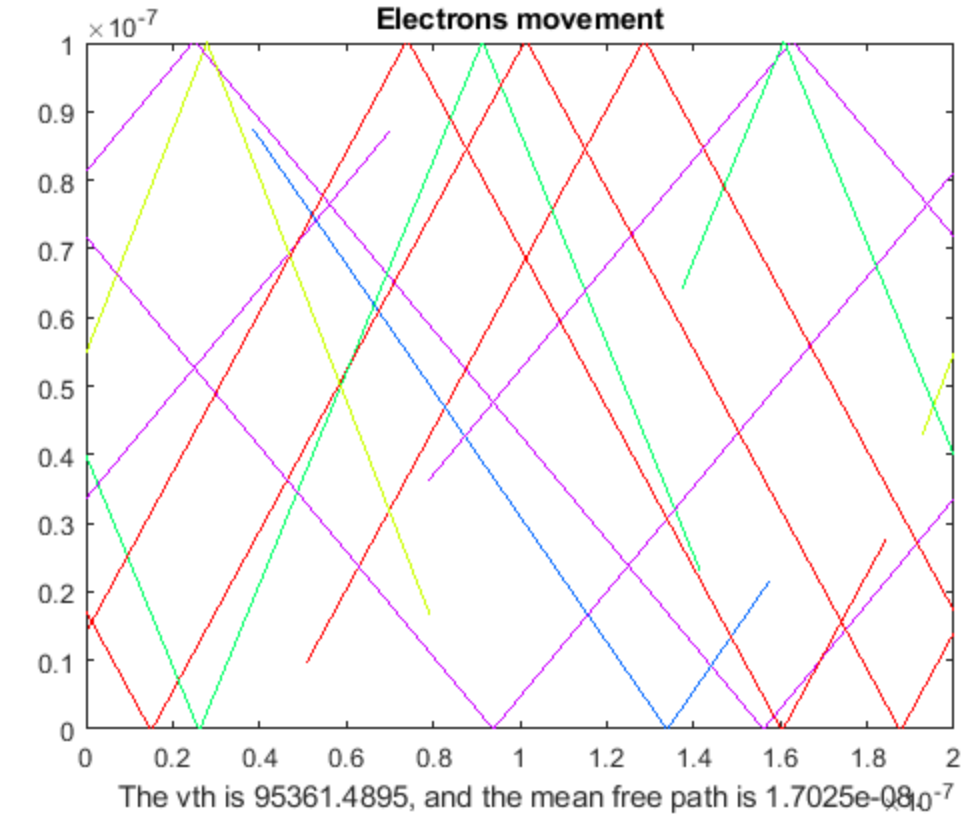
Assignment 1

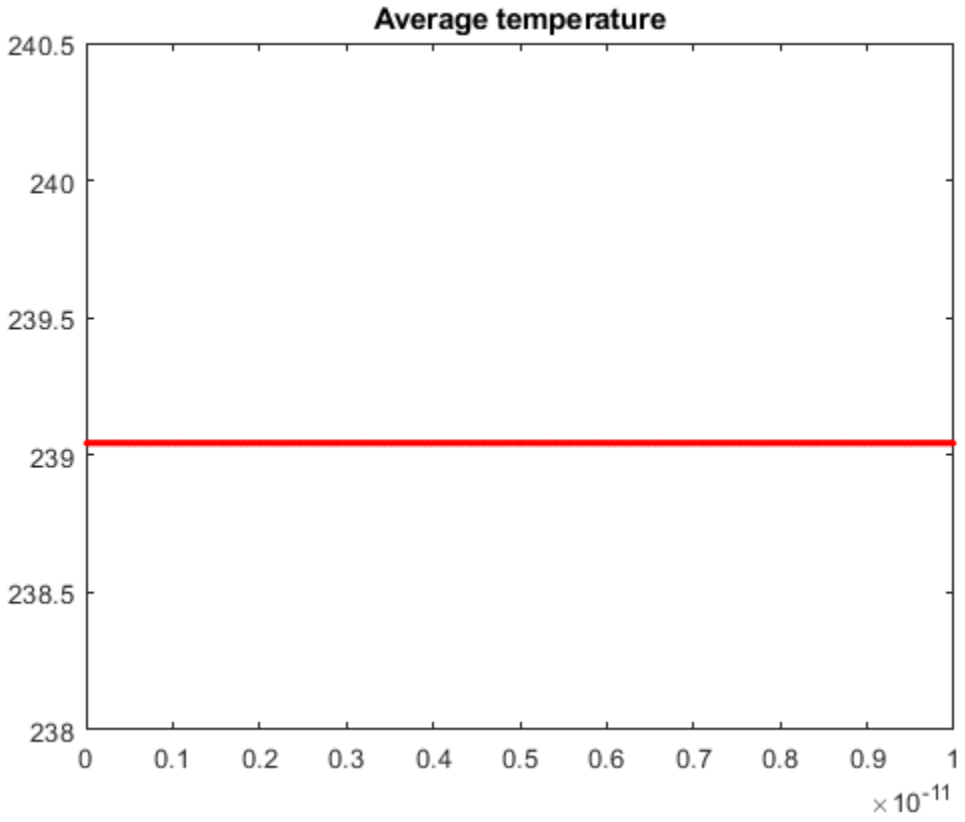
Part 1

In this assignment, we are going to simulate electron movement with different condition and boundaries. In part 1, we are just setting the basic boundaries that the electrons can move in and the electron will always move in straight until it hits 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
vthdis = sqrt(vth_ex.^2+vth_ey.^2);      % Distribution of electrons
 thermal velocity
vthav = mean(sqrt(vth_ex.^2+vth_ey.^2));% Average of thermal velocity
MFP = vthav*tmn;                         % Mean free path of electrons

% 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

for n = 0:dt:t
    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');
        xlabel(['The vth is ' num2str(vth_e) ', and the mean free path
 is ' num2str(MFP) '.']);
        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
    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
```


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
1.4
1.6
1.8
2
The vth is 95361.4895, and the mean free path is 1.7025e-08
×10^-7


Average temperature
240.5
240
239.5
239
238.5
238
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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