Assignment #3 with Fixes to #1 and #2

ELEC 4700

Modelling of Integrated Devices

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ASSIGNMENT #1

P1.Q1.

Vth = 1.87e+5 V

```
q_0 = 1.60217653e-19;            % electron charge
%hb = 1.054571596e-34;            % Dirac constant
%h = C.hb * 2 * pi;               % Planck constant
m_0 = 9.10938215e-31;            % electron mass
kb = 1.3806504e-23;              % Boltzmann constant
%eps_0 = 8.854187817e-12;         % vacuum permittivity
%mu_0 = 1.2566370614e-6;          % vacuum permeability
%c = 299792458;                   % speed of light
%g = 9.80665;                     % metres (32.1740 ft) per s²
Ne = 2.7182818;                   % eulers number
tm = 0.2e-12;                      % Mean Collision time

%CONSTANTS
Vth = sqrt(2 * kb * 300/ (0.26 * m_0));
```

Figure 1. Constants and Code for Vth

P1.Q2.

Mean free path using mean time between collision as 0.2ps is 3.7404e-08s

```
%MEAN FREE PATH CALCULATED
MFPCalc = Vth * 0.2e-12
```

Figure 2. Code for MFP

P1.Q3.

Attached File "Assignment1Fixed.m". Set all flags to zero as seen below.

```
%FLAGS

ScatterFlag = 0;
BoxFlag = 0;
ReflectFlag = 0;
InjectFlag = 0;
```

Figure 3. Flag Setting for P1.Q3.

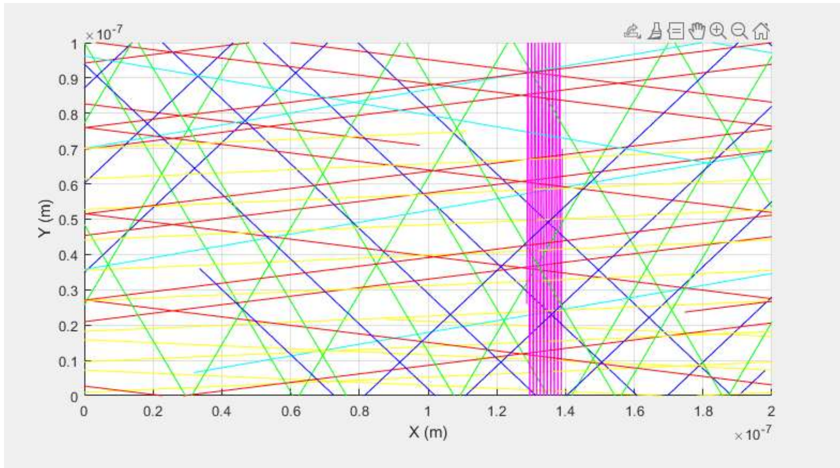

Figure 4. 2-D Plot tracking Particles.

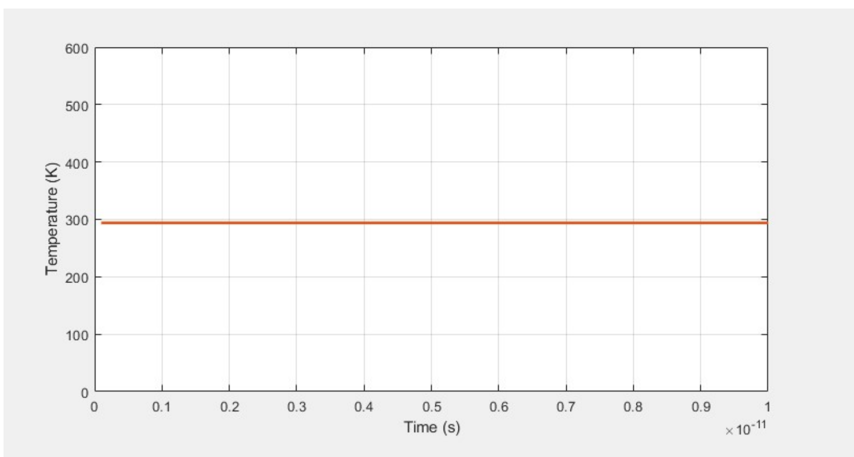

Figure 5. 2-D Plot tracking Temperature.

```
%% Calculations

VAvg = (sqrt((abs(Vx)).^2 + (abs(Vy)).^2)); % get current average Velocity
TAvg = mean((VAvg.^2 .* (0.26*m_0))/ (2 * kb)); % get current average Temp
```

Figure 6. Code Showing how Temp is found

P2.Q1.

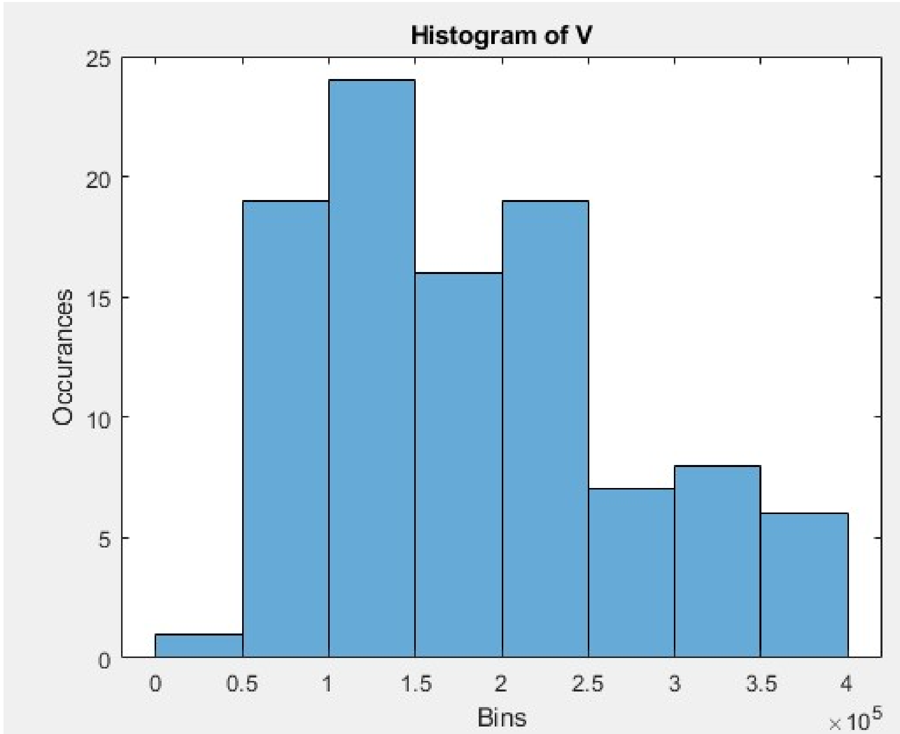

Figure 7. Histogram of V

P2.Q2.

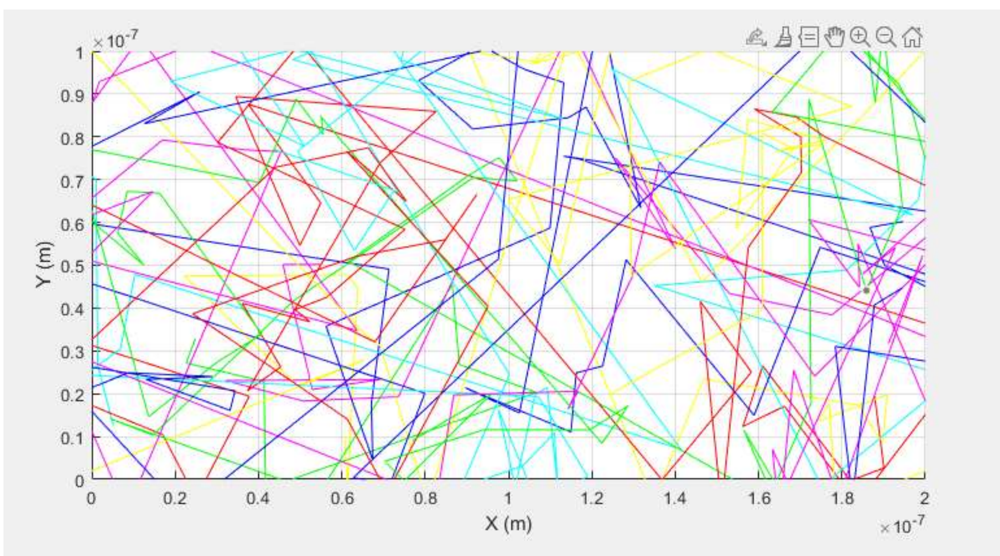

Figure 8. 2-D plot tracking Particles

P2.Q3.

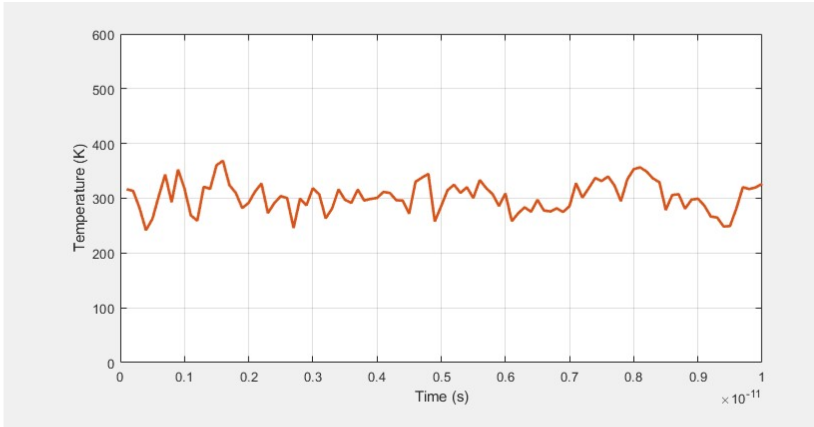

Figure 9. 2-D plot tracking Temperature

P2.Q4.

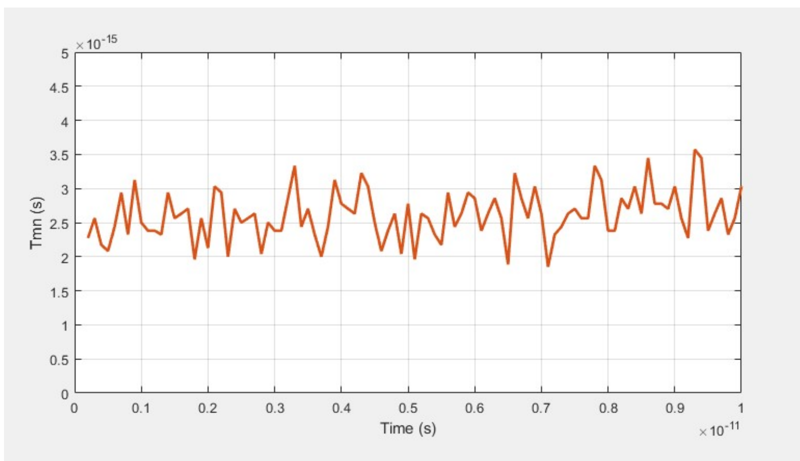

Figure 10. 2-D plot tracking MFP

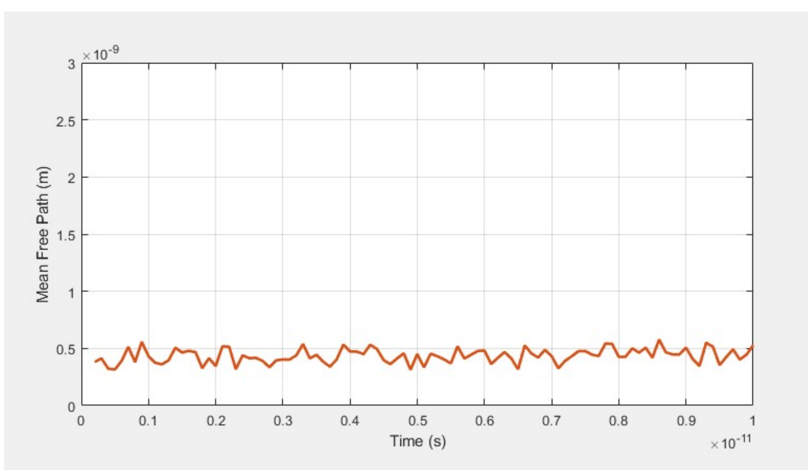

Figure 11. Code for Tmn

```
for i=1:1:nElecCount

    if ScatterFlag == 1
    %Scatter Test
    rScat = rand(1,nElecCount);
    if rScat(i) <= pScat
    scattercount = scattercount+1;
    Vx(i) = Vth/sqrt(2) * randn();
    Vy(i) = Vth/sqrt(2) * randn();
    end
    end
```

Figure 12. Code for Scatter Checking

```
%% Calculations

VAvg = (sqrt((abs(Vx)).^2 + (abs(Vy)).^2)); % get current average Velocity
TAvg = mean((VAvg.^2 .* (0.26*m_0))/ (2 * kb)); % get current average Temp
MFPcurrent = mean(VAvg) * dt / scattercount; % gets current MFP
Tmn = dt / scattercount; % gets Tmn
TempPlot(count,:) = TAvg; % store array of Temp
TmnPlot(count,:) = Tmn;  % store array of Tmn
scatterPlot(count,:) = ScatterAvg; % store array of scatter probabilities
timePlot(count,:) = [t]; % store array of times
MFP(count,:) =  MFPcurrent; % length of paths / number of scatters
```

Figure 12. Code for Calculating Values for MFP Tmn, and Temp

P3.Q1. INJECTION

Set all Flags to 1

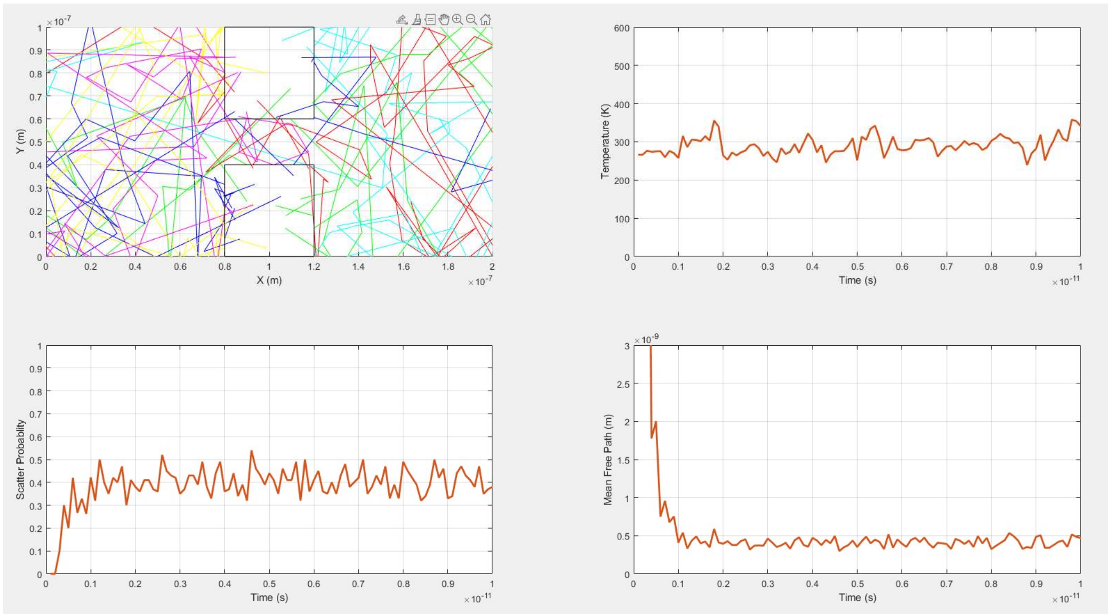

Figure 12. Plots for Part 3

ASSIGNMENT #2

P1.Q1.

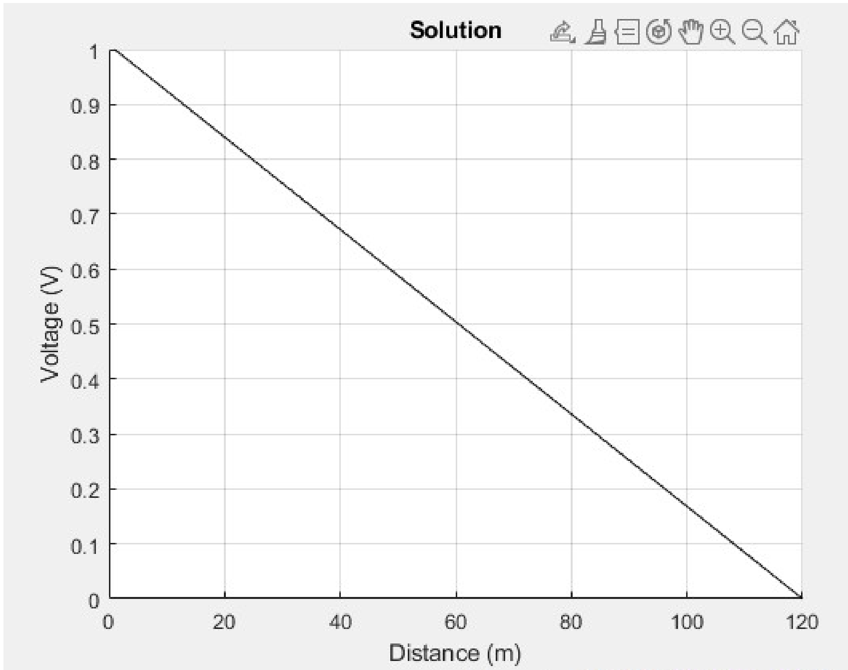

Figure 13. 2-D Plot of V

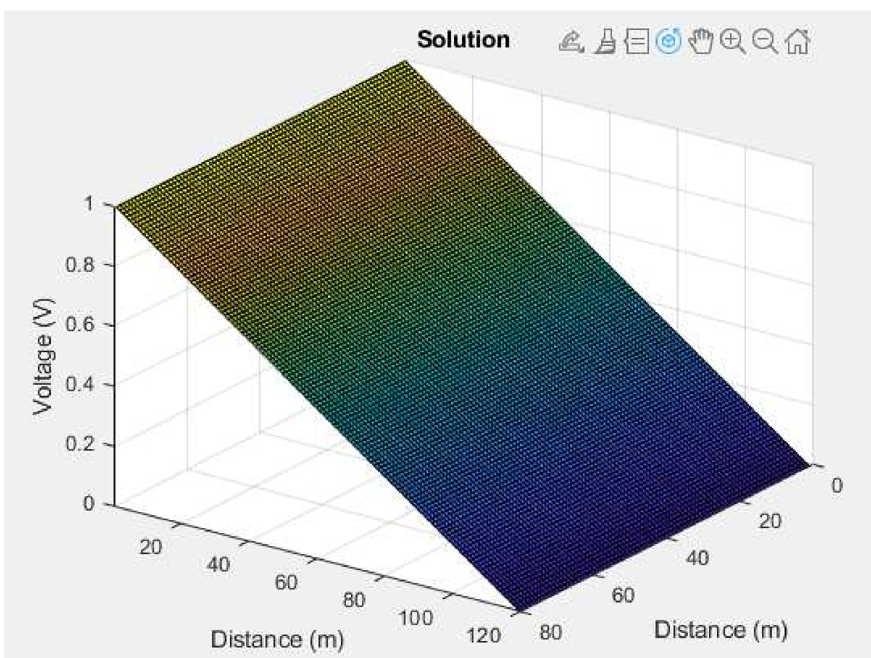

Figure 14. 3-D Plot of V

P1.Q2.

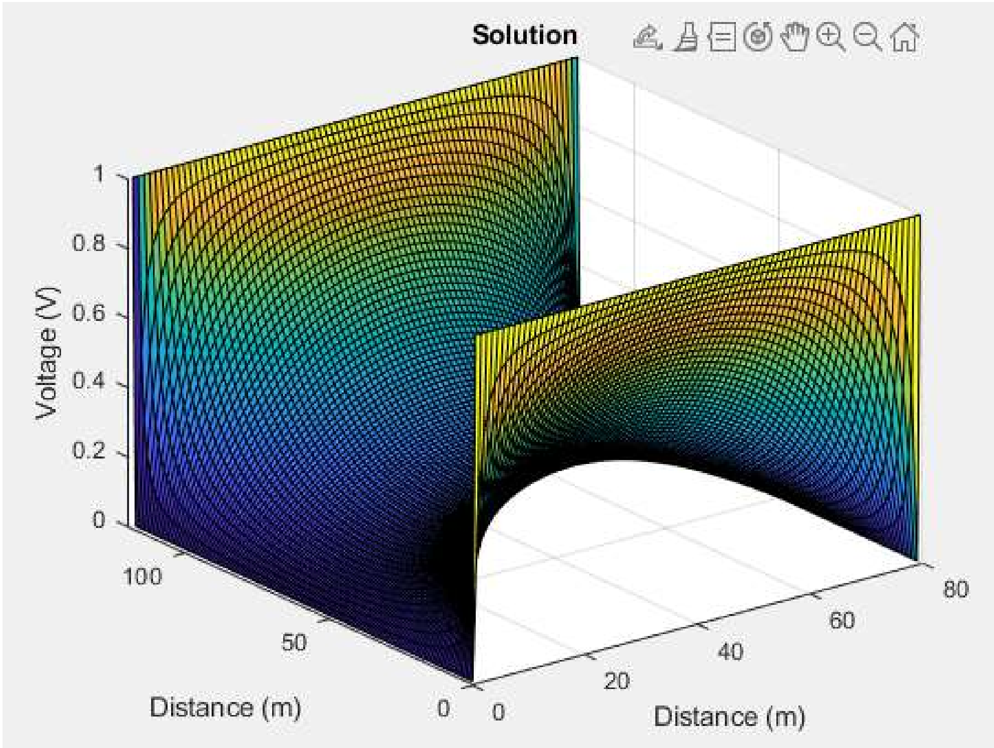

Figure 15. 3-D Plot of V with meshing

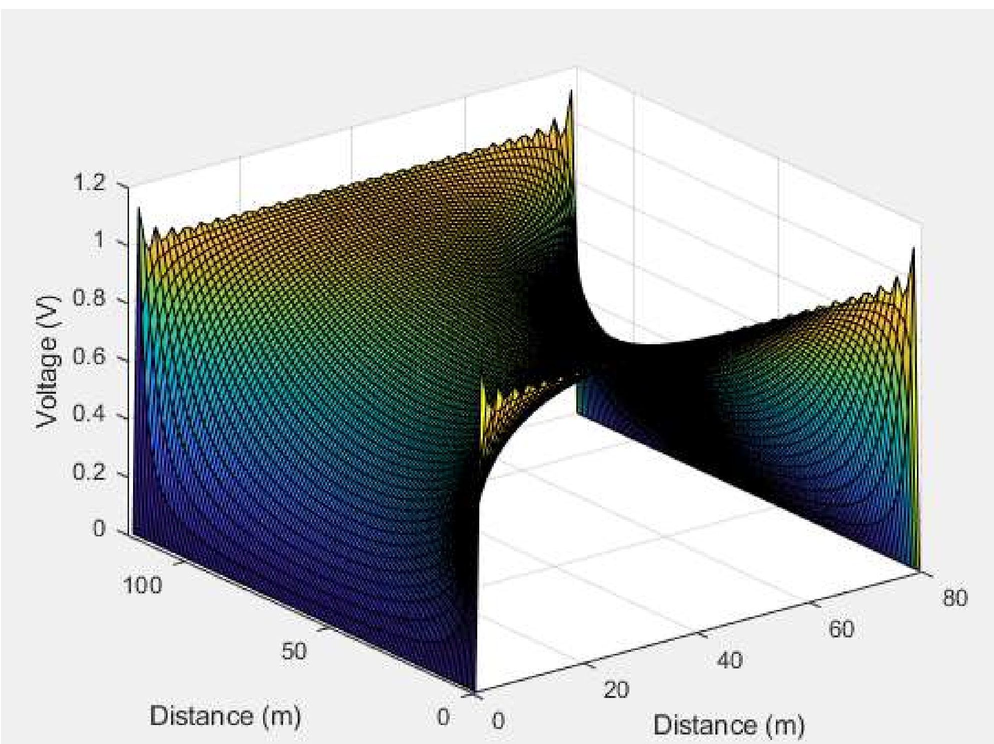

Figure 16. 3-D Plot of V using analytical

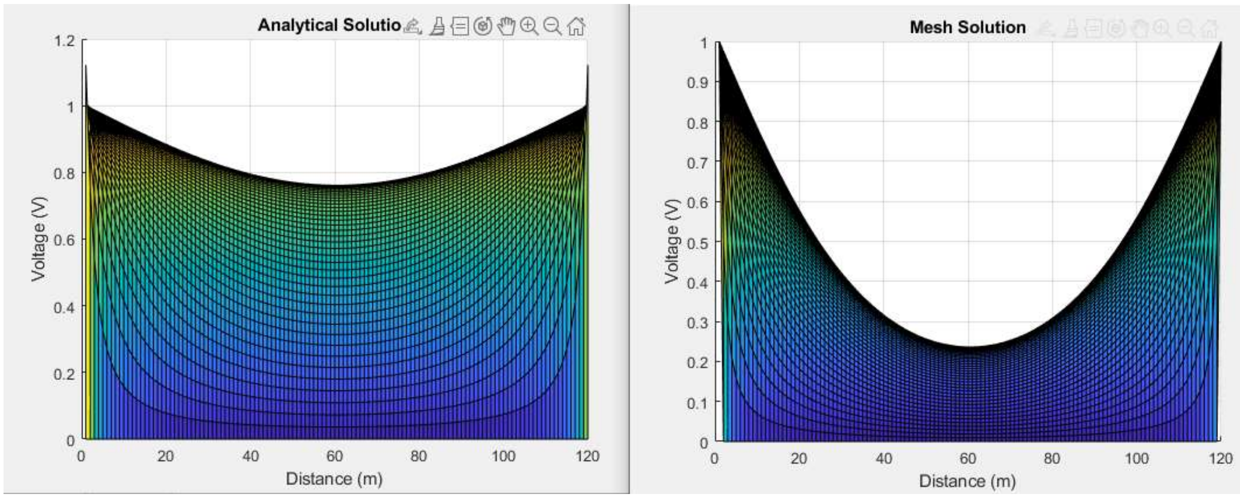

Figure 16. 3-D Plot of V with both solution methods

Meshing and analytical Solution yield similar results. A key difference is that the analytical solution does not have points on its boundary conditions and the values at the corners go above the boundary condition. Another difference is the middle of the 2 solutions. In analytical the values are significantly higher than the meshing solution.

P2.Q1.

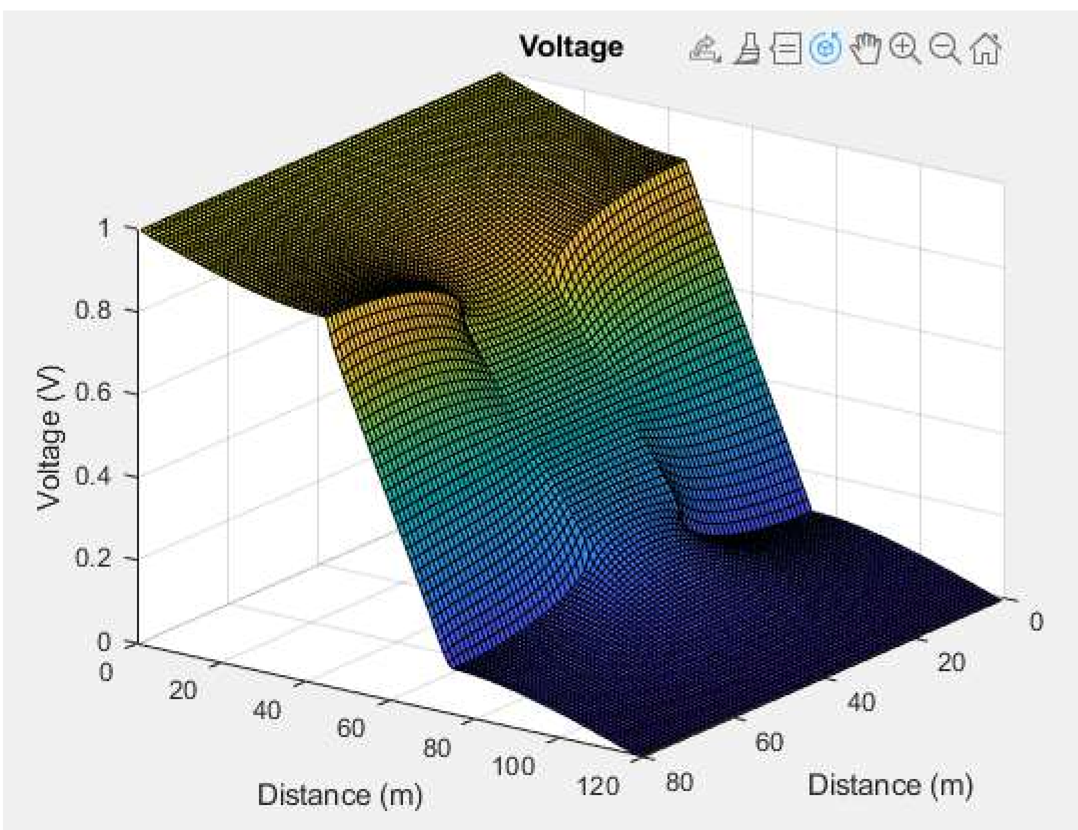

Figure 16. 3-D Plot of Voltage

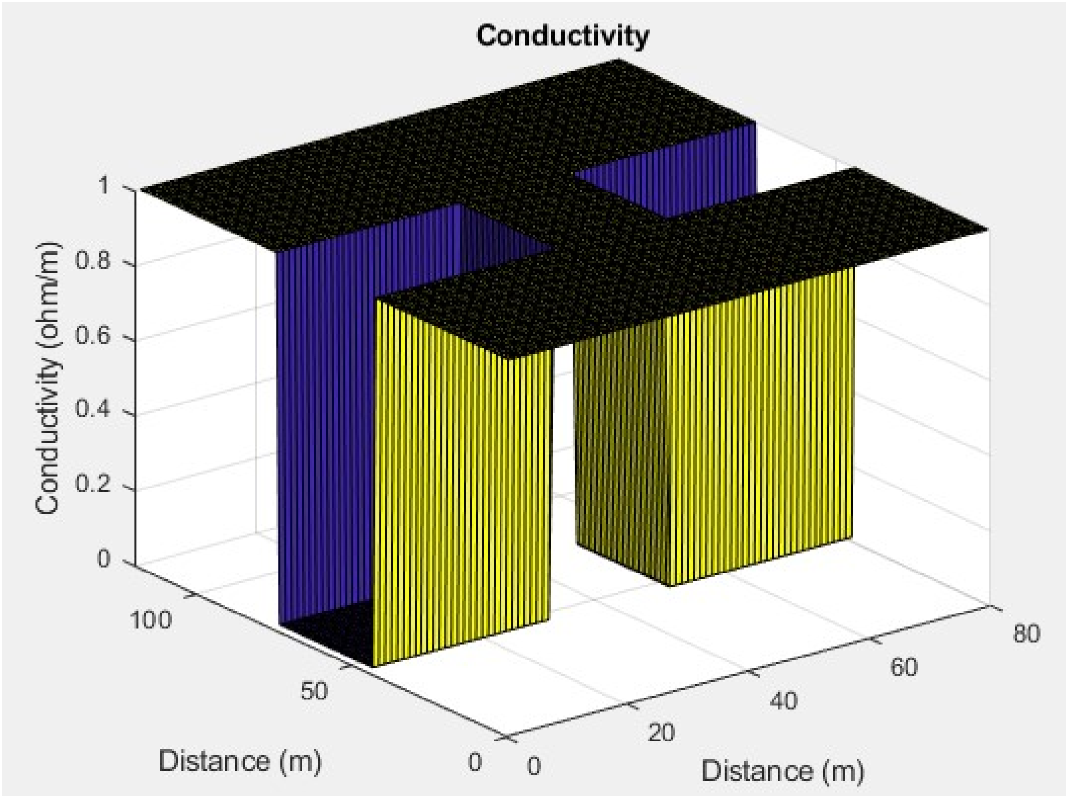

Figure 17. 3-D Plot of Conductivity

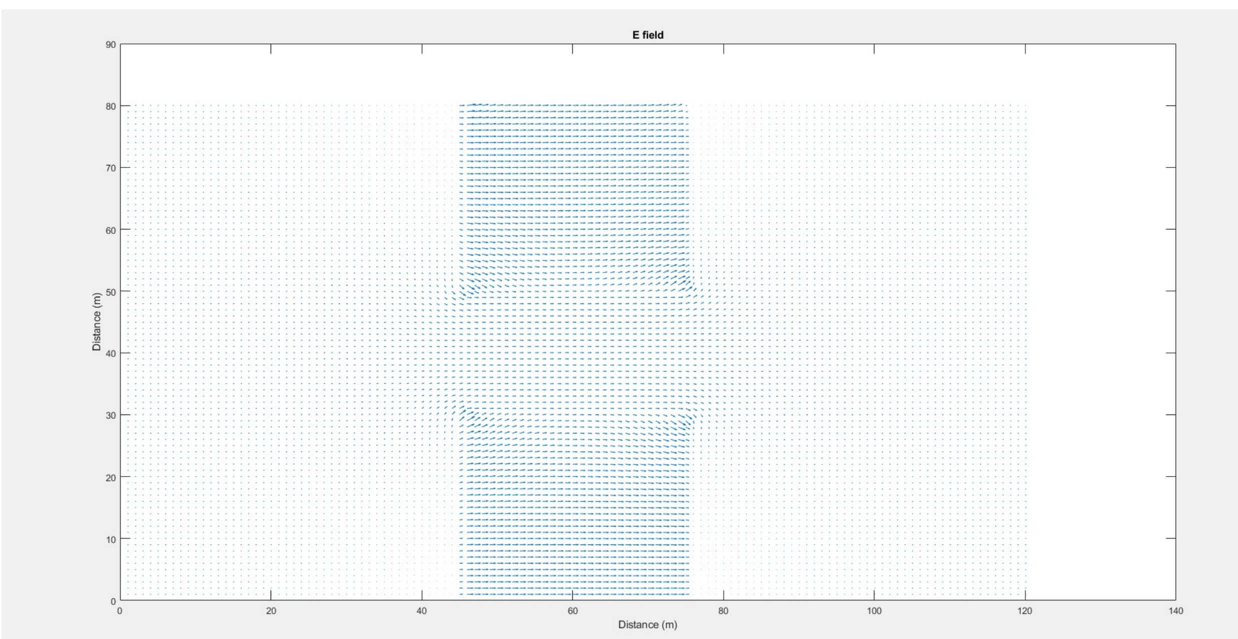

Figure 18. 2-D Plot of E field

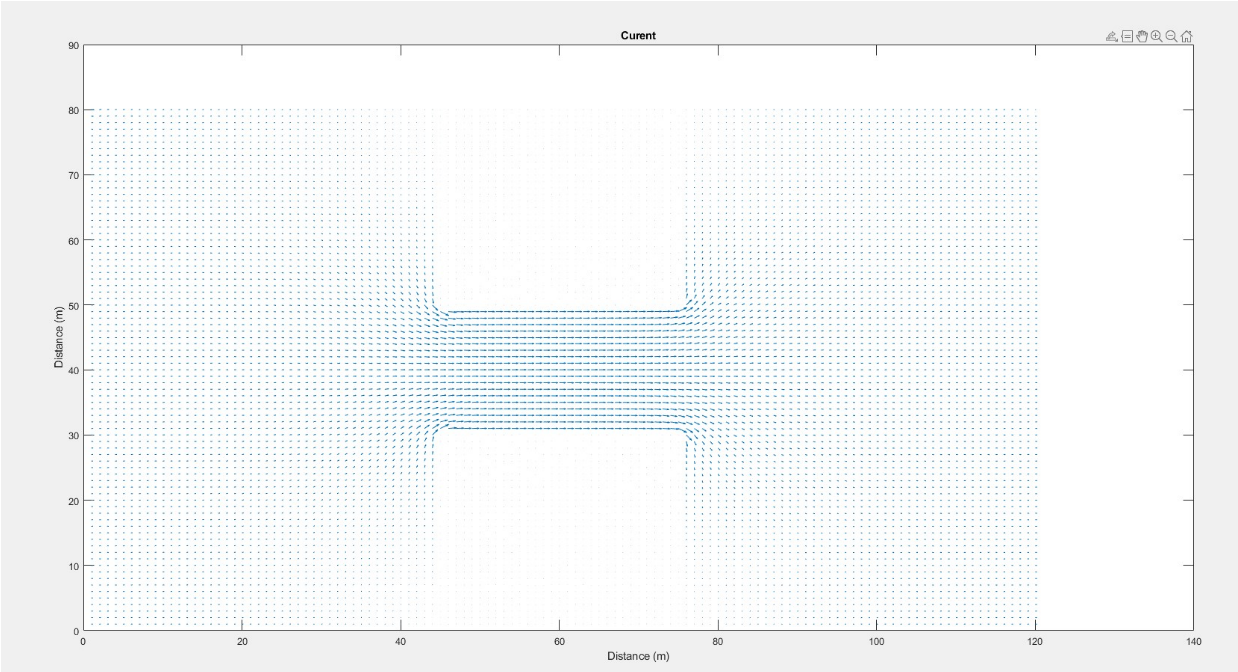

Figure 19. 2-D Plot of Current

P2.Q2.

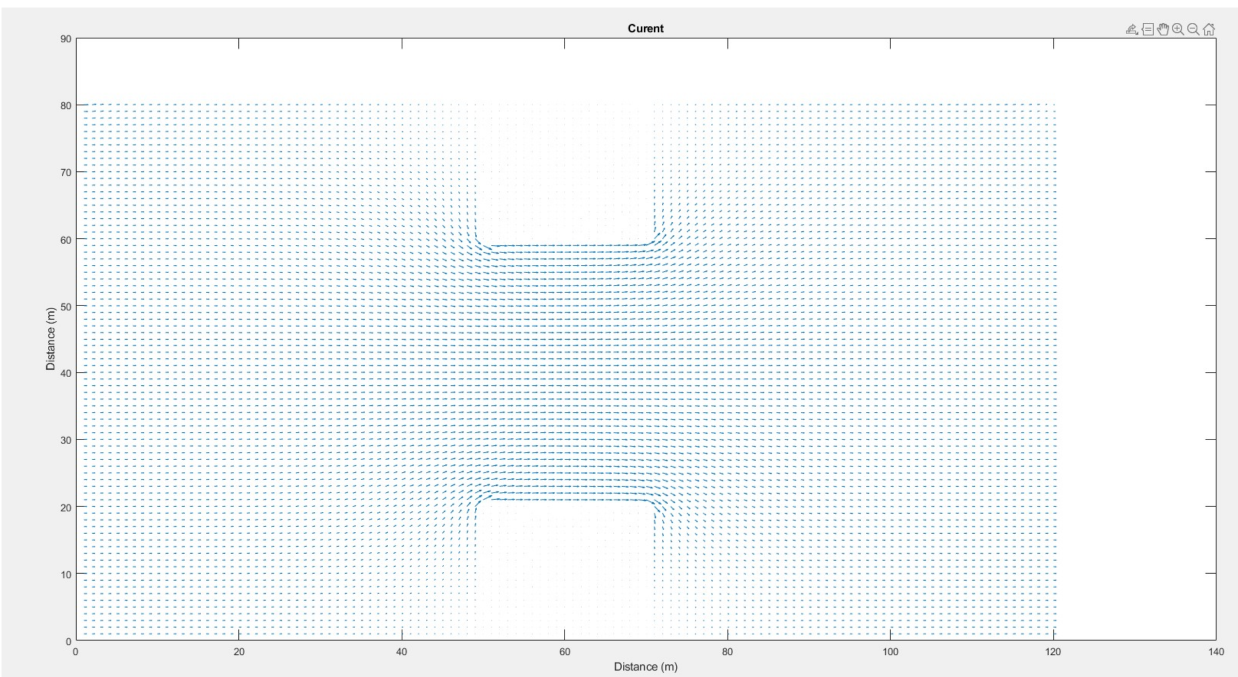

Figure 20. 2-D Plot of Current with smaller box

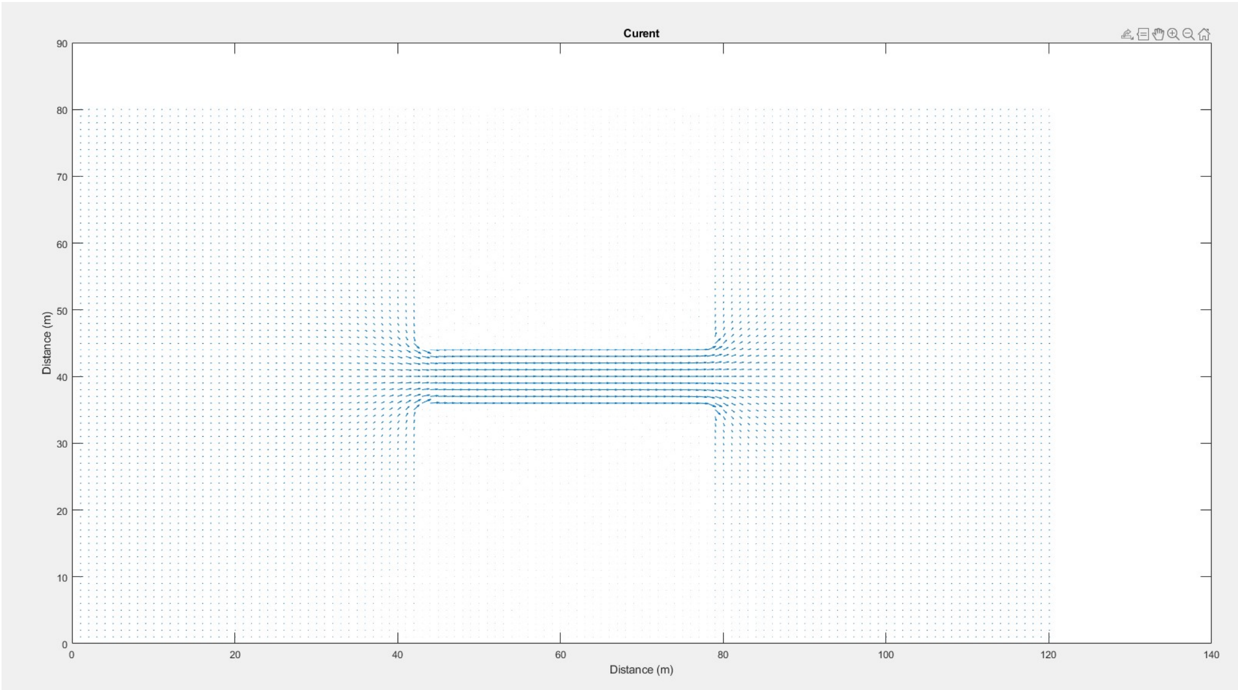

Figure 21. 2-D Plot of Current with bigger box

Changing the box size changes how strong the current is in the center. Larger boxes condense the area in which the current must travel.

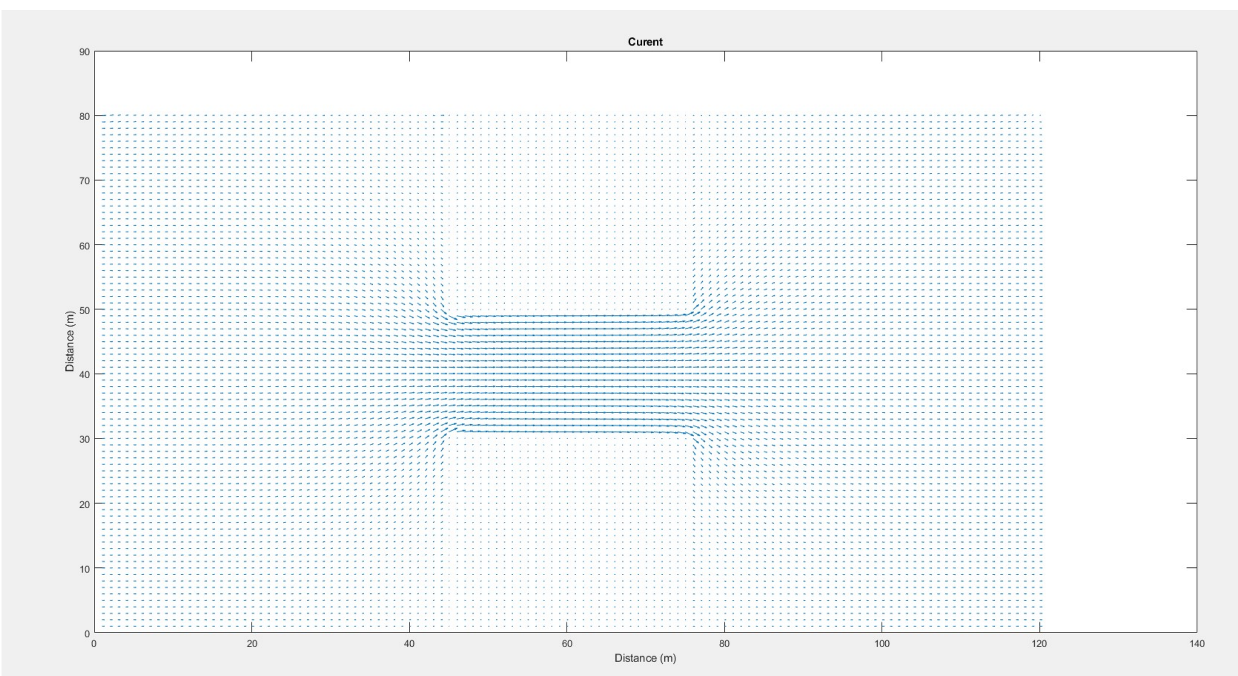

Figure 21. 2-D Plot of Current with larger conductivity

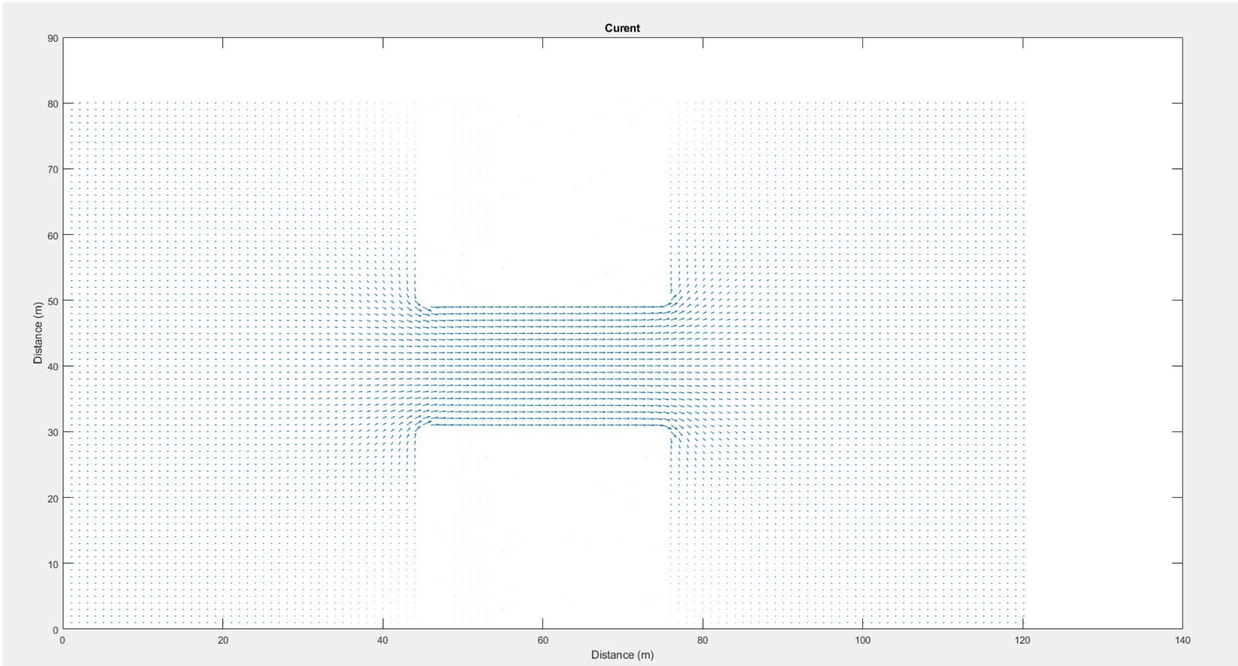

Figure 21. 2-D Plot of Current with smaller conductivity

Increasing conductivity allows more current to move through boxes while decreasing it forces more current to travel in between the boxes.

ASSIGNMENT#3

P1.Q1-3.

```
%Initialize E field
VoltX = 0.1;
EfieldX = VoltX/xMax;
AccelX = (EfieldX * q_0) / (0.26 * m_0);
```

Figure 22. Code for E and Acceleration

The force term is in the last line above (EfieldX * q_0)

E = 5.000000000000001e+05 V

F = 8.010882650000002e-14 N

A = 3.382346531085494e+17 m/s

P1.Q4.

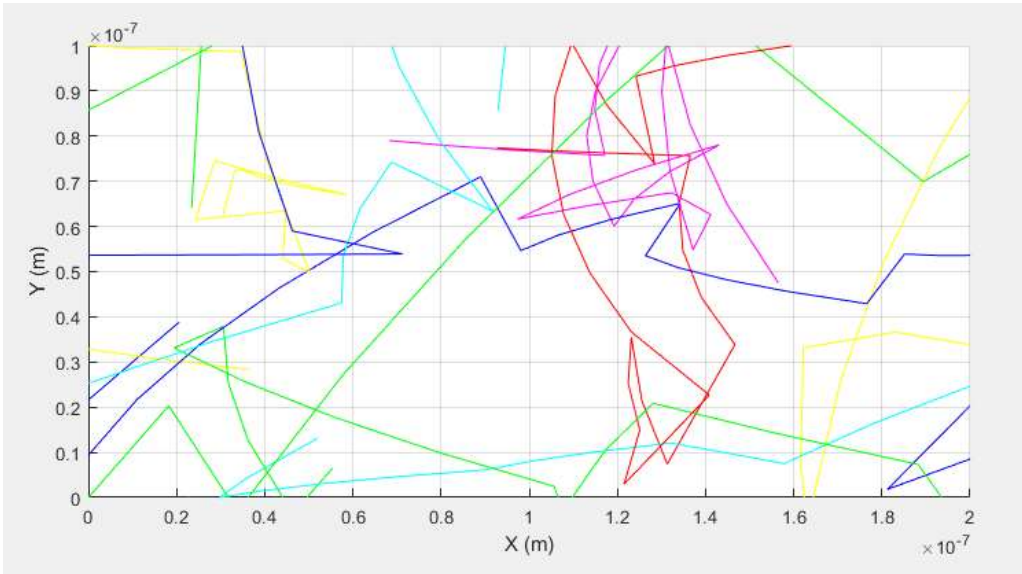

Figure 23. 2-D plot tracking electrons

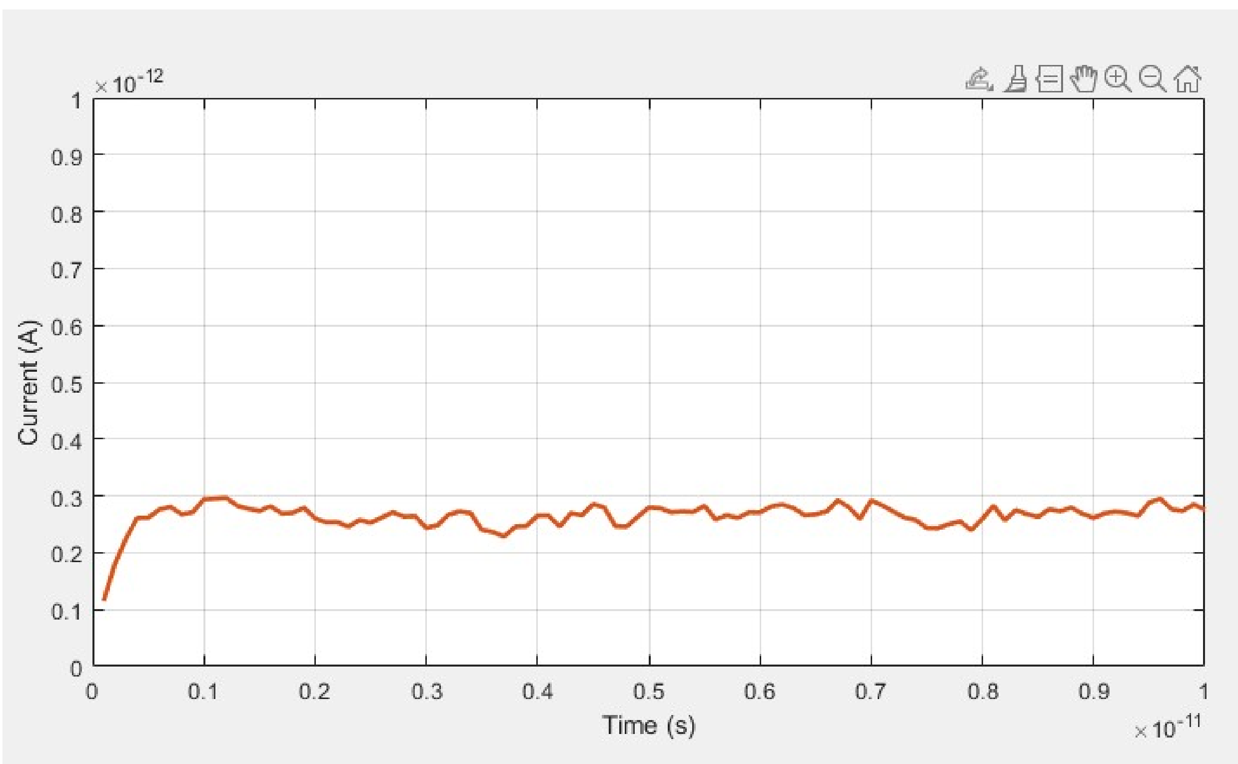

Figure 24. 2-D plot tracking current

P1.Q5.

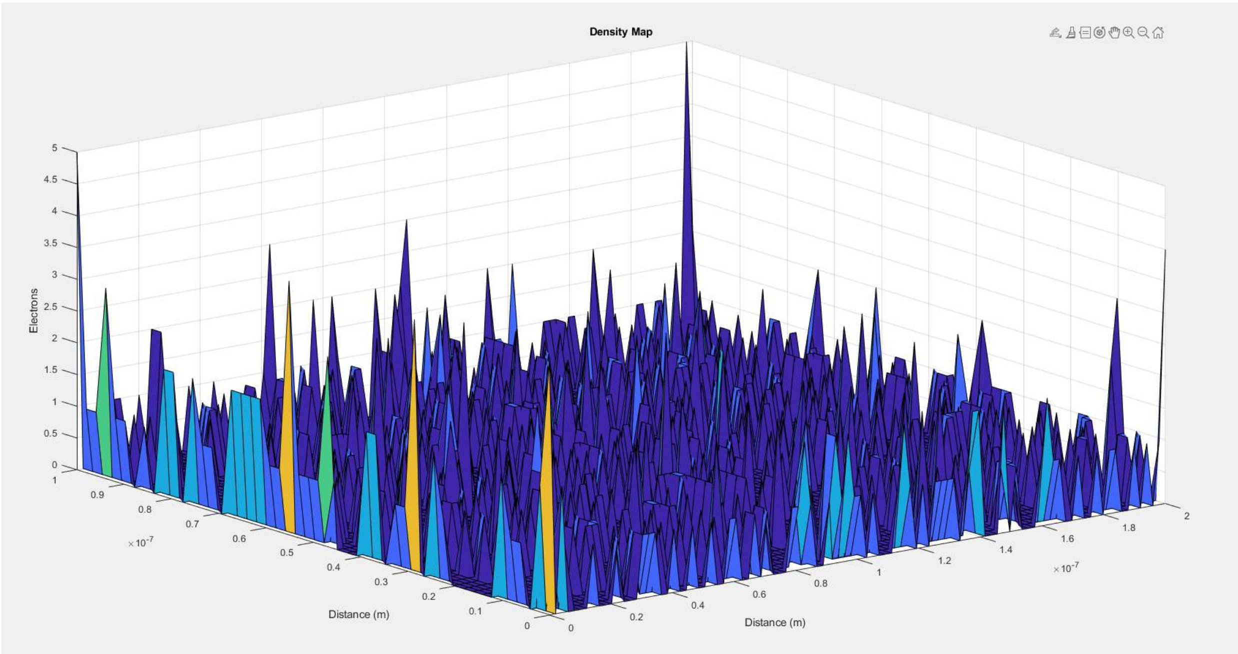

Figure 25. 3-D plot of density of electrons

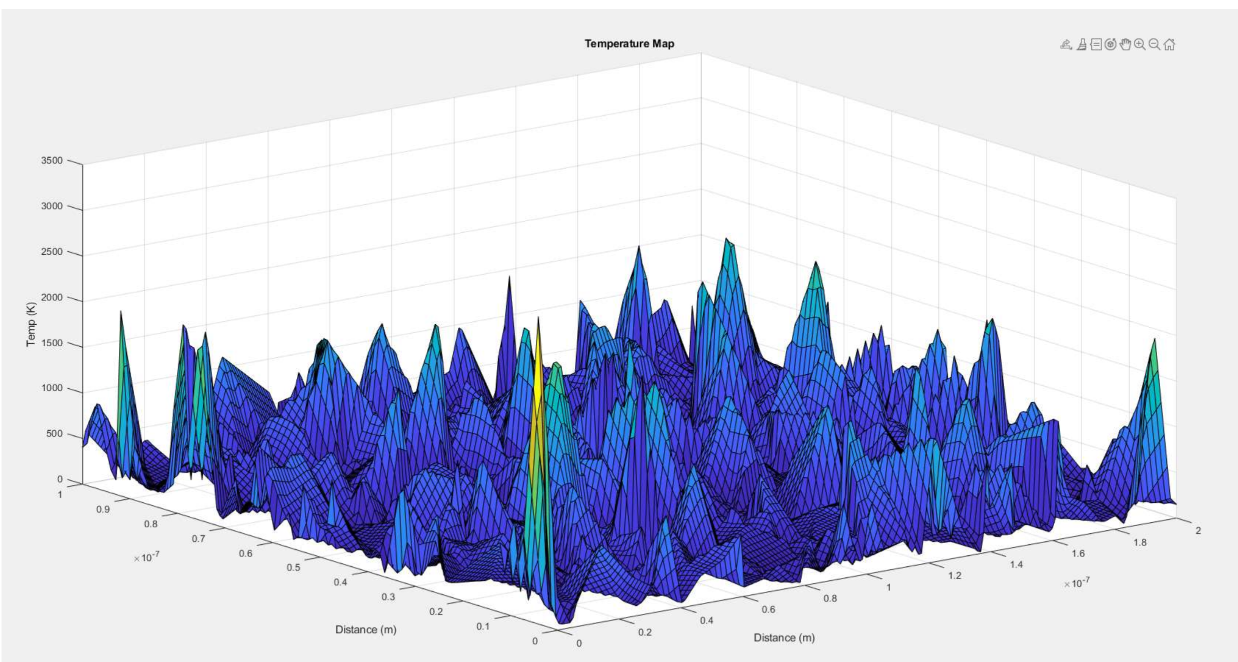

Figure 26. 3-D plot of Temperature

P2.Q1.

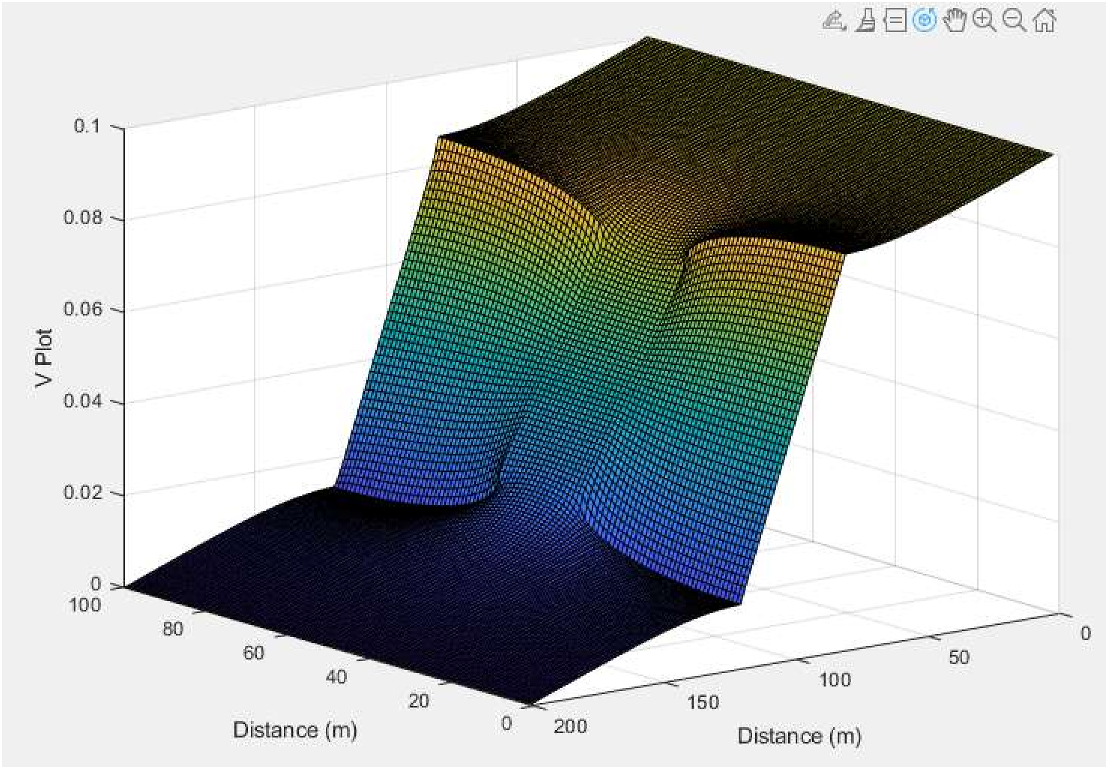

Figure 27. 3-D V field

P2.Q2.

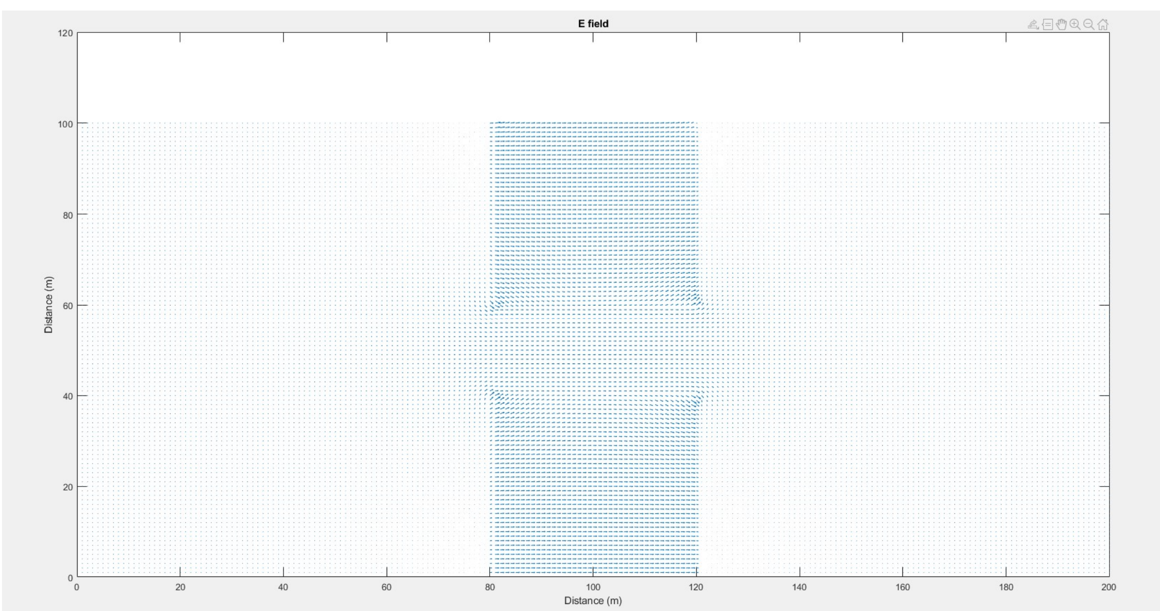

Figure 28. 2-D E field

P3.Q1.

AccelX

1x1000 double

	1	2	3	4	5	6	7
1	6.3169e-44	7.1947e-44	6.7150e-44	7.1914e-44	4.5723e-44	7.6456e-44	7.3236e-44
2							
3							

Figure 29. Values from Accel in X due to E Field

The values obtained were very low even at 0.8 V and hence had little effect on the plots.

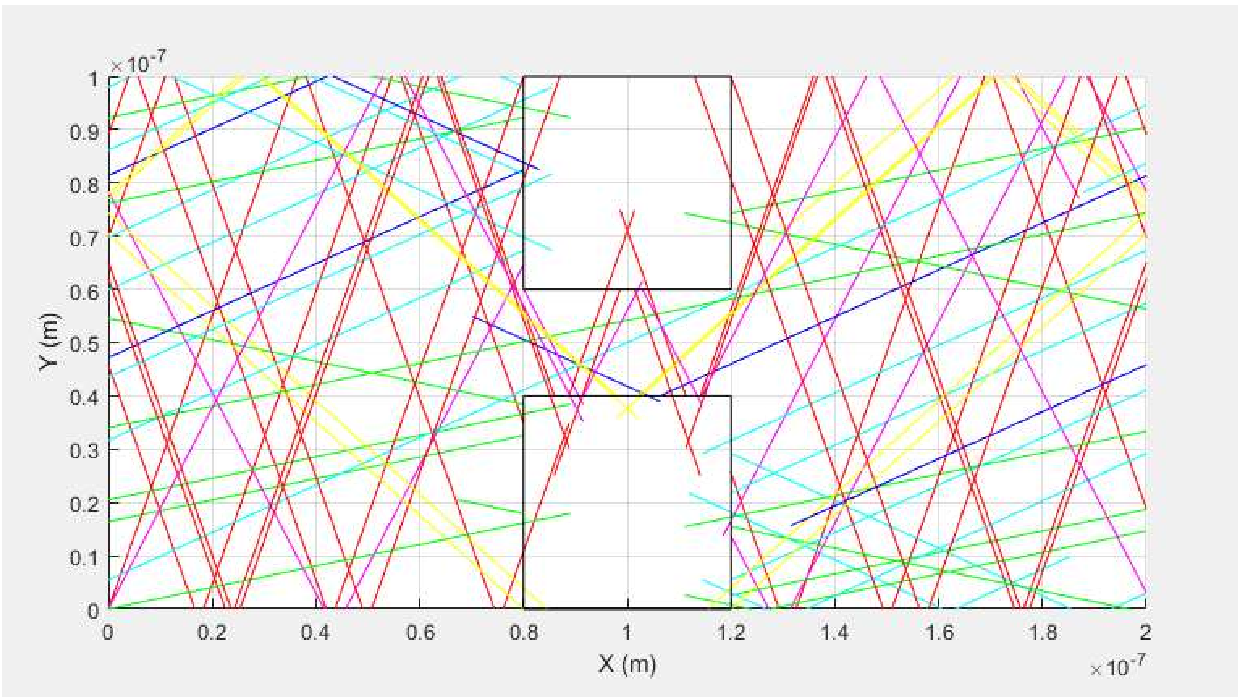

Figure 30. 2-D Electron Trajectories

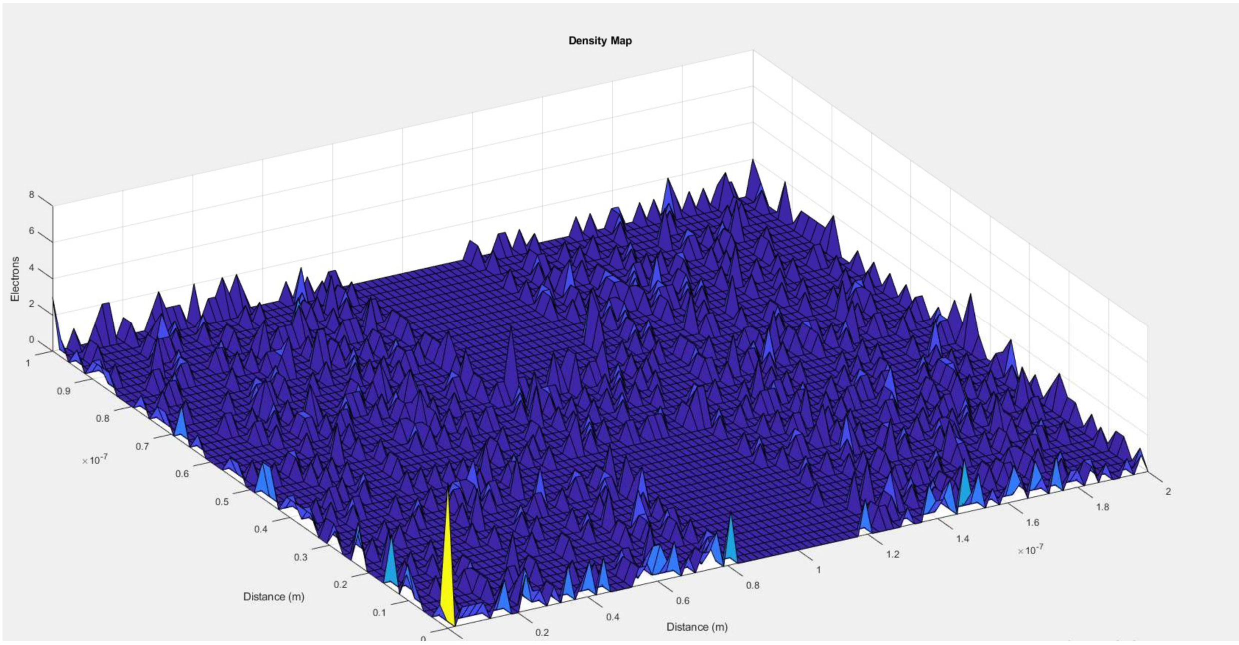

Figure 31. 3-D Density Map

The most noticeable thing in the Density map is the lack of electrons in the squares.