Assignment 3

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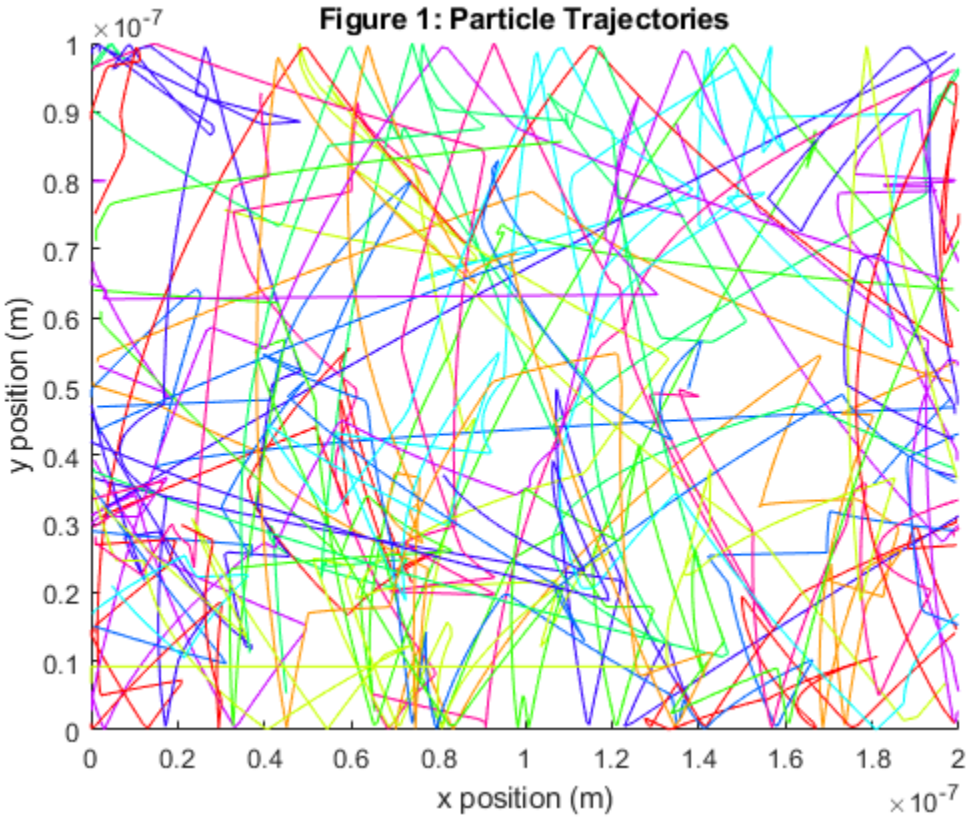
Question 1 - Monte-Carlo for Linear Voltage

The Assignment 1 was re-run without a bottle neck. The applied voltage was set to 0.1 V.

The simulation was run:

```
electron_box_3modes_A3(2)
pause(2);
```

```
The electric field is: 5.000e+05 V/m.
The force on each electron is: 8.011e-14 N.
The accelation of each electron is: 3.382e+17 m/s^2.
```



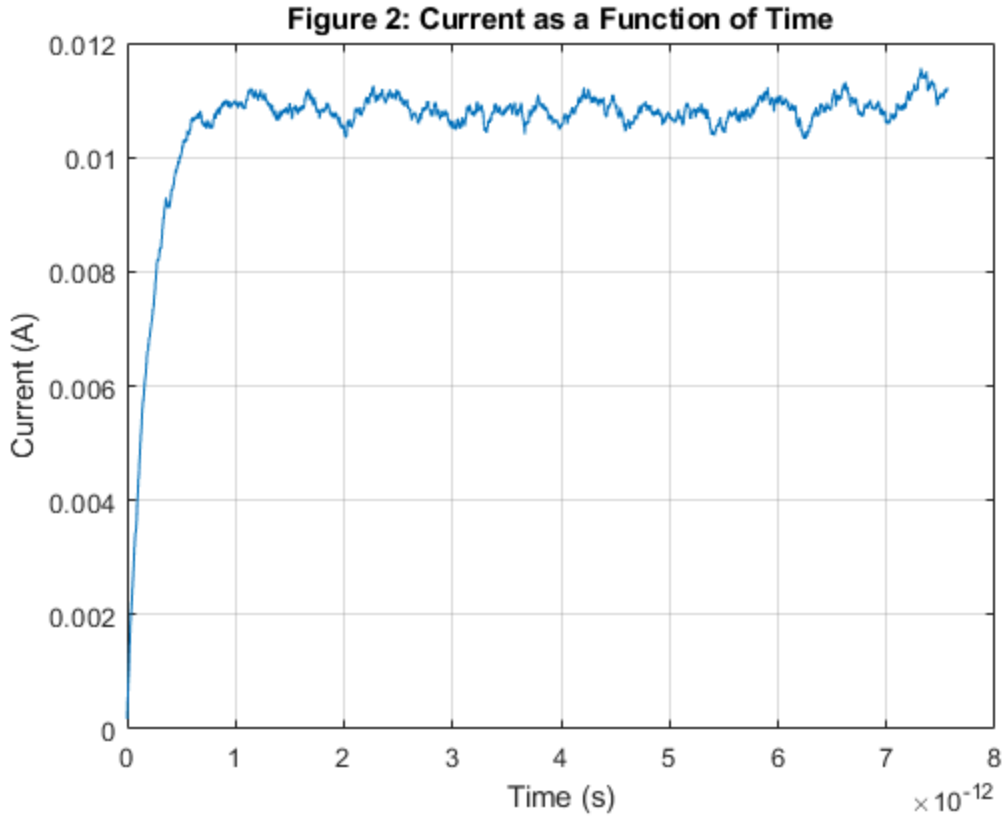


Figure 2: Current as a Function of Time
Current (A)
Time (s)
0.012
0.01
0.008
0.006
0.004
0.002
0
0
1
2
3
4
5
6
7
8
×10^-12

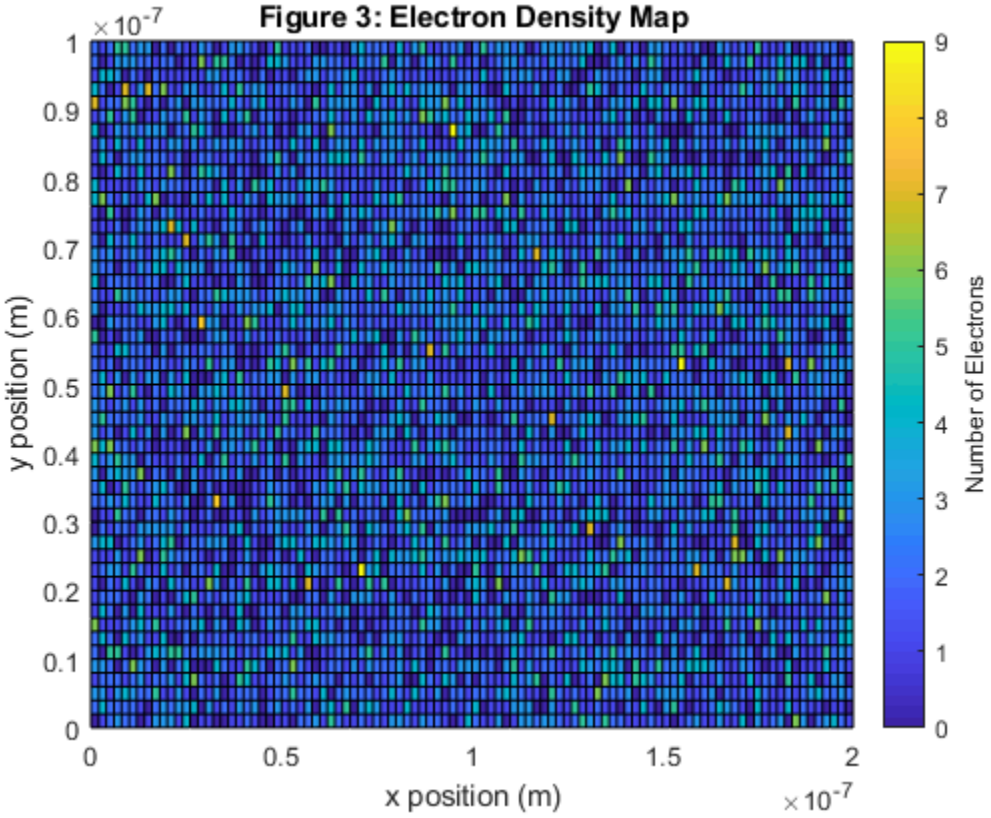
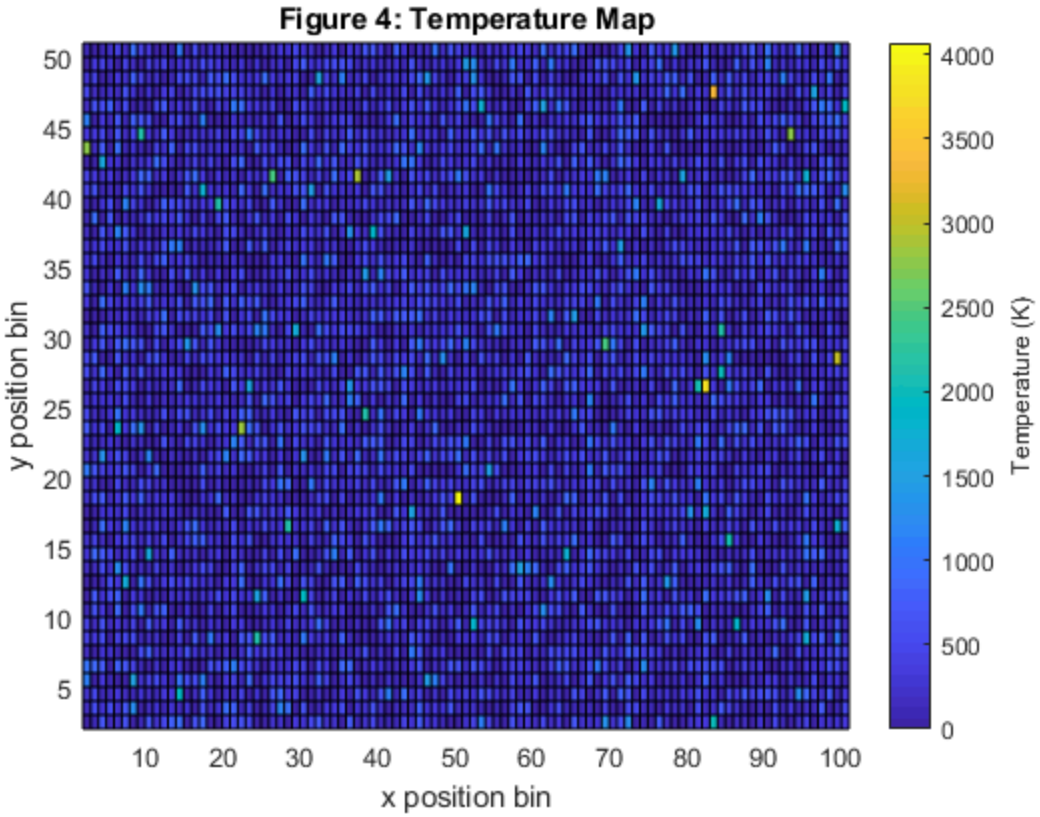


Figure 3: Electron Density Map
×10^-7
y position (m)
x position (m)
×10^-7
Number of Electrons
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
9
8
7
6
5
4
3
2
1
0



(a)

The electric field (as calculated above) is $5.000 \times 10^5 V/m$.

(b)

The force on each electron (as calculated above) is $8.011 \times 10^{-14} N$.

(c)

The accelation of each electron (as calculated above) is $3.382 \times 10^{17} m/s^2$.

Figure 1 shows some particle trajectories for the linear voltage gradient. The particles scatter after different distances traveled. The paths are curved towards the right as the acceleration is to the right.

(d)

The current formula is:

$$\bar{v_x} nqW$$

where $\bar{v_x}$ is the average velocity in the x-direction, n is the electron concentration, q is the charge of an electron, and W is the length of the y-direction boundary.

Figure 2 shows the current over time. The current starts low. It increases as the electron accelerate but stop at around $0.012A$ as the current is limited by the collisions and mean free path.

(e)

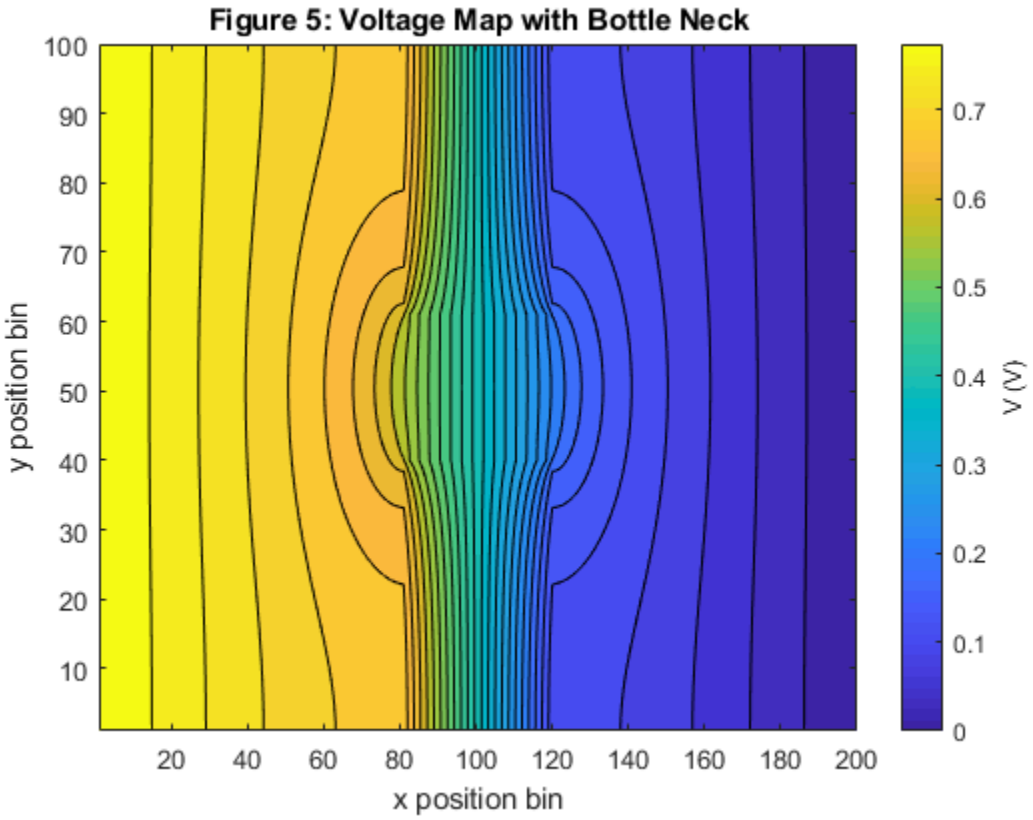
Figure 3 shows the density map at the end of the simulation. Figure 4 shows the temperature map at the end of the simulation. The density and temperature are both relatively uniform as the boundary is periodic in the x-direction. Acceleration is only in the x-direction to the right.

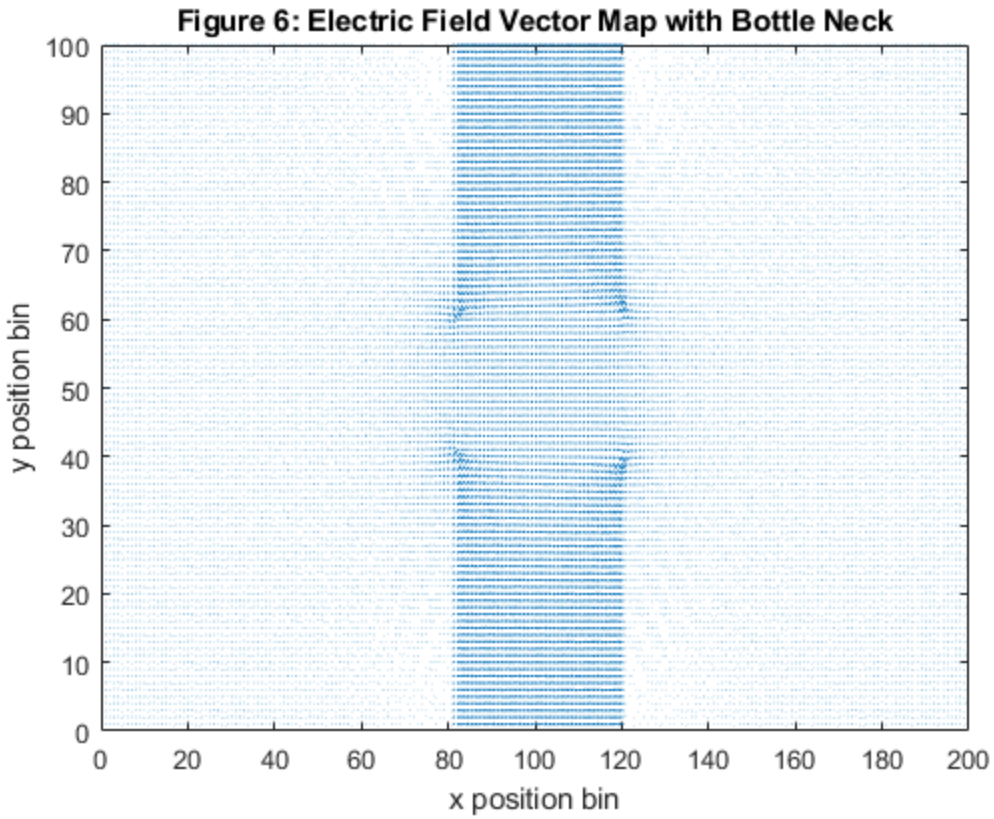
Question 2 - Finite Difference Potential Solution

The Assignment 2 was re-run for the bottle neck case. The applied voltage was set to 0.8 V.

The simulation was run:

```
box_potential_2a_A3_plot(0.8)
pause(2);
```





(a)

Figure 5 shows the voltage map with equipotential lines. The equipotential lines have closer spacing at the "bottle-neck". Thus, the greatest voltage drop is across the "bottle-neck". The low conductivity near the "bottle-neck" equates to a higher resistance. Since current should be conserved, voltage drop is higher for higher resistance according to the equation $V = IR$.

(b)

Figure 6 shows a map of electric field vectors. The vectors are all pointing to the right. The magnitude of the electric field is much higher inside the boxes because the voltage change is much quicker as seen in Figure 5.

Question 3 - Combined Simulations

The Assignment 2 was combined with Assignment 1 for the bottle neck case. The applied voltage was set to 0.8 V.

```
electron_box_3modes_A3(3)
```

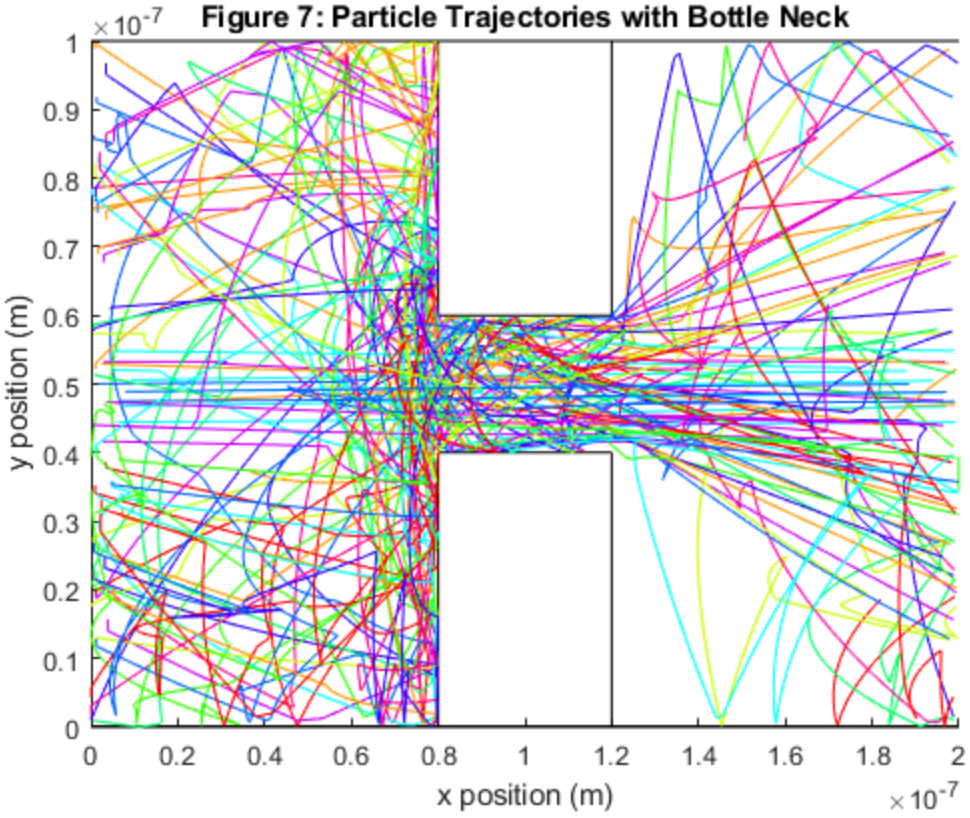


Figure 7: Particle Trajectories with Bottle Neck
×10^-7
y position (m)
x position (m)
×10^-7

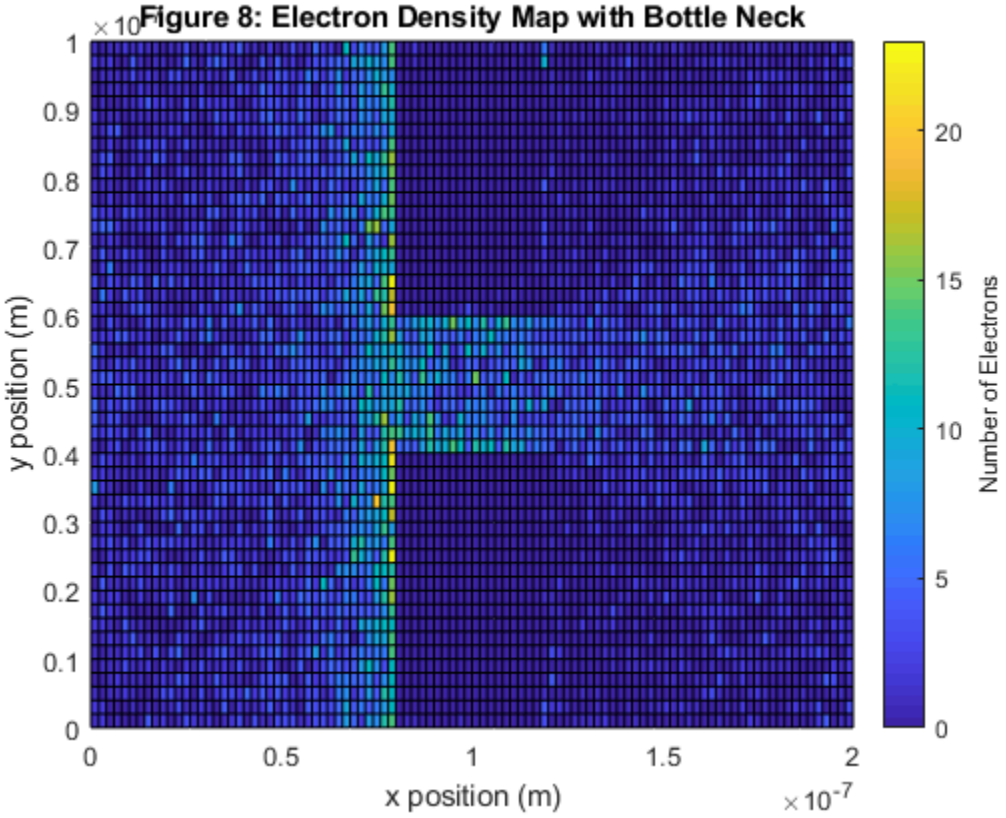


Figure 8: Electron Density Map with Bottle Neck
×10^-7
y position (m)
x position (m)
×10^-7
Number of Electrons

(a)

Figure 1 shows some particle trajectories when the bottle neck is present. The paths are curved towards the right as the acceleration is to the right.

(b)

Figure 3 shows the density map at the end of the simulation. The density is high to left of the boundaries. The acceleration is to the right so electrons often get stuck on the left.

(c)

There are a few possible next steps to make the simulation more accurate. The number of electrons could be increased for the Monte-Carlo simulation. The mesh density could be increased for the finite difference method of the voltage solution.

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