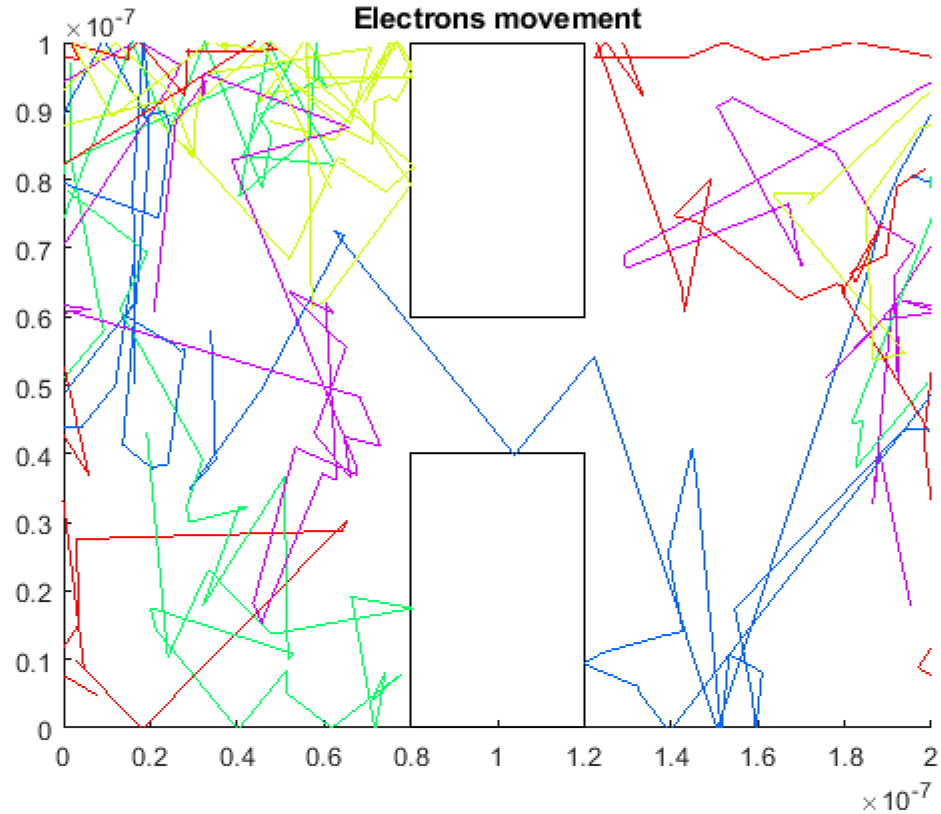
Part 3

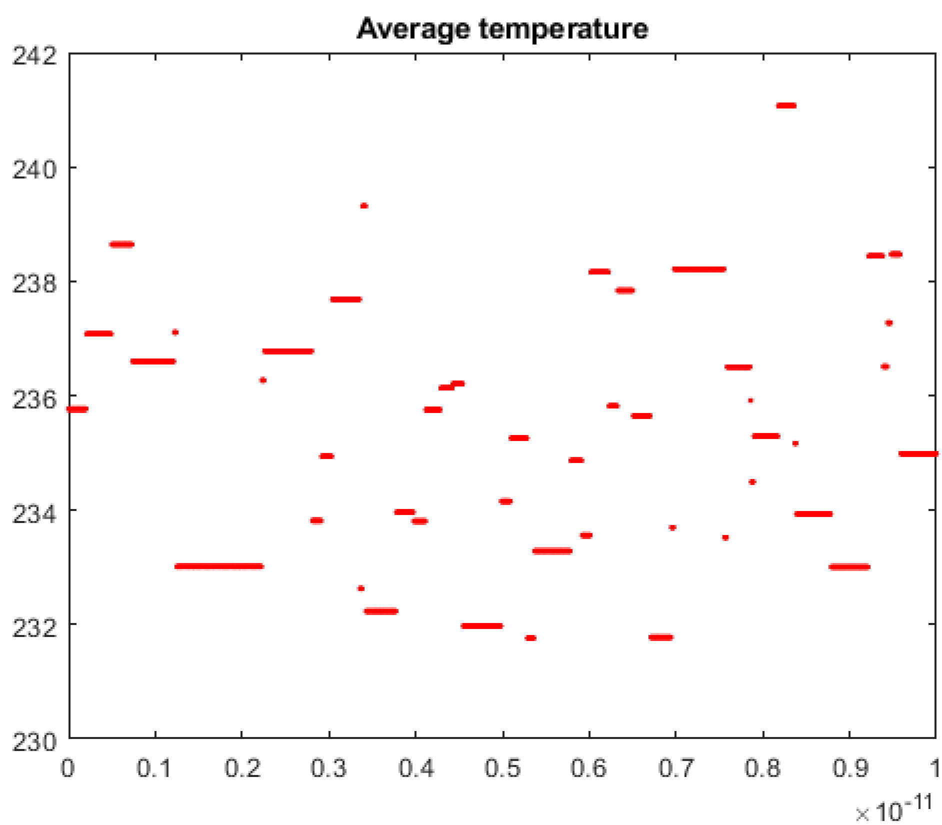
In this part of the assignment, we are required to create two block in the middle to create a bottle neck for the electrons to move through, the electrons will also include previous scattering probability. The electrons cannot spawn inside the blocks and they would have to bounce off the block like when they hit the boundary walls.

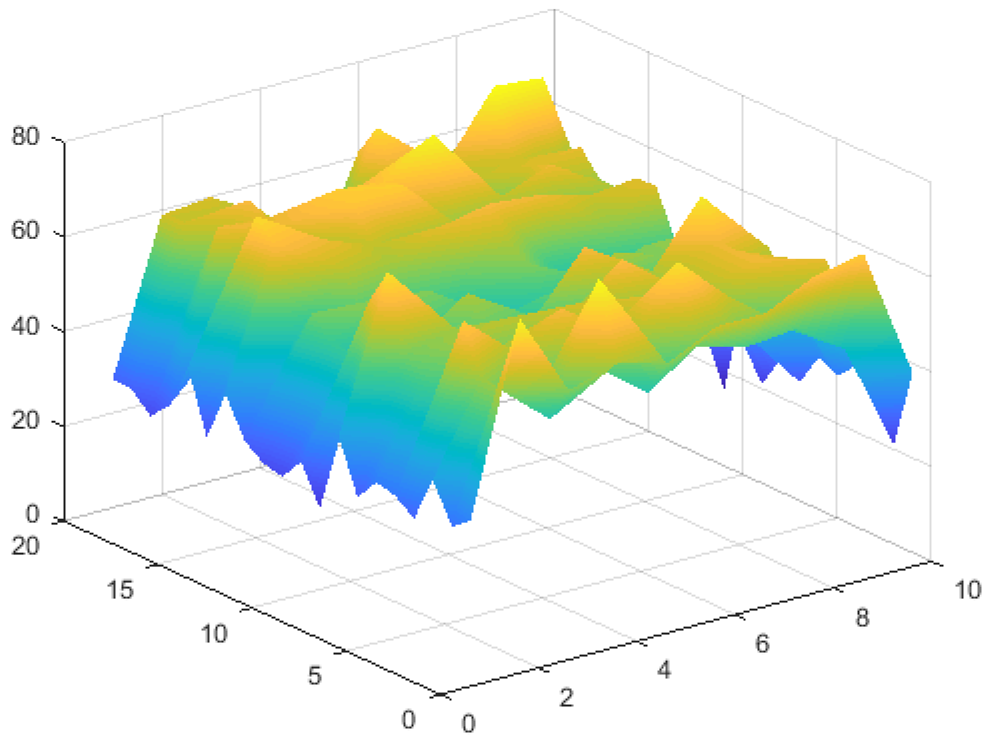
```
% Reset everything
close all
clear

% Constant
q_0 = 1.60217653e-19;                       % electron charge
m_0 = 9.10938215e-31;                       % electron mass
kb = 1.3806504e-23;                         % Boltzmann constant
tmn = 0.2e-12;                              % mean time between collisions

% Region Defining
L = 200e-9;
W = 100e-9;

% Current Condition and variables
num = 1e4;                                  % Number of electrons
T = 300;                                    % Temperature (Kelvin)
vth_e = sqrt((2*kb*T)/(m_0));               % Thermal velocity of an
 electron
vth_ex = (vth_e/sqrt(2))*randn(num, 1); % X-component of thermal
 velocity
vth_ey = (vth_e/sqrt(2))*randn(num, 1); % Y-component of thermal
 velocity
vthav = mean(sqrt(vth_ex.^2+vth_ey.^2));% Average of thermal velocity

% Electrons Defining
Elec = zeros(num, 4);
Elec(:, 1) = L*rand(num, 1);
Elec(:, 2) = W*rand(num, 1);
Elec(:, 3) = vth_ex;
Elec(:, 4) = vth_ey;
previous = zeros(num, 4);
previous = Elec;

% Electron simulation
figure(2);
t = 1e-11;                                   % Total Time
dt = 1e-14;                                 % Time Step
Psat = 1 - exp(-dt/tmn);                    % Exponential Scattering
 Probability
numplot = 5;                                % Number of electron plotted
color = hsv(numplot);                       % Colour Setup

% Part 3 simulation, setting up limitation for electrons spawning
for m = 1:1:num
```

```
    if Elec(m, 1) > 80e-9 && Elec(m, 1) < 120e-9 && (Elec(m, 2) >
 60e-9 || Elec(m, 2) < 40e-9)
            Elec(m, 1) = L*rand();
            Elec(m, 2) = W*rand();
    end
end

% Part 3 Simulation, setting up rectangles boundaries
rectangle('Position', [80e-9 0 40e-9 40e-9])
rectangle('Position', [80e-9 60e-9 40e-9 40e-9])
hold on

for n = 0:dt:t

    % Part 2 Simulation
    if Psat > rand()
        vth_ex = (vth_e/sqrt(2))*randn(num, 1);
        vth_ey = (vth_e/sqrt(2))*randn(num, 1);
        Elec(:, 3) = vth_ex;
        Elec(:, 4) = vth_ey;
    end

    for p = 1:1:num
        previous(p, 1) = Elec(p, 1);
        previous(p, 2) = Elec(p, 2);
        Elec(p, 1) = Elec(p, 1)+ Elec(p, 3)*dt;
        Elec(p, 2) = Elec(p, 2)+ Elec(p, 4)*dt;
    end

    % Plotting limited amount of electrons
    figure(2)
    for q = 1:1:numplot
        title('Electrons movement');
        plot([previous(q, 1), Elec(q, 1)], [previous(q, 2),
 Elec(q,2)], 'color', color(q, :))
        xlim([0 L])
        ylim([0 W])
        hold on
    end

    % Setting up the boundaries
    for o = 1:1:num
        % Looping on x-axis
        if Elec(o, 1) > L
            Elec(o, 1) = Elec(o, 1) - L;
            previous = Elec;
        end
        if Elec(o, 1) < 0
            Elec(o, 1) = Elec(o, 1) + L;
            previous = Elec;
        end
        % Reflecting on y-axis
        if Elec(o, 2) > W || Elec(o, 2) < 0
            Elec(o, 4) = -1*Elec(o, 4);
```

```
        end
        % Part 3 Simulation, boundaries for electrons movements
        if Elec(o, 1) > 80e-9 && Elec(o, 1) < 120e-9 && (Elec(o, 2) <
 40e-9 || Elec(o, 2) > 60e-9)
            if Elec(o, 2) < 40e-9
                if previous(o, 2) > 40e-9
                    Elec(o, 4) = -1*Elec(o, 4);
                else
                    Elec(o, 3) = -1*Elec(o, 3);
                end
            end
            if Elec(o, 2) > 60e-9
                if previous(o, 2) < 60e-9
                    Elec(o, 4) = -1*Elec(o, 4);
                else
                    Elec(o, 3) = -1*Elec(o, 3);
                end
            end
        end
    end

    % Plotting average temperature
    vthav = mean(sqrt(vth_ex.^2 + vth_ey.^2)); % Average thermal
 velocity
    aveT = (0.5*m_0*vthav^2)/kb;              % Average temperature
    figure(3)
    plot(n, aveT, 'r.')
    title('Average temperature');
    hold on
end

% Density Plot
Den = hist3(Elec(:, 1:2), 'Nbins', [20, 10]);
figure(4);
surf(Den)
shading interp
```


Electrons movement
×10⁻⁷
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
×10⁻⁷


Average temperature
242
240
238
236
234
232
230
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
×10⁻¹¹



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