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% ELEC4700 Assignment 3

% By Huanyu Liu 100986552

% Part1

clear;

clc;



% Initialize the parameters

n=50; % number of particles

T=300; % temperture of the backgound

L=200e-9; % length of the frame (figure 1)

H=100e-9; % height of the frame

tao=0.2e-12; % the given mean time between collisions

m0=9.109e-31; % mass of a particle

mn=0.26*m0; % effective mass

kb=1.38e-23; % constant coeffient

vth=sqrt(2*kb*T/mn); % average speed of each particle

con=1e11; % The electron concentration

% Initialize the positions of each particle

Pox = L*rand(1,n);

Poy = H*rand(1,n);



% New parameters for assignment3
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V=0.1;

E=V/L;

e=1.60217662e-19;

F=E*e;

a=F/m0;



% Initialize the speed of each particle and measure the initial temperature

for num=1:n

Vx(num) = randn()*vth/sqrt(2);

Vy(num) = randn()*vth/sqrt(2);

end

% draw the first locations of the particles and the blocks

figure(1)

plot(Pox,Poy,'.');

xlim([0 L]);

ylim([0 H]);

hold on

% more parameters that will be used in the loop

TStop = 1e-12; % max running time

t=0; % start time

dt=1e-14; % step time

intervals=round(TStop/dt); % number of steps
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Vz=zeros(1,intervals); % initial the size of all changing speed (will be used in hist)

ddt = 0; % time since last timestop

collisions=0; % number of timestops

time=0; % initialize the duration between collisions

path=zeros(1,n); % initialize the size of path length

j=0; % before the model runs, the current is 0

current(1)=0;

 while t < TStop

     z=round(1+t/dt); % index, the z-th interval between collisions

     Pscat = 1-exp(-ddt/tao); % scattering posibility

     if Pscat > rand % if scatter

         time=time+ddt; % total time when scattering occur

         ddt=0; % reset the parameter for the possibility as required

         collisions=collisions+1; % one more collision occurs

         Vx = randn(1,n).*vth/sqrt(2);

         Vy = randn(1,n).*vth/sqrt(2); % velocity changes (in maxwell-boltzmann
distribution)

         average_path_length(collisions)=sum(path)/n; % average path length for this
interval

         path=zeros(1,n); % reset the path length

     else % nothing happens, same speed the next duration of time step

         path=path+sqrt(Vx.^2+Vy.^2).*dt; % add the next timestep's path length to the total
path length

         ddt=ddt+dt; % add the timestep size to the parameter
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    end

        Vact=sqrt(sum(Vx.^2+Vy.^2)/n); % the average speed of all the particles

        Vz(z)=Vact; % will be used to get the distribution in hist



    Vx = Vx + a.*t;

    tPx = Pox + Vx.*dt; % predict the position

    tPy = Poy + Vy.*dt;

% when the particles go to the right and left border

    px1 = Pox >= L;

    Pox(px1) = Pox(px1) - L;

    px2 = Pox <= 0;

    Pox(px2) = Pox(px2) + L;



    py1 = tPy <= 0;

    Vy(py1) = Vy(py1) .* (-1);

    py2 = tPy >= H;

    Vy(py2) = Vy(py2) .* (-1);

        % now all velocity have been modified to the correct direction,

        % update the position

    PreviousPox = Pox;

    PreviousPoy = Poy;

    Pox = Pox + Vx.*dt;
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    Poy = Poy + Vy.*dt;



    j=j+1;

    current(j)=H*e*con*sum(Vx)/n; % current formula

    figure(1)

    for i=1:n

    plot([PreviousPox(i),Pox(i)],[PreviousPoy(i),Poy(i)]);

    end

    xlim([0 L]);

    ylim([0 H]);

    hold on




    pause(0.01)

    t=t+dt;

    pre=current;

end



    figure(2)

    recordt=0:dt:TStop;

    plot(recordt,current);

    xlabel('time');
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    ylabel('current (A)');

    title('current vs. time');



n1=Pox<0.2*L;

n2=Pox<0.4*L;

n3=Pox<0.6*L;

n4=Pox<0.8*L;

n5=Poy<0.25*H;

n6=Poy<0.5*H;

n7=Poy<0.75*H;

Den=zeros(5,4);

temper=zeros(5,4);

Den(1,1)=sum(n1&n5);

temper(1,1)=sum(Vx(n1&n5).^2+Vy(n1&n5).^2).*mn./(2*kb*Den(1,1));

Den(1,2)=sum(n1&n6&(~n5));

temper(1,2)=sum(Vx(n1&n6&(~n5)).^2+Vy(n1&n6&(~n5)).^2).*mn./(2*kb*Den(1,2));

Den(1,3)=sum(n1&n7&(~n6));

temper(1,3)=sum(Vx(n1&n7&(~n6)).^2+Vy(n1&n7&(~n6)).^2).*mn./(2*kb*Den(1,3));

Den(1,4)=sum(n1&(~n7));

temper(1,4)=sum(Vx(n1&(~n7)).^2+Vy(n1&(~n7)).^2).*mn./(2*kb*Den(1,4));

Den(2,1)=sum((~n1)&n2&n5);

temper(2,1)=sum(Vx((~n1)&n2&n5).^2+Vy((~n1)&n2&n5).^2).*mn./(2*kb*Den(2,1));
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Den(2,2)=sum((~n1)&n2&n6&(~n5));

temper(2,2)=sum(Vx((~n1)&n2&n6&(~n5)).^2+Vy((~n1)&n2&n6&(~n5)).^2).*mn./(2*kb*Den(2,2));

Den(2,3)=sum((~n1)&n2&n7&(~n6));

temper(2,3)=sum(Vx((~n1)&n2&n7&(~n6)).^2+Vy((~n1)&n2&n7&(~n6)).^2).*mn./(2*kb*Den(2,3));

Den(2,4)=sum((~n1)&n2&(~n7));

temper(2,4)=sum(Vx((~n1)&n2&(~n7)).^2+Vy((~n1)&n2&(~n7)).^2).*mn./(2*kb*Den(2,4));

Den(3,1)=sum((~n2)&n3&n5);

temper(3,1)=sum(Vx((~n2)&n3&n5).^2+Vy((~n2)&n3&n5).^2).*mn./(2*kb*Den(3,1));

Den(3,2)=sum((~n2)&n3&n6&(~n5));

temper(3,2)=sum(Vx((~n2)&n3&n6&(~n5)).^2+Vy((~n2)&n3&n6&(~n5)).^2).*mn./(2*kb*Den(3,2));

Den(3,3)=sum((~n2)&n3&n7&(~n6));

temper(3,3)=sum(Vx((~n2)&n3&n7&(~n6)).^2+Vy((~n2)&n3&n7&(~n6)).^2).*mn./(2*kb*Den(3,3));

Den(3,4)=sum((~n2)&n3&(~n7));

temper(3,4)=sum(Vx((~n2)&n3&(~n7)).^2+Vy((~n2)&n3&(~n7)).^2).*mn./(2*kb*Den(3,4));

Den(4,1)=sum((~n3)&n4&n5);

temper(4,1)=sum(Vx((~n3)&n4&n5).^2+Vy((~n3)&n4&n5).^2).*mn./(2*kb*Den(4,1));

Den(4,2)=sum((~n3)&n4&n6&(~n5));

temper(4,2)=sum(Vx((~n3)&n4&n6&(~n5)).^2+Vy((~n3)&n4&n6&(~n5)).^2).*mn./(2*kb*Den(4,2));

Den(4,3)=sum((~n3)&n4&n7&(~n6));

temper(4,3)=sum(Vx((~n3)&n4&n7&(~n6)).^2+Vy((~n3)&n4&n7&(~n6)).^2).*mn./(2*kb*Den(4,3));

Den(4,4)=sum((~n3)&n4&(~n7));

temper(4,4)=sum(Vx((~n3)&n4&(~n7)).^2+Vy((~n3)&n4&(~n7)).^2).*mn./(2*kb*Den(4,4));
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Den(5,1)=sum((~n4)&n5);

temper(5,1)=sum(Vx((~n4)&n5).^2+Vy((~n4)&n5).^2).*mn./(2*kb*Den(5,1));

Den(5,2)=sum((~n4)&n6&(~n5));

temper(5,2)=sum(Vx((~n4)&n6&(~n5)).^2+Vy((~n4)&n6&(~n5)).^2).*mn./(2*kb*Den(5,2));

Den(5,3)=sum((~n4)&n7&(~n6));

temper(5,3)=sum(Vx((~n4)&n7&(~n6)).^2+Vy((~n4)&n7&(~n6)).^2).*mn./(2*kb*Den(5,3));

Den(5,4)=sum((~n4)&(~n7));

temper(5,4)=sum(Vx((~n4)&(~n7)).^2+Vy((~n4)&(~n7)).^2).*mn./(2*kb*Den(5,4));

[X,Y]=meshgrid(H/4:H/4:H,L/5:L/5:L);

figure(3)

subplot(1,2,1),surf(X,Y,Den);

title('Density');

subplot(1,2,2),surf(X,Y,temper);

title('Temperature');

    fprintf(' The electrical field is: %g V/m\n',E);

    fprintf(' The force on each particle is: %g N\n',F);

    fprintf(' The acceleration of each particle is: %g m/s^2\n', a);
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The electrical field is: 500000 V/m

The force on each particle is: 8.01088e-14 N

The acceleration of each particle is: 8.79447e+16 m/s^2
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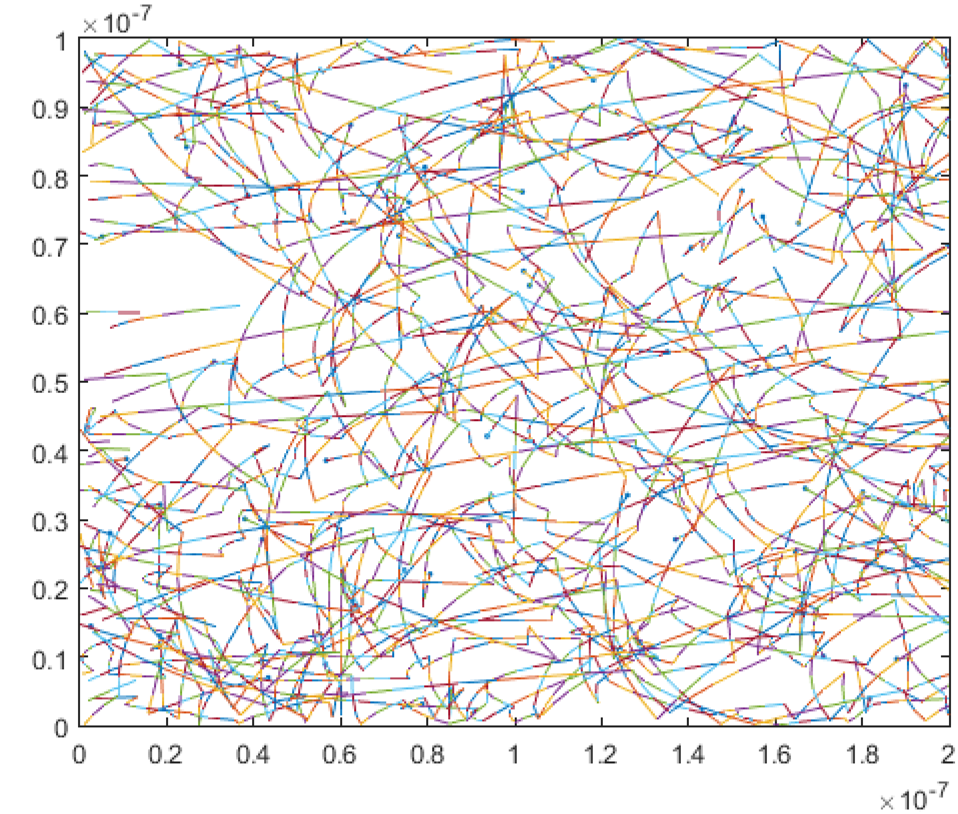
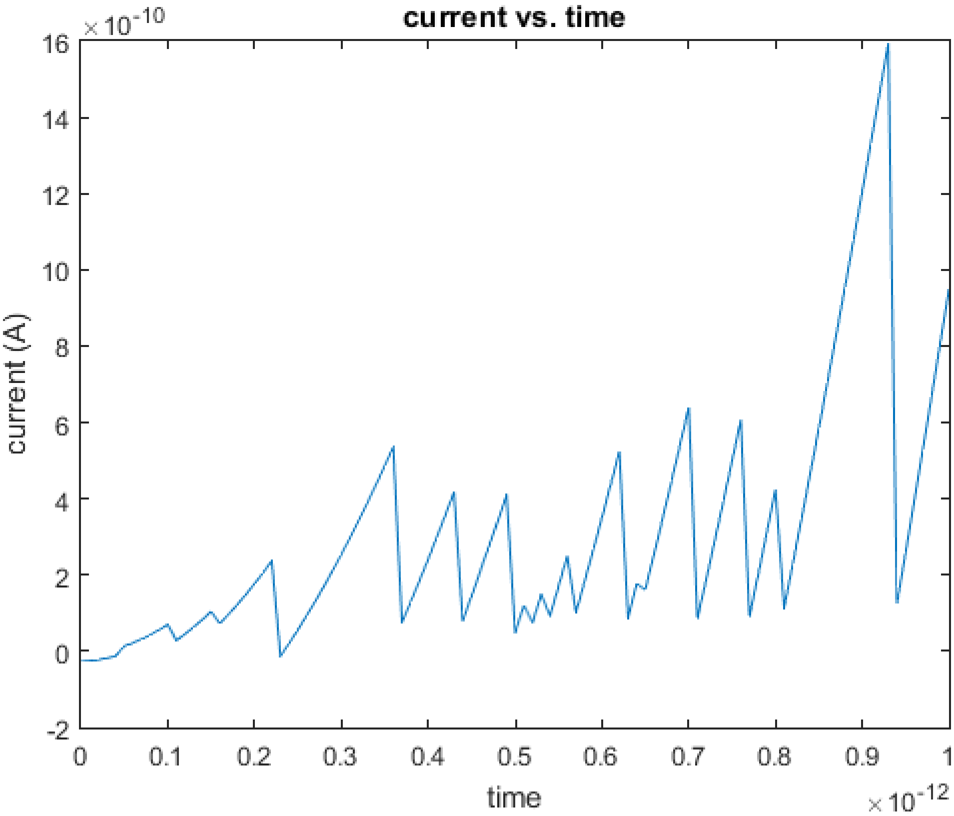
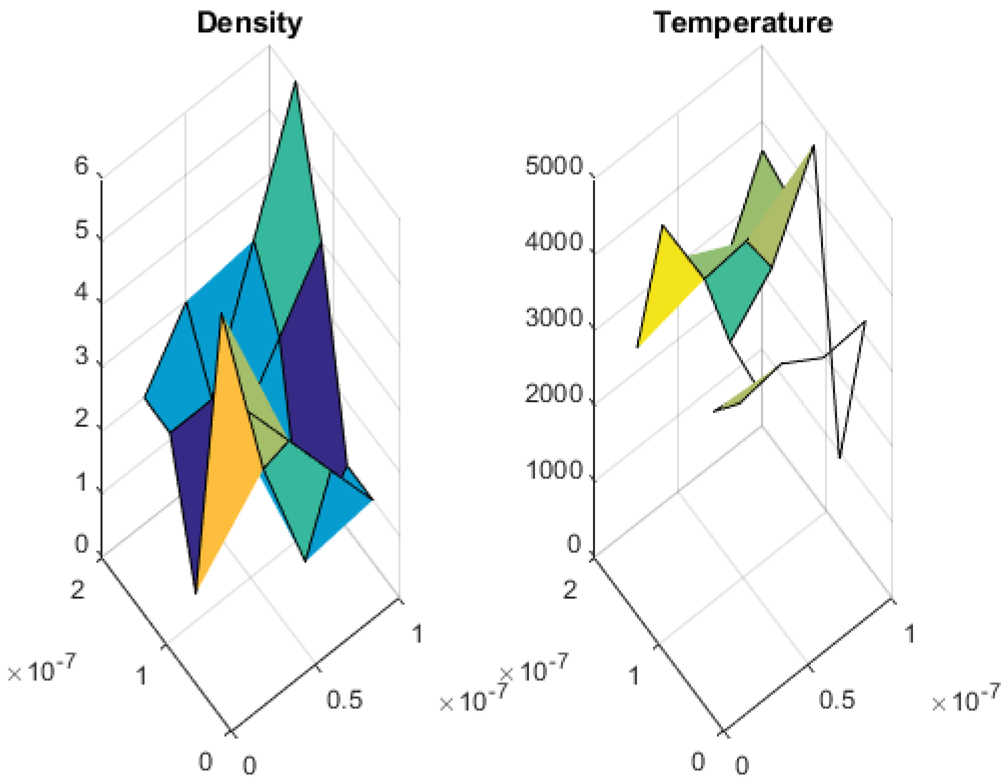


×10⁻⁷
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
×10⁻⁷



current vs. time
×10⁻¹⁰
16
14
12
10
8
6
4
2
0
-2
current (A)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
time
×10⁻¹²


Density
Temperature
6
5
4
3
2
1
0
5000
4000
3000
2000
1000
0
2
1
0
0.5
×10^-7