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```
clear all
close all
clc

cd code
```

# Introduction

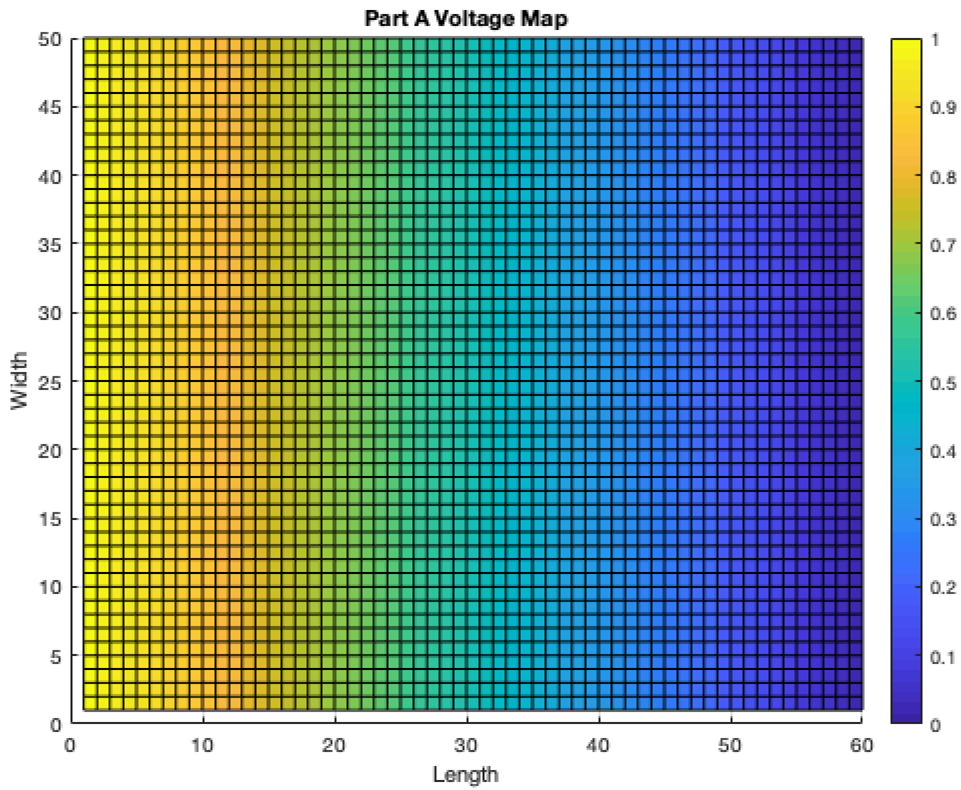
The purpose of assignment 2 was to solve Laplace's equation using finite difference method for electrostatic potential problems.

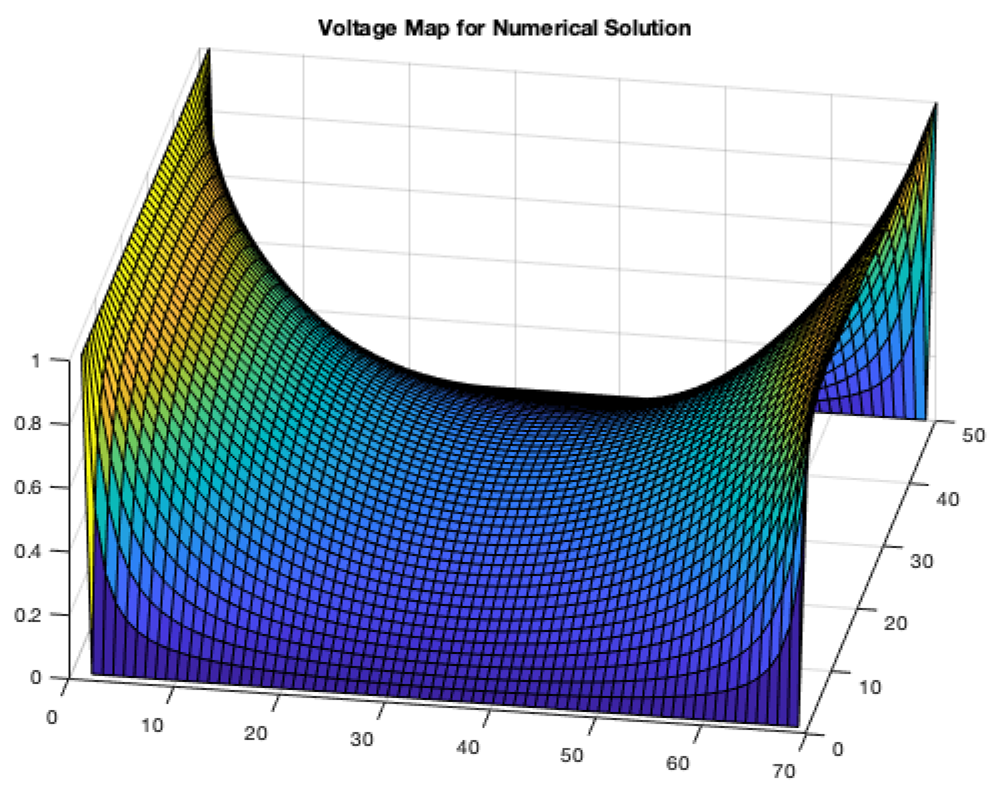
# Part 1 Introduction

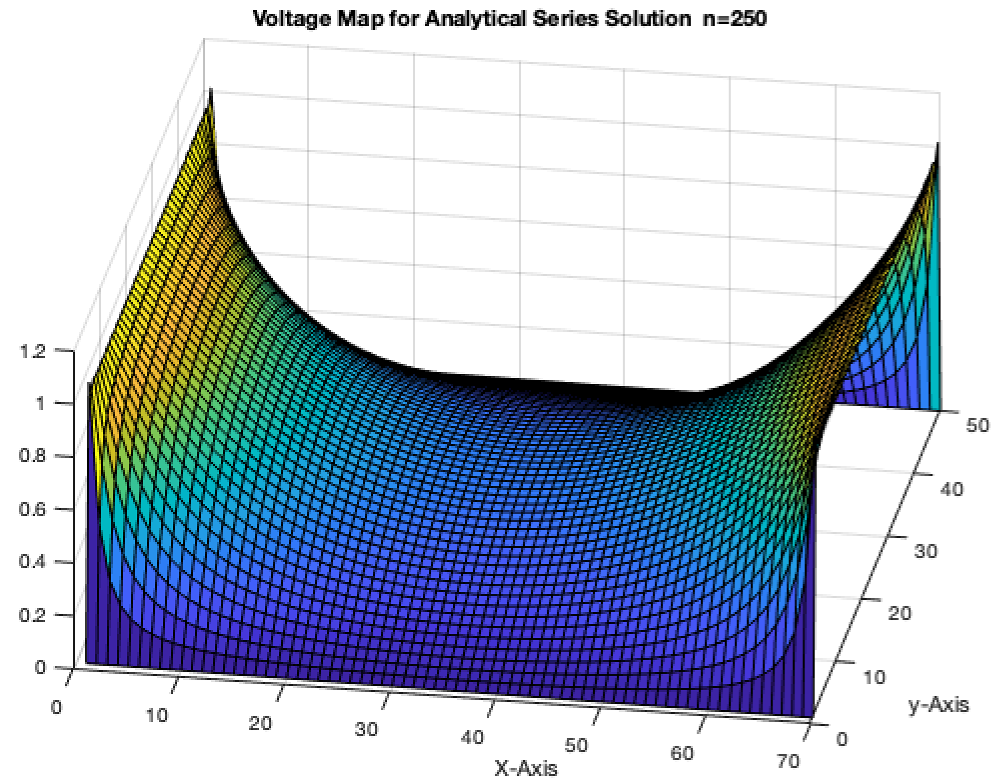
The first objective of part one was to solve for the voltage map when V = 1 Volt at x=0 and V = 0 volts at x = L. The top and bottom boundary conditions where set so that dV/dy = 0. The second objective of part one was to solve for the voltage map when V = 1 volt at x=0, x=L and V= 0 volts at y =0, y =W. The numerical solution was then compared with the analytical series solution in order to determine to what extent they agree with each other. The conduction within the rectangular region was set to one everywhere.

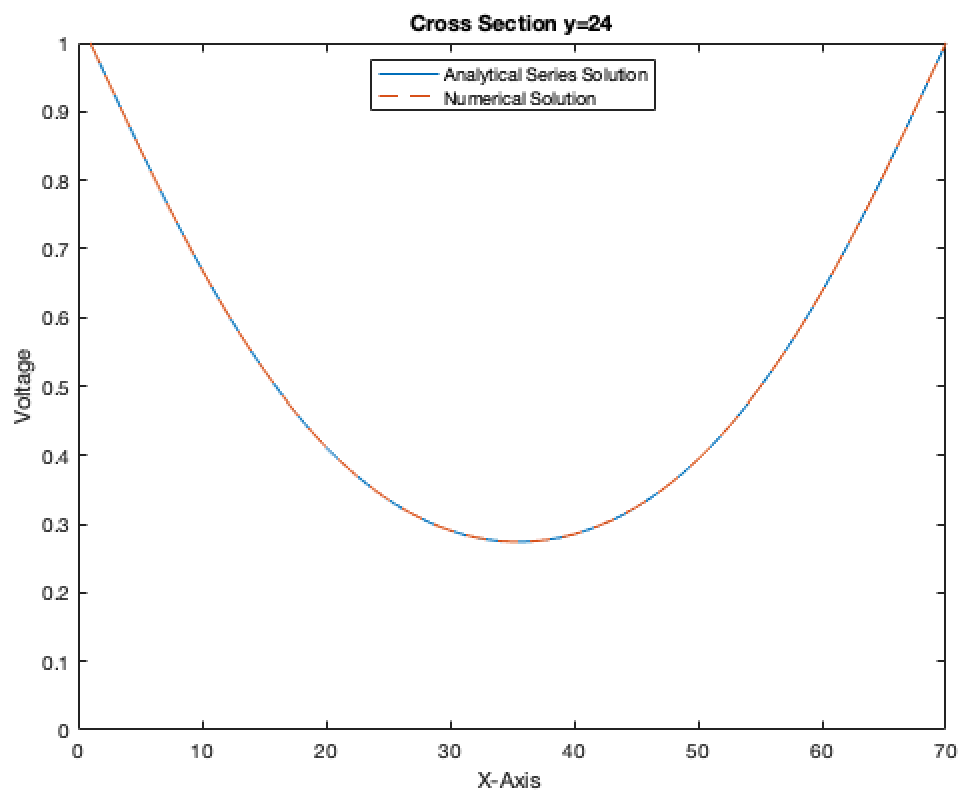
# Part 1 Figures and Command Line Outputs

```
cd part_1_final

part1

cd ..
```


Part A Voltage Map
Width
Length
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Voltage Map for Numerical Solution
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
60
70
0
10
20
30
40
50


Voltage Map for Analytical Series Solution n=250
X-Axis
y-Axis
0
0.2
0.4
0.6
0.8
1
1.2
0
10
20
30
40
50
60
70
0
10
20
30
40
50


Cross Section y=24
Analytical Series Solution
Numerical Solution
Voltage
X-Axis
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70

# Part 1 Conclusion

The results of part 1 are as expected. The voltage map relating to the first objective changed linearly in x, constant in y, and satisfied the boundary conditions. This makes sense given the conduction was the same everywhere and the geometry of the problem. The numerical solution voltage map relating to the second objective strongly resembles the analytical series solution for large n. One disadvantage of the numerical solution is that it requires large amounts of memory in order to store the various matrixes. Another disadvantage of the numerical solution is it requires a numerical computing environment that can invert large matrices. An advantage to the numerical solution is it is very fast. One disadvantage of the analytical series solution is for large n the analytical series may not be able to be evaluated. For the analytical series solution provided error began to occur around n=250. Another disadvantage of the analytical series solution is for some problem geometries an analytic series solution can be incredibly tricky or imposable to produce. One advantage of the analytical series solution is that it does not require large amounts of memory or the ability to invert large matrices.

# Part 2 Introduction

The first objective of part two was to create a model where V = 1 Volt at x=0 and V = 0 volts at x = L. The top and bottom boundary conditions where set so that dV/dy = 0. Two boxed areas where also added with low conductivity which created a bottleneck. A voltage map, conductivity map, electric field vector plot, and current density vector plot was then determined for the given model. The second objective of part two was to analysis how meshes density, barrier size, and barrier conductivity effects current.

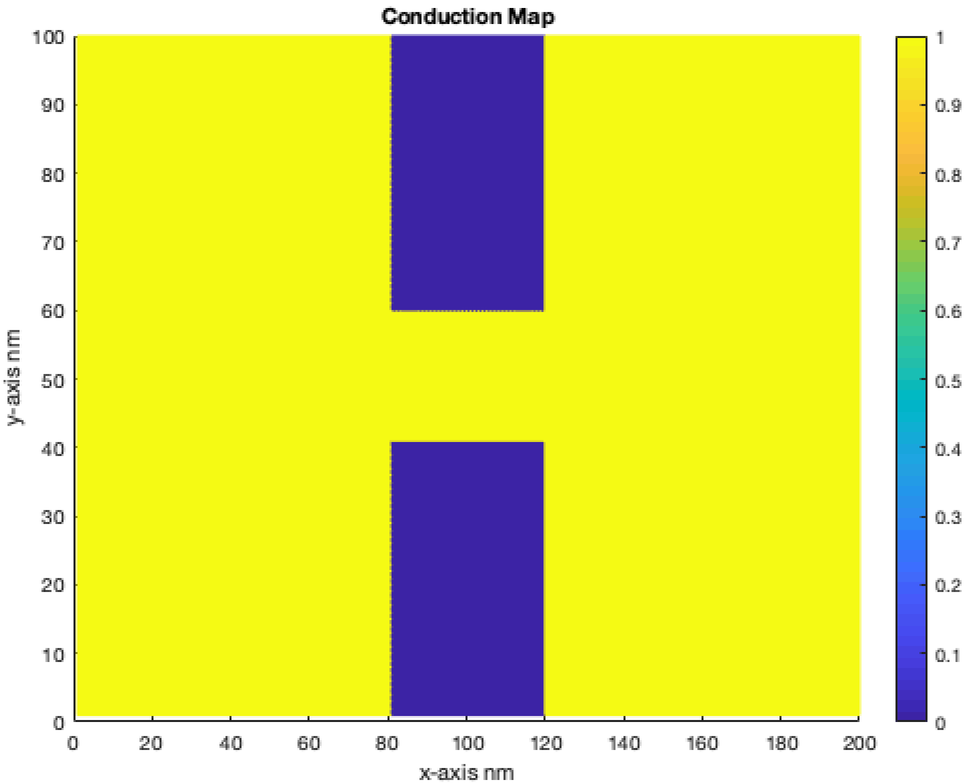
# Part 2 Figures and Command Line Outputs

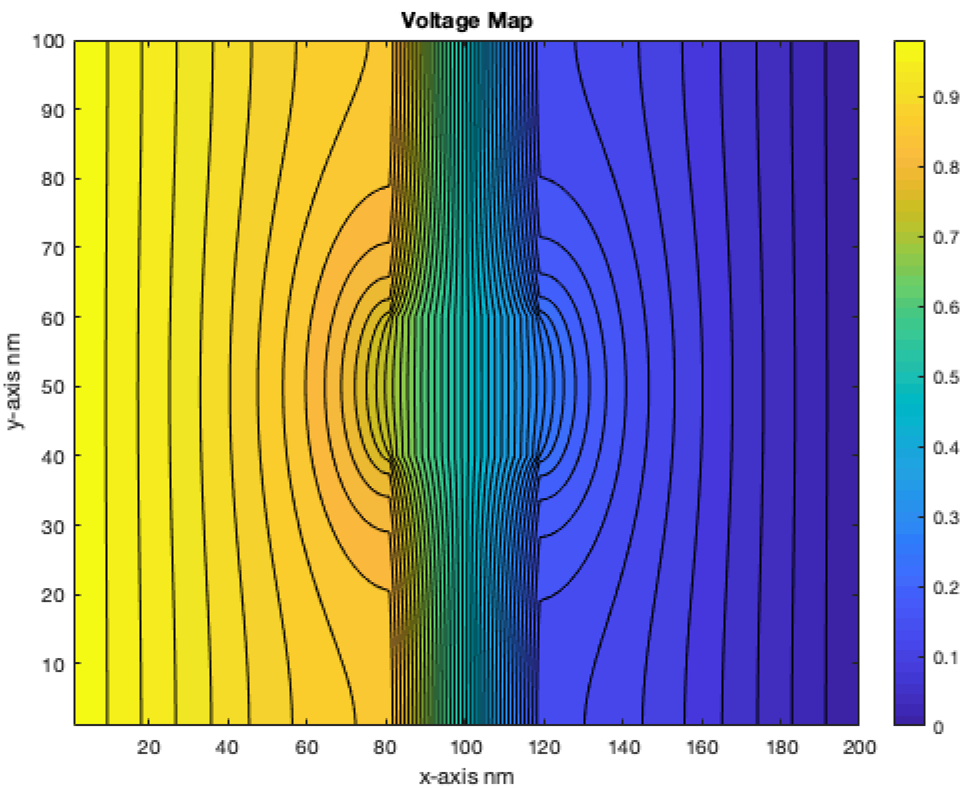
```
cd part_2_final
```

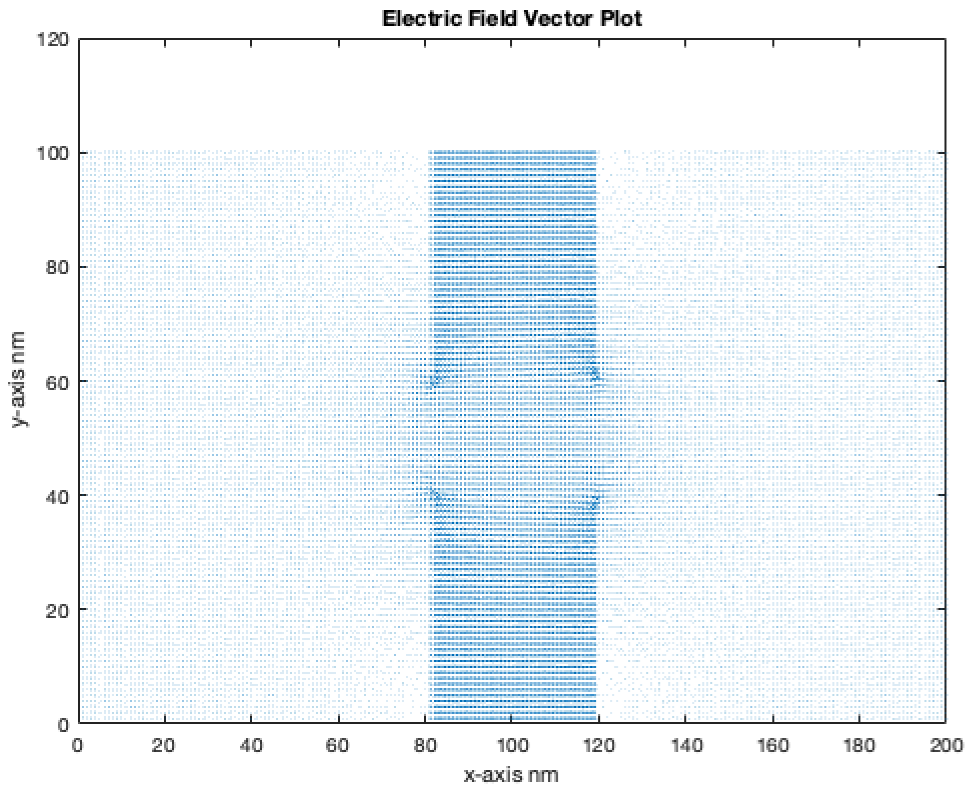
```
part2
```

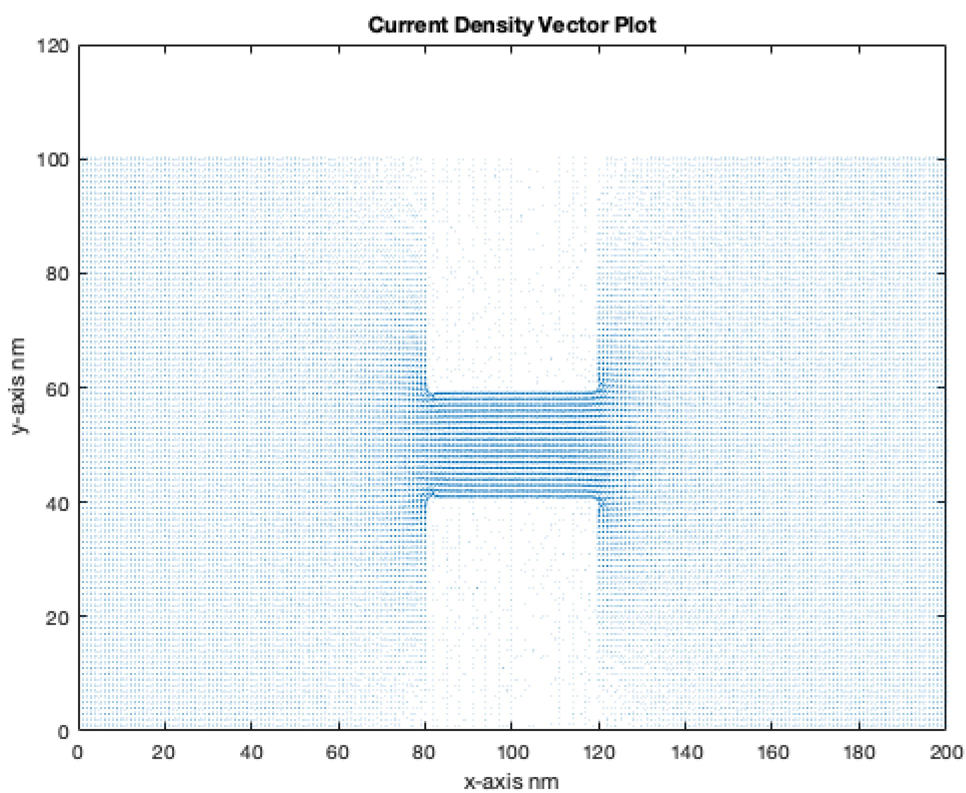
```
cd ..
```

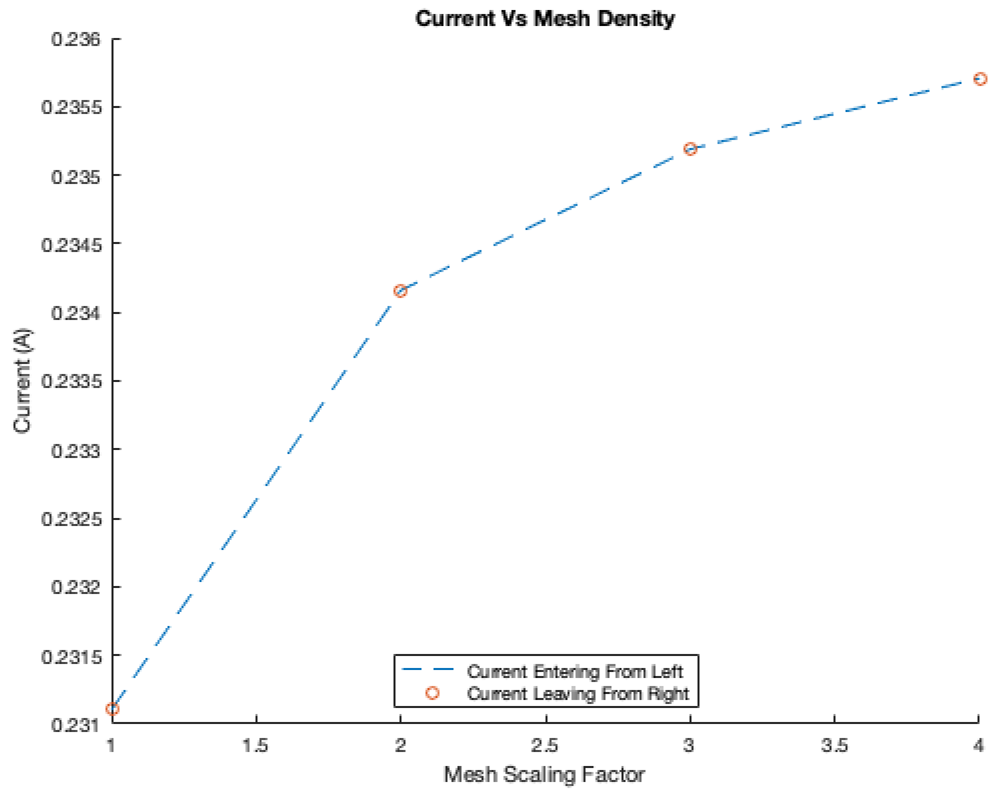
```
The left side calculated current density is 2.34e-03 A/nm^2
The right side calculated current density is 2.34e-03 A/nm^2
```

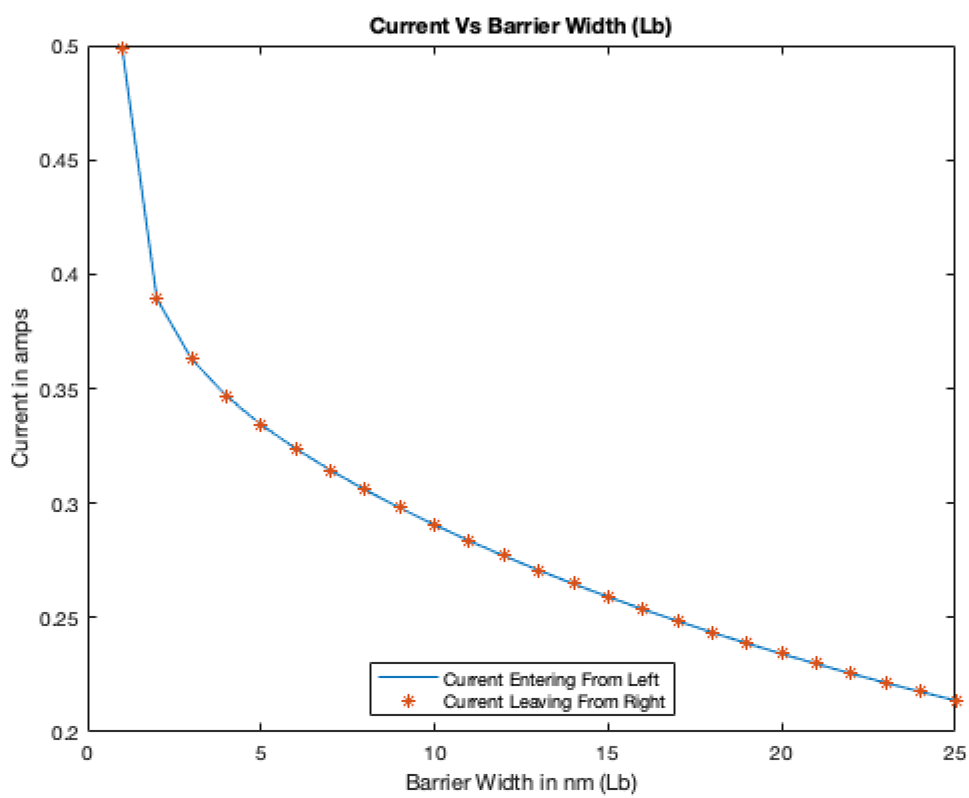

Conduction Map
y-axis nm
x-axis nm

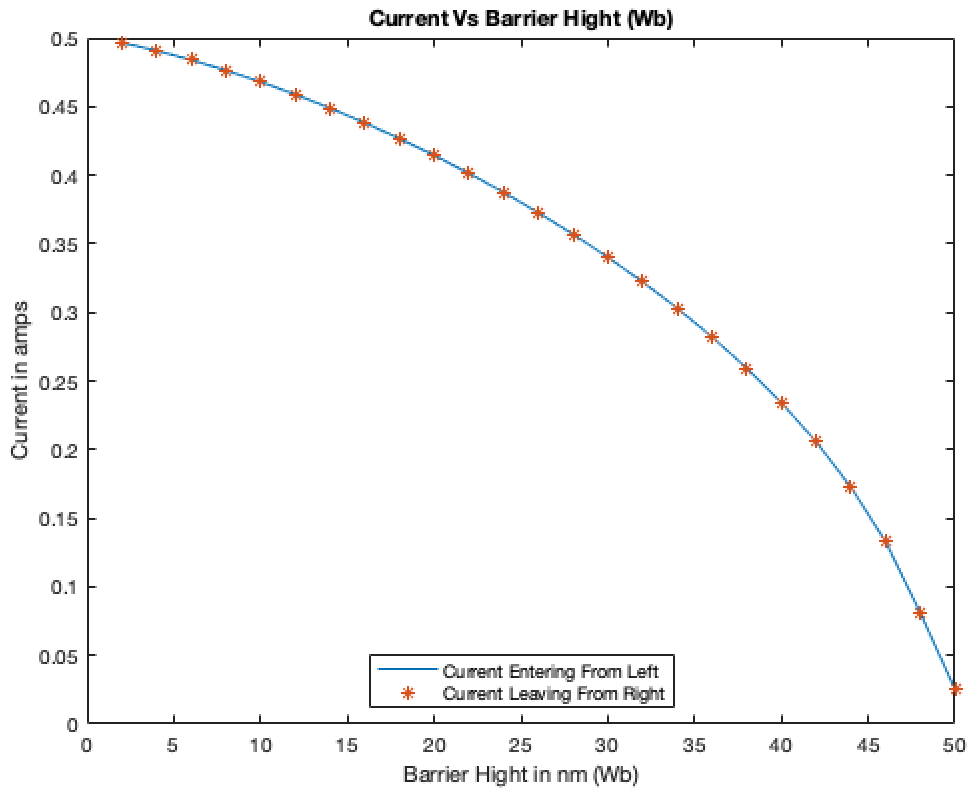

Voltage Map
y-axis nm
x-axis nm

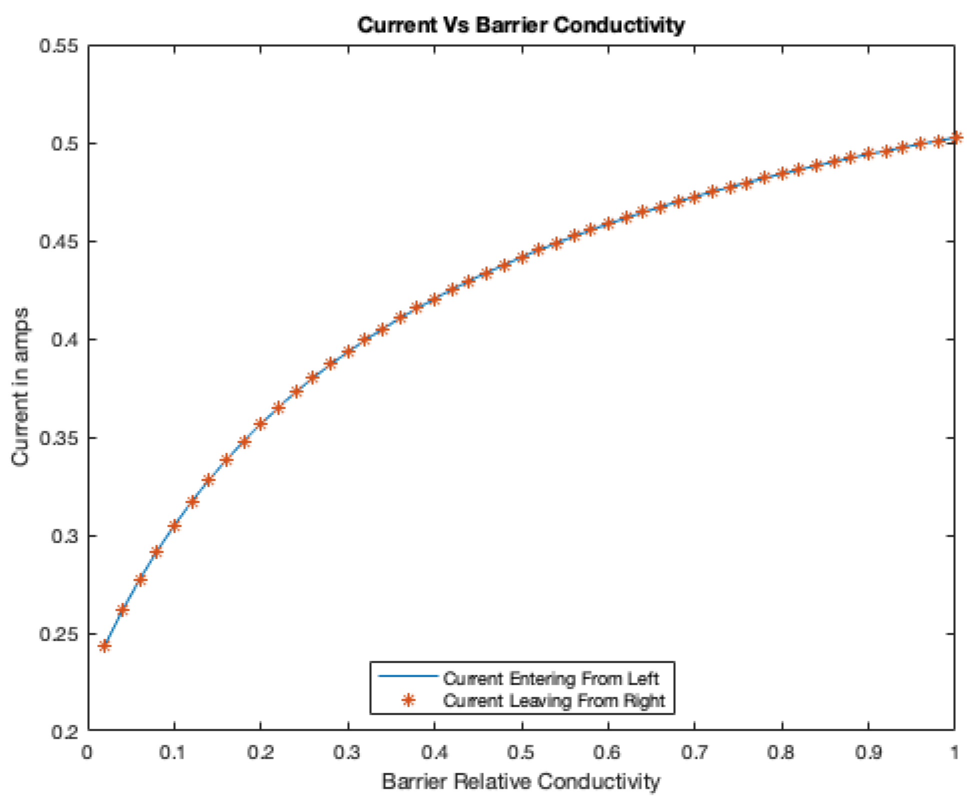

Electric Field Vector Plot
y-axis nm
x-axis nm
0
20
40
60
80
100
120
140
160
180
200


Current Density Vector Plot
y-axis nm
x-axis nm
0
20
40
60
80
100
120
140
160
180
200


Current Vs Mesh Density
Current (A)
Mesh Scaling Factor
Current Entering From Left
Current Leaving From Right


Current Vs Barrier Width (Lb)
Current in amps
Barrier Width in nm (Lb)
Current Entering From Left
Current Leaving From Right


Current Vs Barrier Hight (Wb)
Current in amps
Barrier Hight in nm (Wb)
Current Entering From Left
Current Leaving From Right
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
35
40
45
50


Current Vs Barrier Conductivity
Current in amps
Barrier Relative Conductivity
Current Entering From Left
Current Leaving From Right
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

# Part 2 Conclusion

The results of part two are as expected. The voltage map relating to the first objective changed quickly near the barrier and satisfied the boundary conditions. The voltage changing quickly near the barrier makes sense given the resistance is large near the barrier and ohms law states that the voltage drop is proportional to resistance. The electric field in general points from left to right and are strongest at the barrier corners. The electric field is also strong within the barrier. This result agrees with theory as areas with high resistance and constant current have relatively large magnetic field strengths. Current density is very large between the two barriers and small within the barriers. This makes sense, as current will follow through the area with the least resistance. The current density was calculated to be 2.34e-3 A/nm^2 on both the left and right side. This makes sense, as all current following from the left side must leave through the right side due to the upper and lower boundary conditions. For objective two when the mesh size is increased the current appears to converge. This makes sense because as the mesh size increases the model becomes a better approximation of reality. As barrier width is increased the current appears to drop quickly and then slowly. This makes sense because as the barrier width increases the overall resistance increase rapidity and then slowly. As barrier height is increased the current appears to drop slowly and then quickly. This makes sense because as the barrier height increases the overall resistance increase slowly and then quickly as the bottleneck shrinks. As barrier conductivity is increased the current appears to increase quickly and then slowly. This makes sense because as the barrier conductivity increases the overall resistance decreases quickly and then slowly.

# Conclusion

Overall Assignment 2 was a success. I was able to complete every objective and my results match my expectations.

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