ELEC 4700 Monte-Carlo Modeling of Electron Transport

Part 2: Collisions with Mean Free Path (MFP)

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The puepose of this code is to model the electrons in the silicon as parti
with the effective mass above using a simplistic Monte-Carlo model.
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%In Part 2 I added in scattering


%Author: Richard Finney 100967048
clear all;
close all;

%Constants

q_0 = 1.60217653e-19;              % electron charge
m_0 = 9.10938215e-31;              % electron mass
kB = 1.3806504e-23;                % Boltzmann constant
deltat = 0.2e-12;                  % mean time between collisions
mn = 0.26*m_0;                     % effective mass of electrons



%variables

numofelec = 25;              %current numbers of electrons t be
 simulated
T = 300;                       %temperature in kelvin

dt = 1;
%Assign each particle with the fixed velocity given by vth but give
 each one a
%random direction.

vth = sqrt((kB*T)/mn);
%Spatial Boundaries

Length = 200;
Width = 100;


    %I am going to represent the location of each electron using
 vectors

x = randi([0 Length], 1, numofelec)*1e-9;       %initializing x
y = randi([0 Width], 1, numofelec)*1e-9;        %initializing y

    %now we have position vectors for the x and y positions of each
```

```
    %electron. Need to create vectors for vy and vx. Remember that
 each
    %electron has a rand angle to start with, but same velocity vth.

angles = randi([0 360], 1, numofelec);
v_x = zeros(1, numofelec);
v_y = zeros(1, numofelec);

v_x = vth*cos(angles);
v_y = vth*sin(angles);

figure(1)
hist(v_x,100);
title('x axis component of v thermal');

figure(2)
hist(v_y,100);
title('y axis component of v thermal');

    %scatter
    pscat = 1 - exp(-1e-14/(1e-12*0.2));
    pscatvector = ones(1,numofelec)*pscat;

    %wil be used to make electrons different colors
    colorarray= rand(1,numofelec);
for time= 1:dt:1000

    random = rand(1,numofelec);

    %all electrons with higher probabilities
    new = random < pscat;

    %all electrons with lower probabilities
    new2 = random >= pscat;


    rand_v_x = zeros(1,numofelec);
    rand_v_y = zeros(1,numofelec);

   for i = 1:1:numofelec
     r1 = randi([1 numofelec], 1,1);
     r2 = randi([1 numofelec], 1,1);
        rand_v_x(1,i) = v_x(1,r1);
        rand_v_y(1,i) = v_y(1,r2);
   end
        %all electrons with lower probabilities will stay the same
   v_x = v_x.*new2;
   v_y = v_y.*new2;

   rand_v_x=rand_v_x.*new;
   rand_v_y=rand_v_y.*new;

   v_x = v_x+rand_v_x;
   v_y = v_y+rand_v_y;
```

```
    %
    dx = v_x*dt*1e-15*5;
    dy = v_y*dt*1e-15*5;

    x = x + dx;
    y = y + dy;

    %if y is greater than 200
    temp = y>=Width*1e-9;
    temp1 = y<Width*1e-9;

    temp = temp*(-1);

    temphigher = temp + temp1;

    v_y = temphigher.*v_y;

     %if y is less than 100
    temp2 = y>=0;
    temp3 = y<0;

    temp3 = temp3*(-1);
    templower = temp3 + temp2;
    v_y = templower.*v_y;



%if x greater than 200
  temp5 = x<200*1e-9;

  x = x .* temp5;

  %if x is less than 0
  temp4 = x< 0;
  temp4 = temp4*200*1e-9;

  %temp4 = temp4*200*1e-9;
  x = x + temp4;

    %average thermal velocity
    v_avg = mean(sqrt((v_x.^2)+(v_y.^2)));
    T_avg = (mn*(v_avg^2))/kB;


    %mean free path

    mfp = (10^-15)*(v_avg);

    figure(3)
    scatter(x,y,3,colorarray);
    axis([0 200*10^-9 0 100*10^-9])
    title(['The mean free path is ', num2str(mfp)]);
  % pause(0.0000000000000000000000000000000000000001)
```

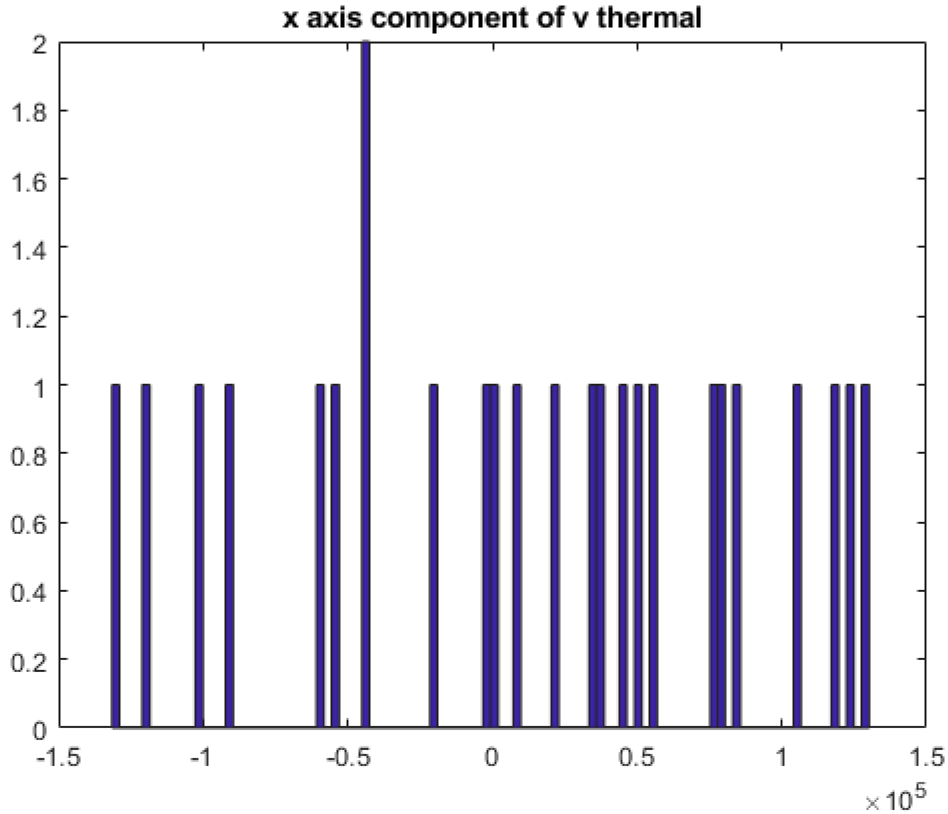
```
    hold on

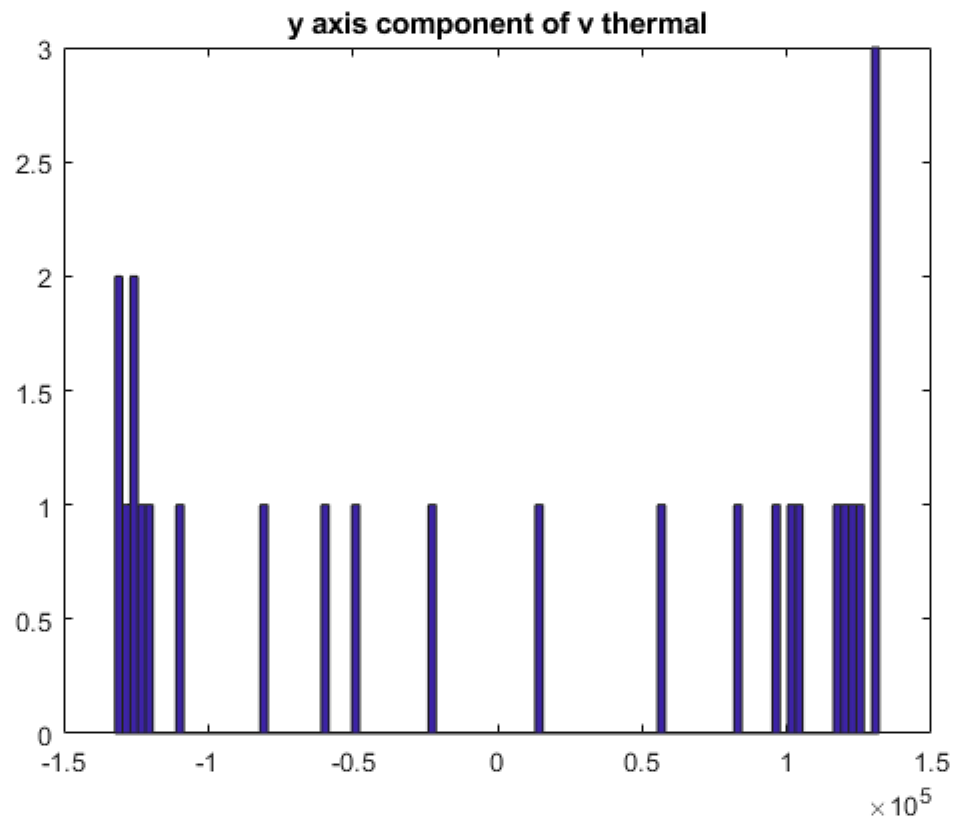
    figure(4)
    plot(time,T_avg,'.b')
    title(['The Average Temperature is ', num2str(T_avg)]);
    axis([0 1000 0 500])
    hold on

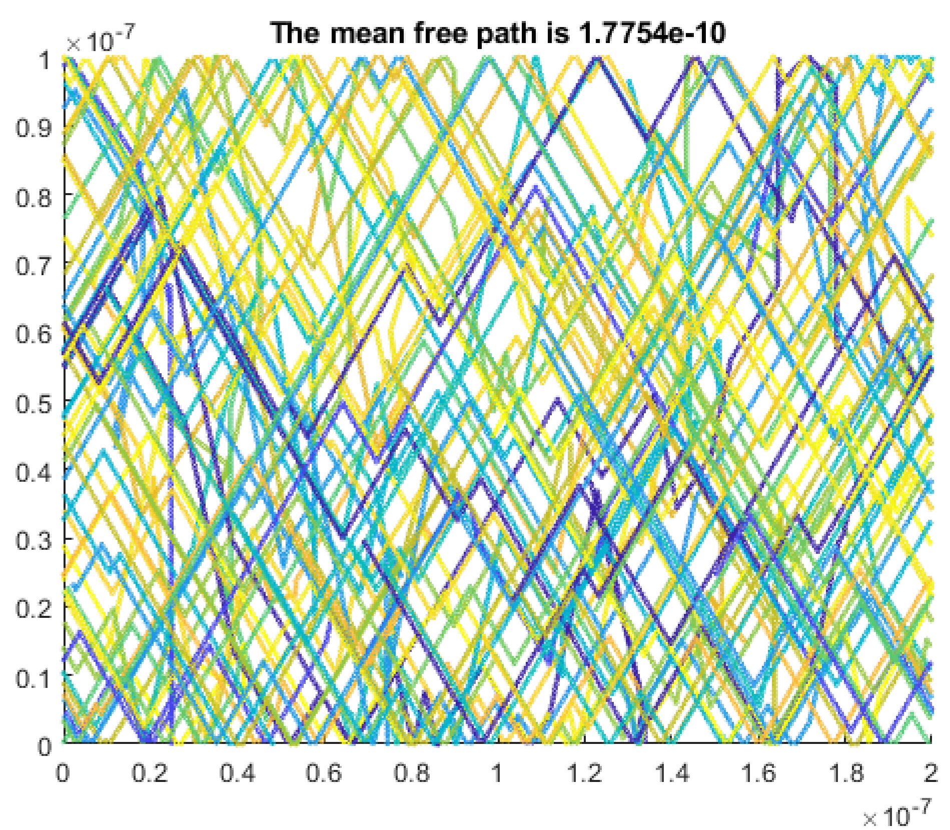
    %average thermal velocity

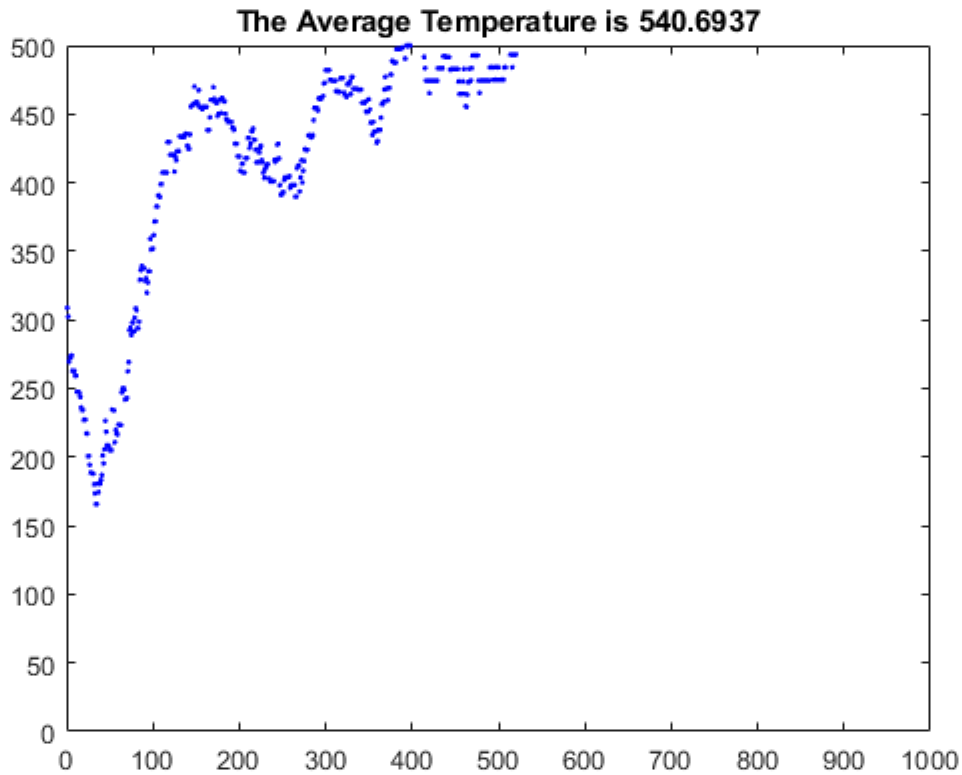
end

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%               END OF PART 2           %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```




y axis component of v thermal
3
2.5
2
1.5
1
0.5
0
-1.5
-1
-0.5
0
0.5
1
1.5
×10^5


The mean free path is 1.7754e-10
×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



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