic simulations. The assignment comprises of 2 modules each requiring the application of the Finite Difference Method to Laplace's Equation for solving electrostatic problems.

The calculations, code and atomistic simulations required for this assignment were completed with the aid of MATLAB. The report discusses the techniques applied and results obtained after the completion of the assignment.

2. <u>Results and Discussion</u>

The assignment consisted of 2 sections requiring MATLAB programming for each. The sections covered in the assignment are:

- Finite Difference Method to determine Electrostatic Potential in a Rectangular domain.
- Finite Difference Method to determine Current Flow in a Rectangular domain.

The results obtained for each part have been discussed in this report.

1. <u>Electrostatic Potential Calculation</u>

The first segment of the assignment involved the determination of the electrostatic potential of a rectangular region of dimensions L x W using the Finite difference method. The ratio of L/W utilized was 3/2. The first part consisted of two different scenarios where the region was subject to different conditions.

a) $V = V_0$ at $x = 0$ and $V = 0$ at $x = L$

The conditions were set up and the case was treated as 1-D and solved through the process of iteration.

b) $V = V_0$ at $x = 0, x = L$ and $V = 0$ at $y = 0$, $y = W$

The conditions were set up and the case was treated as 1-D and solved through the process of iteration.

The results obtained have been compared with the analytical solutions and have been discussed in this section.

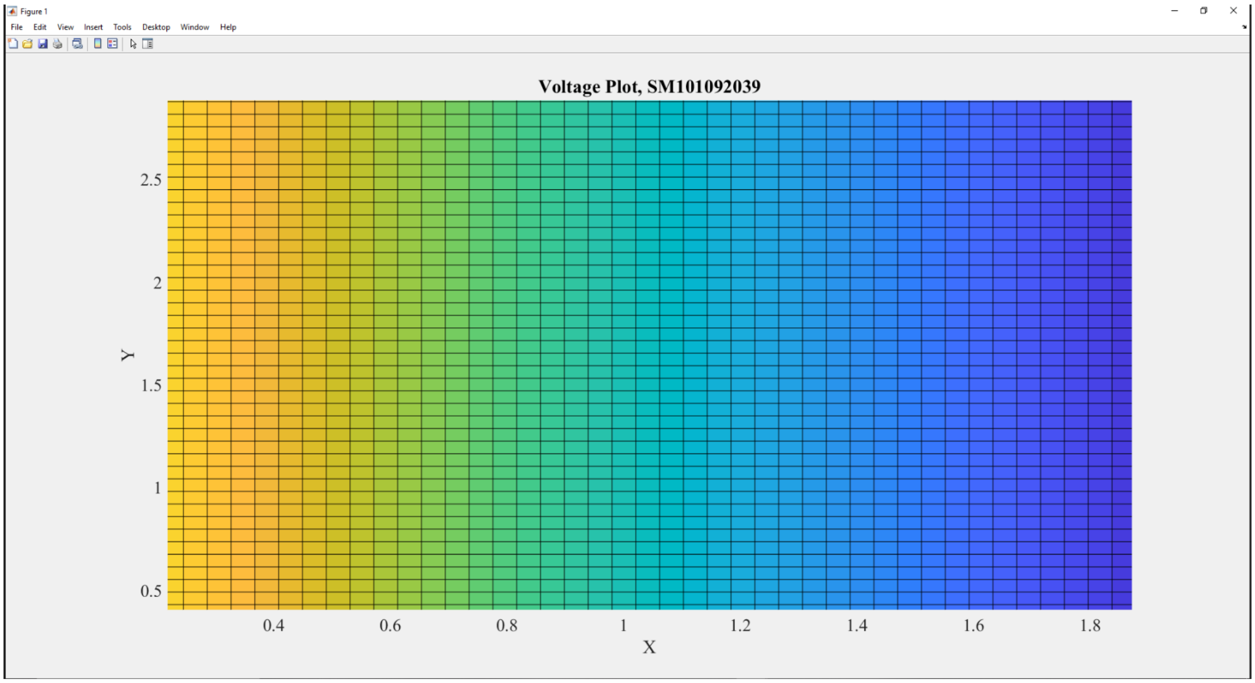

Figure 1: 2D Voltage Plot.

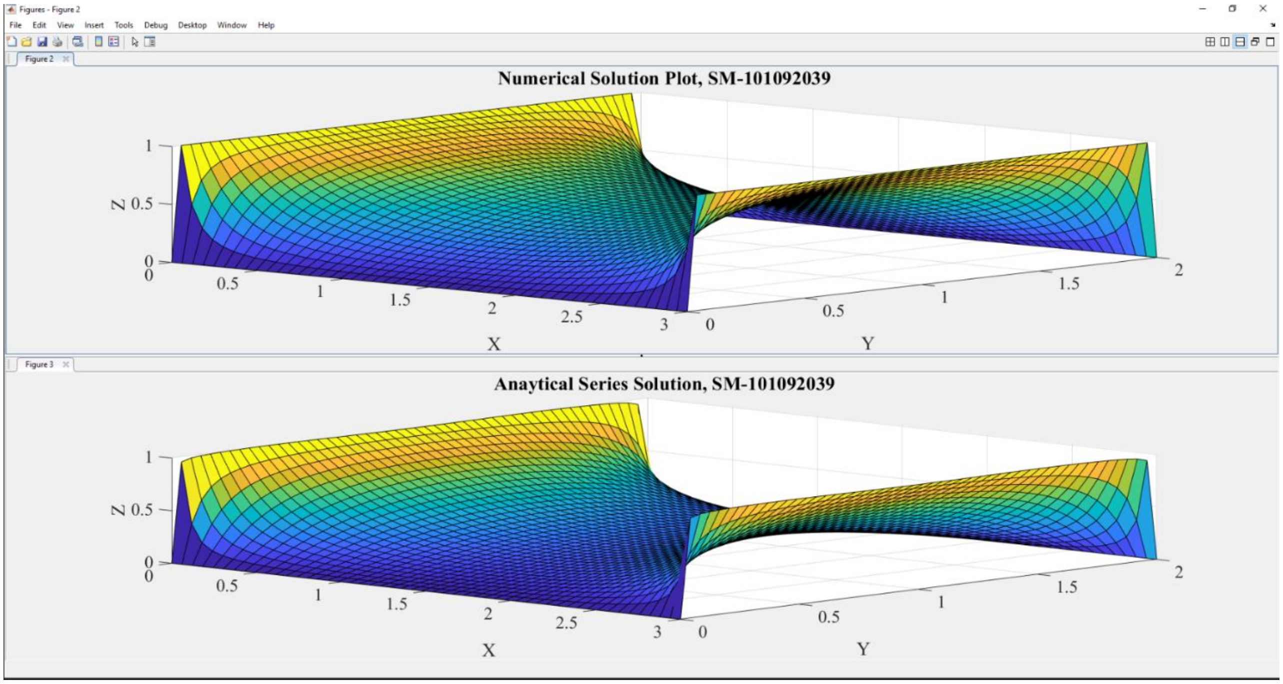

Figure 2: The Numerical and Analytical Solution Plots from the Calculation of Electrostatic Potential.

The analysis of the simulated data was utilized to draw comparisons between the numerical solution and the analytical solution. The numerical solution and analytical solution were consistent. However, the numerical solution requires larger storage capacity for its execution as creation of more G and F matrices is required. The analytical solution requires a relatively less memory allocation, however, some inconsistencies might be encountered as a complex problem set may require more memory for its execution which will result in incomplete calculations.

2. Current Flow Calculation

The second segment of the assignment involved the determination of the current flow through a rectangular region of dimensions L x W using the Finite difference method. The model was modified by the addition of two inner rectangular boxes to form a bottle neck structure. The current flow at the two contacts was determined. The module also required analysis of mesh density, the effects as a result of variations in the bottle neck model and the influence of a varying σ of the rectangular region. The results and plots obtained from the simulations have been discussed below.

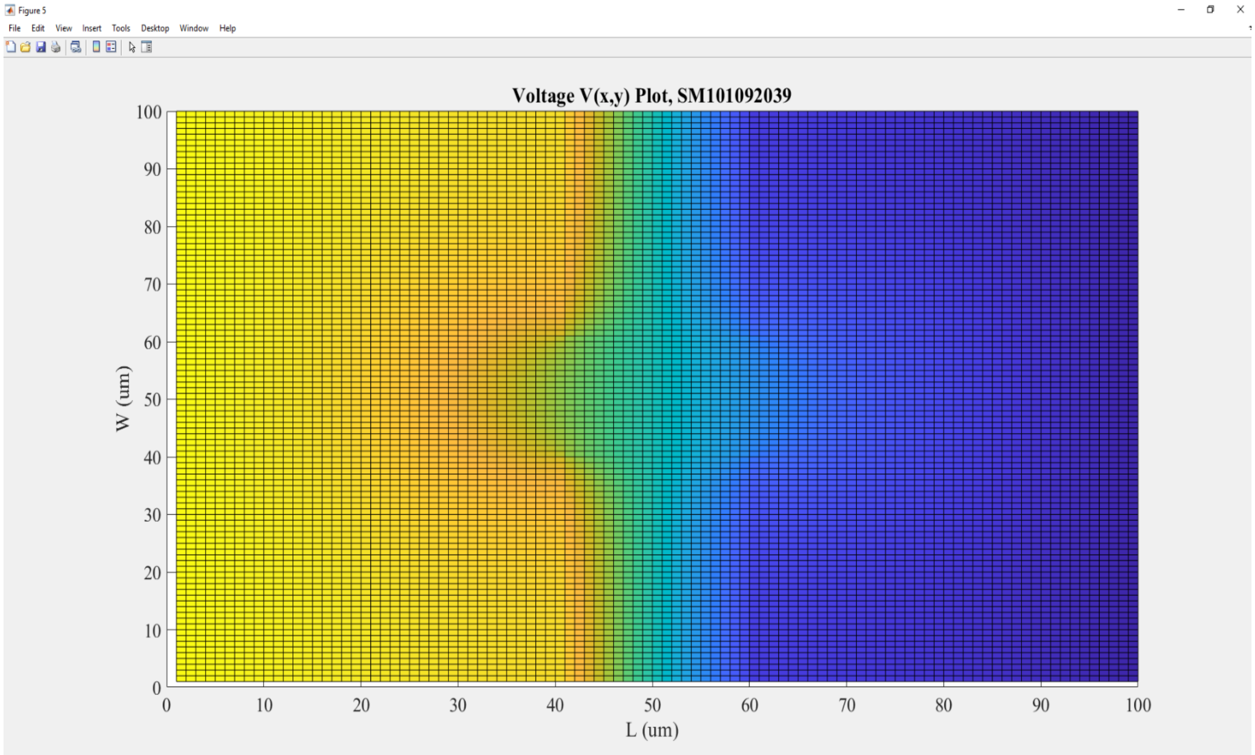

Figure 3: Voltage Plot as a result of bottle neck analysis

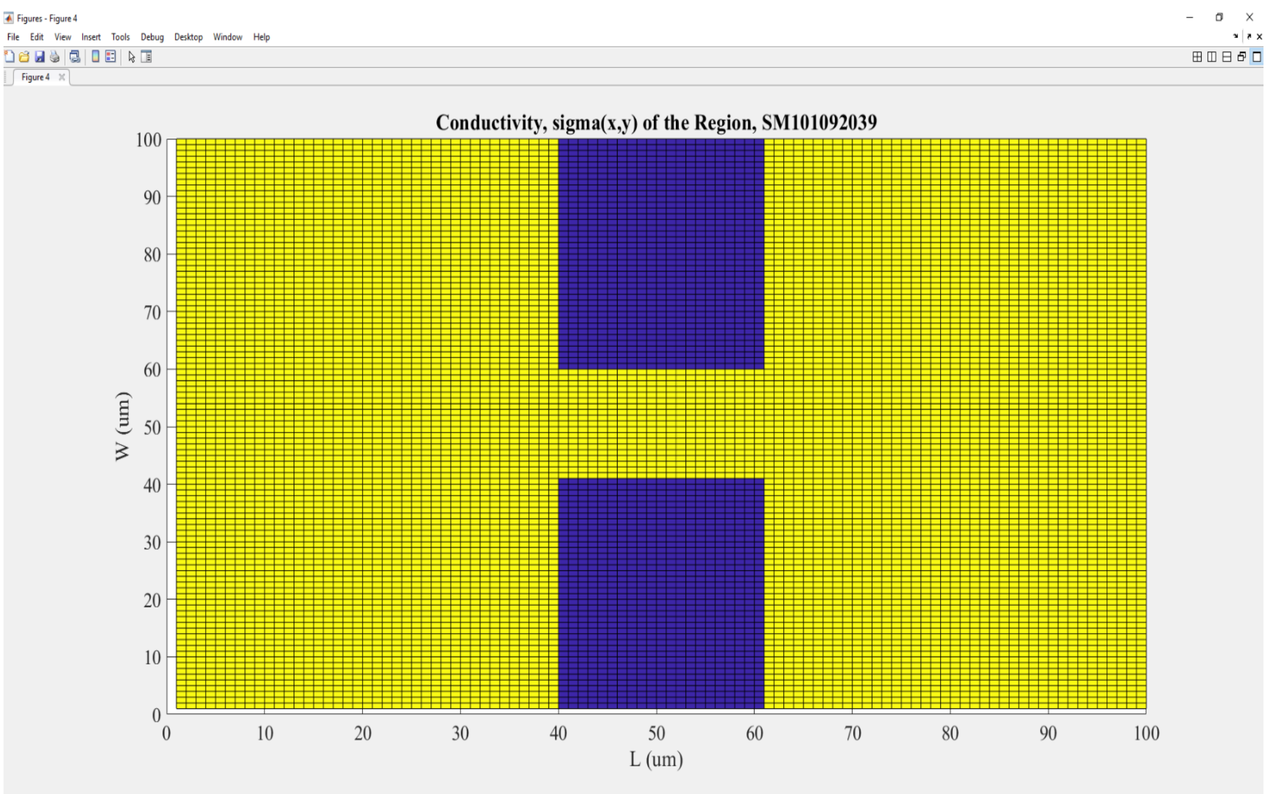

Figure 4: Plot of σ (x.y).

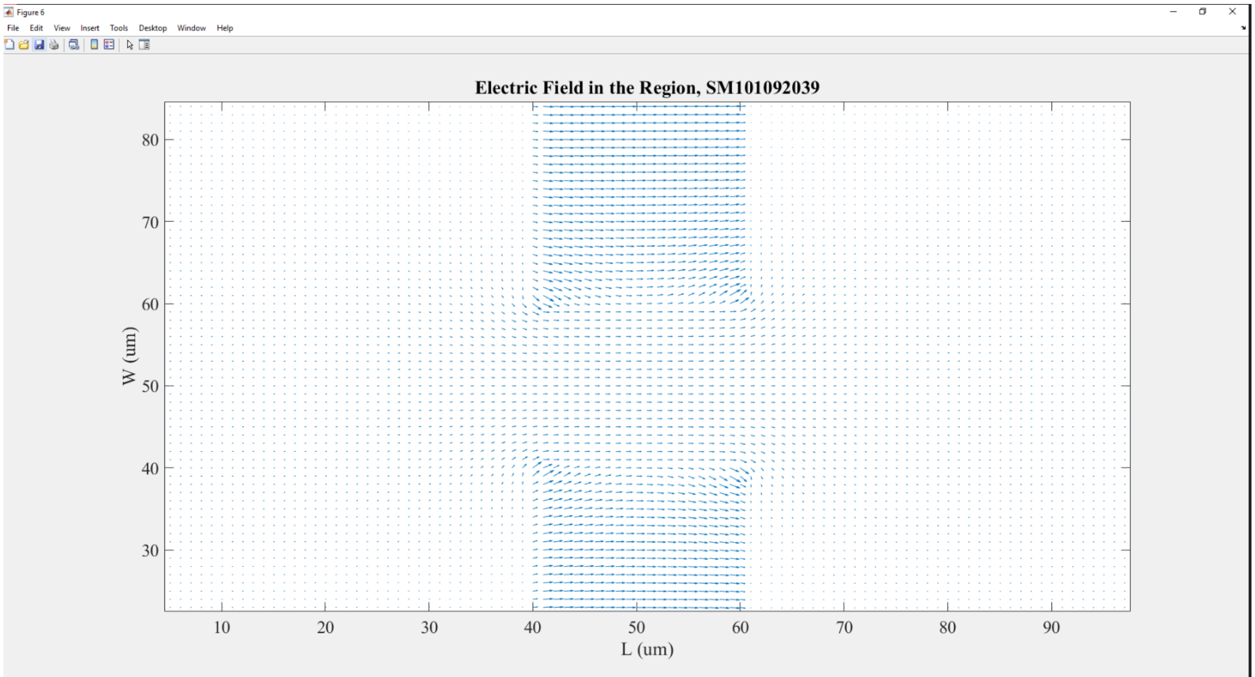

Figure 5: Electric Field Plot

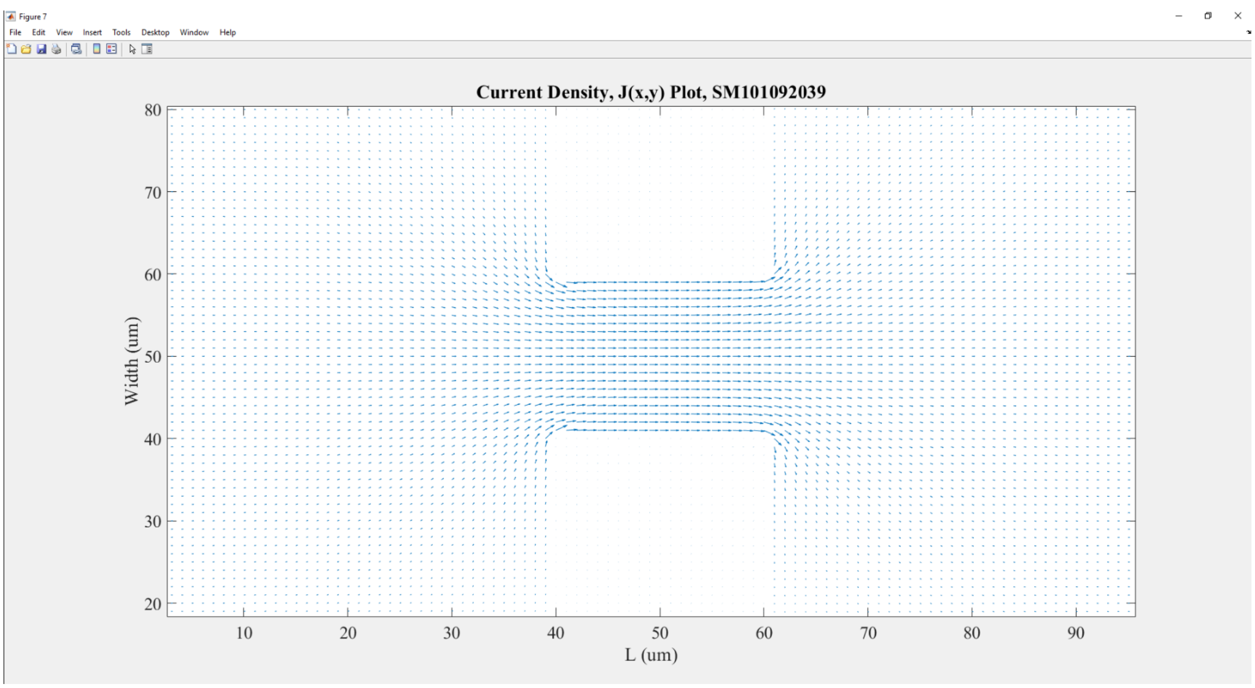

Figure 6: Current Density Plot of the region.

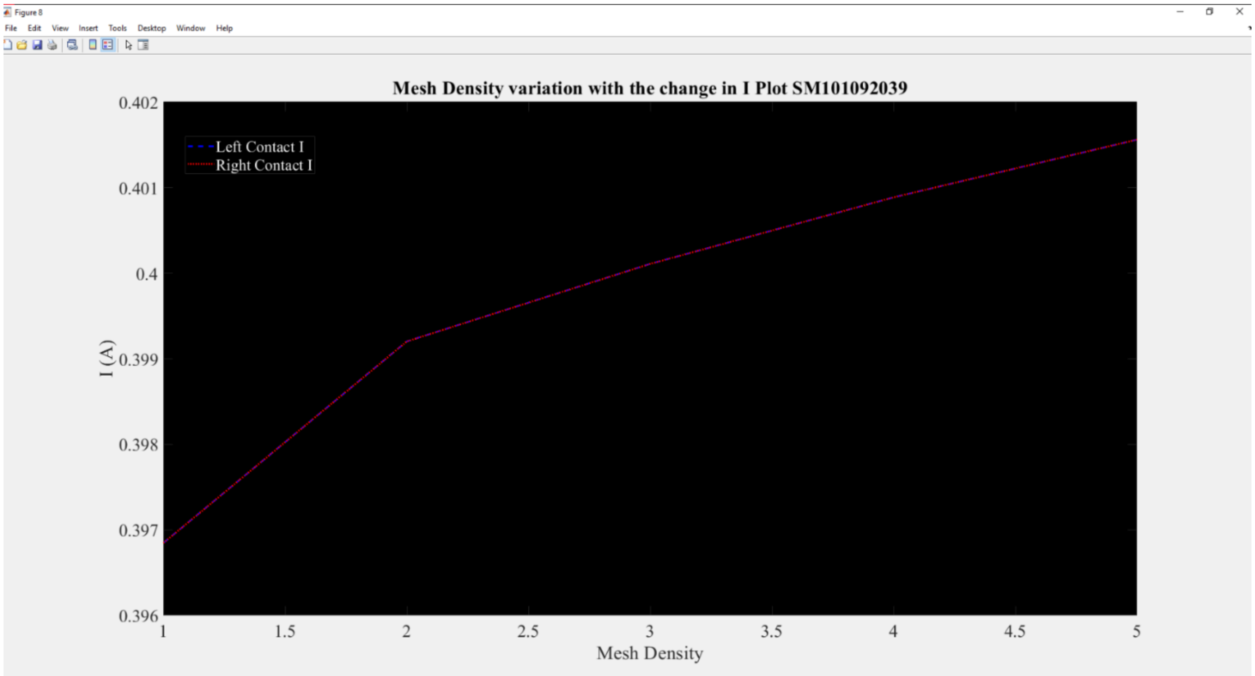

Figure 7: Plot of Current versus Mesh Size.

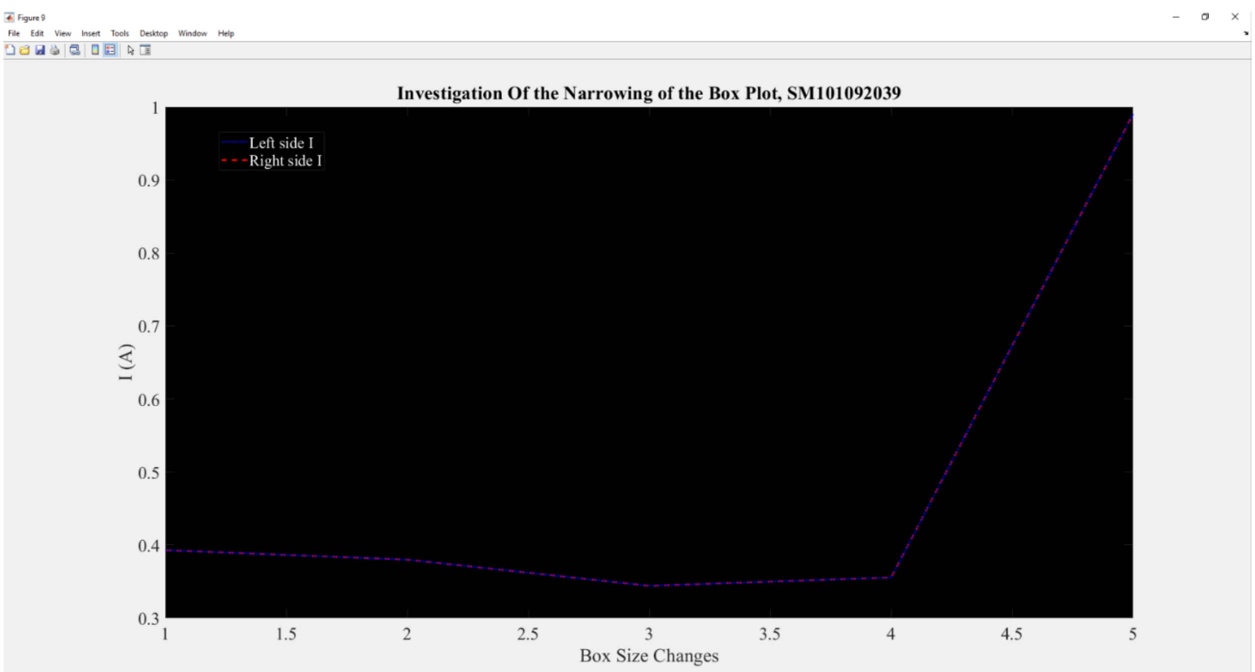

Figure 8: Plot of Current versus Varying Box Sizes.

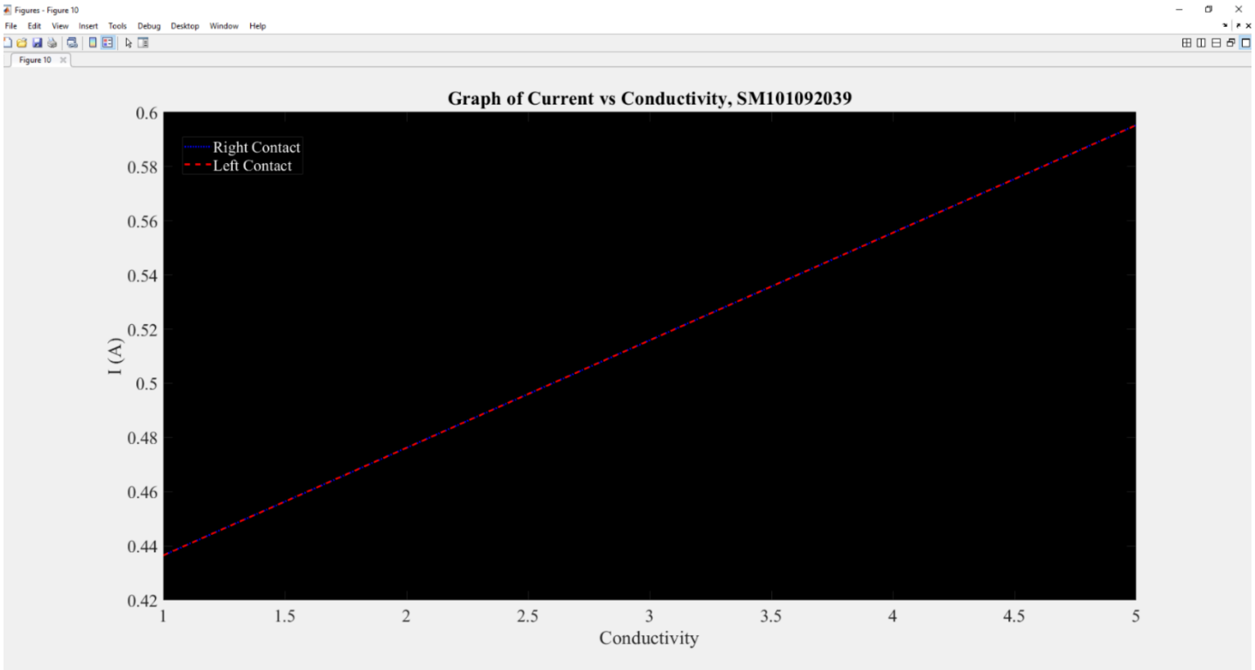

Figure 9: Plot of Current versus σ.

3. ***Conclusion***

The primary objective of the assignment was to utilize the Finite Difference Method to solve Laplace's Equation to solve problems associated with electrostatic potential and current flow through a region. The assignment provided a great opportunity to experiment and understand the concept Finite Difference Method. The code was assembled, and a separate file has been prepared which will be attached with the report and submitted on GitHub as well as CuLearn.