```
% By Huanyu Liu

% 100986552

% For elec4700 assignment1



% Initialize the parameters

n=10; % 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

% Initialize the positions of each particle

Pox = L*rand(1,n);

Poy = H*rand(1,n);

op1 = Pox >= 0.4*L;

op2 = Pox <= 0.6*L;

op = op1&op2; %specify the locations of the blocks

count = sum(op(:)==1); % number of particles that may be in the blocks

Poy(op) = 0.4*H.*ones(1,count) + 0.2*H.*rand(1,count); % limit the range so no particles can
exist in the blocks
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% 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

Tmeasured = sum(Vx.^2 + Vy.^2).*mn./(2*kb*n);

% draw the first locations of the particles and the blocks

figure(1)

plot(Pox,Poy,'.');

xlim([0 L]);

ylim([0 H]);

line([0.4*L 0.4*L], [0 0.4*H]);

line([0.4*L 0.6*L], [0.4*H 0.4*H]);

line([0.6*L 0.6*L], [0 0.4*H]);

line([0.4*L 0.4*L], [H 0.6*H]);

line([0.4*L 0.6*L], [0.6*H 0.6*H]);

line([0.6*L 0.6*L], [0.6*H H]);

hold on

% more parameters that will be used in the loop

TStop = 1e-11; % max running time

t=0; % start time

dt=1e-14; % step time
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intervals=round(TStop/dt); % number of steps

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

 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

     end
```

```
        Tmeasured = sum(Vx.^2 + Vy.^2).*mn./(2*kb*n);
        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


    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;
    % when the particles will go across a border
    a=tPy<=0.4*H;
    b=tPy>=0.6*H;
    x=a|b;
    e=tPx>=0.4*L;
    % but now it it outside the blocks
    f=Pox<=0.4*L;
    px3=x&e&f;
    % then it will be reflected
        Vx(px3) = Vx(px3).*(-1); % hit boarder 0.4*L
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```
g=tPx<=0.6*L;

h=Pox>=0.6*L;

px4=x&g&h;

    Vx(px4) = Vx(px4).*(-1); % hit boarder 0.6*L



py1 = tPy <= 0;

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

py2 = tPy >= H;

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

c=tPx>=0.4*L;

d=tPx<=0.6*L;

y=c&d;

i=tPy<=0.4*H;

j=Poy>=0.4*H;

py3=y&i&j;

    Vy(py3) = Vy(py3) .* (-1); % hit boarder 0.4*H

k=tPy>=0.6*H;

l=Poy<=0.6*H;

py4=y&k&l;

    Vy(py4) = Vy(py4) .* (-1); % hit boarder 0.6*H

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

    % update the position
```

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


    figure(1)
    plot(Pox,Poy,'.');
    xlim([0 L]);
    ylim([0 H]);
    hold on


    figure(2)
    plot(t,Tmeasured,'or');
    title('temperature plot');
    hold on


    fprintf('time: %g (%5.2g %%) temperature: %g \n', t/dt, t / TStop * 100, Tmeasured);
    pause(0.01)
    t=t+dt;
end
        figure(3)
        hist(Vz);
        title('velocity histogram');
        xlabel('velocity');
```

```
    fprintf(' vth: %g\n',vth);

        mean_time_between_collisions=time/collisions;

        MFP=sum(average_path_length)/collisions;

    fprintf(' MFP:%g m \n mean time between collisions: %g s\n', MFP,
mean_time_between_collisions);

    % divide the frame into 5 pieces, assume there's no particle in the

    % frame in the beginning

  area=0;

  area2=0;

  area3=0;

  area4=0;

  area5=0;

  % after the compution, count the number of particles in each area

 for m=1:n

    if Pox(m)<=0.2*L

        area=area+1;

    elseif Pox(m)<=0.4*L

        area2=area2+1;

    elseif Pox(m)<=0.6*L

        area3=area3+1;

    elseif Pox(m)<=0.8*L

        area4=area4+1;

    else
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        area5=area5+1;

    end

end

fprintf(' The frame is divided into 5 areas uniformly in x dimension\n Then,\n    %.2g%% is in area1\n     %.2g%% is in area 2\n     %.2g%% is in area 3\n     %.2g%% is in area 4\n and %.2g%% is in area 5\n', 100*area/n,100*area2/n,100*area3/n,100*area4/n,100*area5/n);
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time: 0 (    0 %) temperature: 323.328

time: 1 (  0.1 %) temperature: 323.328

time: 2 (  0.2 %) temperature: 323.328

time: 3 (  0.3 %) temperature: 323.328

time: 4 (  0.4 %) temperature: 323.328

time: 5 (  0.5 %) temperature: 323.328

time: 6 (  0.6 %) temperature: 326.036

time: 7 (  0.7 %) temperature: 326.036

time: 8 (  0.8 %) temperature: 326.036

time: 9 (  0.9 %) temperature: 326.036

time: 10 (    1 %) temperature: 326.036

time: 11 (  1.1 %) temperature: 252.069

time: 12 (  1.2 %) temperature: 252.069

time: 13 (  1.3 %) temperature: 252.069

time: 14 (  1.4 %) temperature: 252.069

time: 15 (  1.5 %) temperature: 252.069

time: 16 (  1.6 %) temperature: 252.069
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time: 17 (1.7 %) temperature: 252.069

time: 18 (1.8 %) temperature: 252.069

time: 19 (1.9 %) temperature: 252.069

time: 20 (2 %) temperature: 275.048

time: 21 (2.1 %) temperature: 275.048

time: 22 (2.2 %) temperature: 275.048

time: 23 (2.3 %) temperature: 275.048

time: 24 (2.4 %) temperature: 275.048

time: 25 (2.5 %) temperature: 275.048

time: 26 (2.6 %) temperature: 275.048

time: 27 (2.7 %) temperature: 275.048

time: 28 (2.8 %) temperature: 275.048

time: 29 (2.9 %) temperature: 275.048

time: 30 (3 %) temperature: 275.048

time: 31 (3.1 %) temperature: 275.048

time: 32 (3.2 %) temperature: 275.048

time: 33 (3.3 %) temperature: 275.048

time: 34 (3.4 %) temperature: 275.048

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time: 40 (4 %) temperature: 294.023

time: 41 (4.1 %) temperature: 294.023

time: 42 (4.2 %) temperature: 294.023

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time: 50 (5 %) temperature: 294.023

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vth: 186979

MFP:9.00027e-09 m

mean time between collisions: 5.55629e-14 s

The frame is divided into 5 areas uniformly in x dimension

Then,

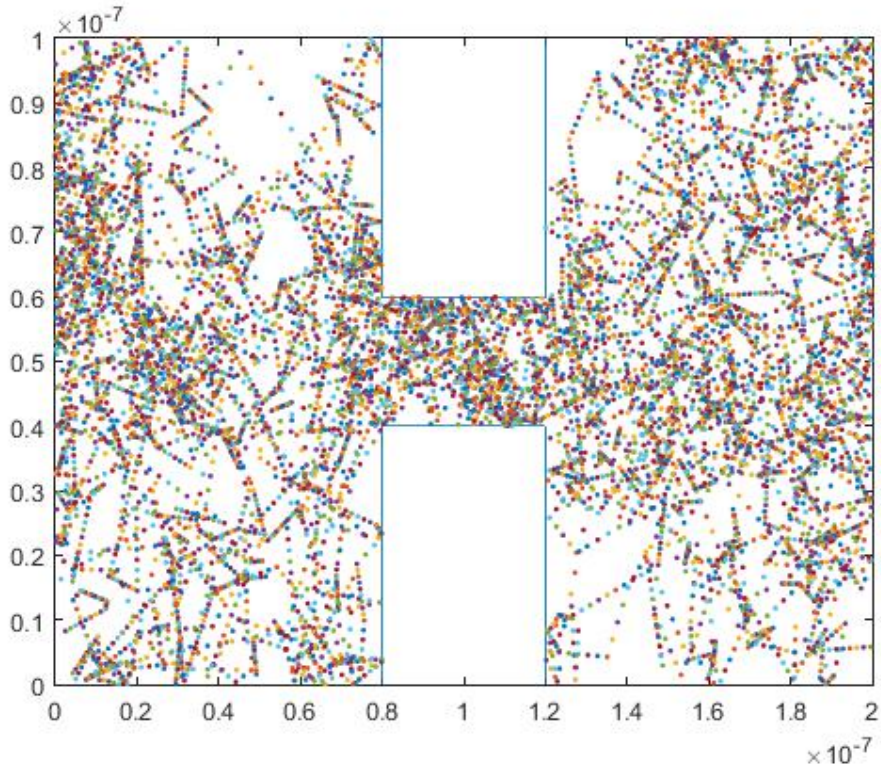
10% is in area1

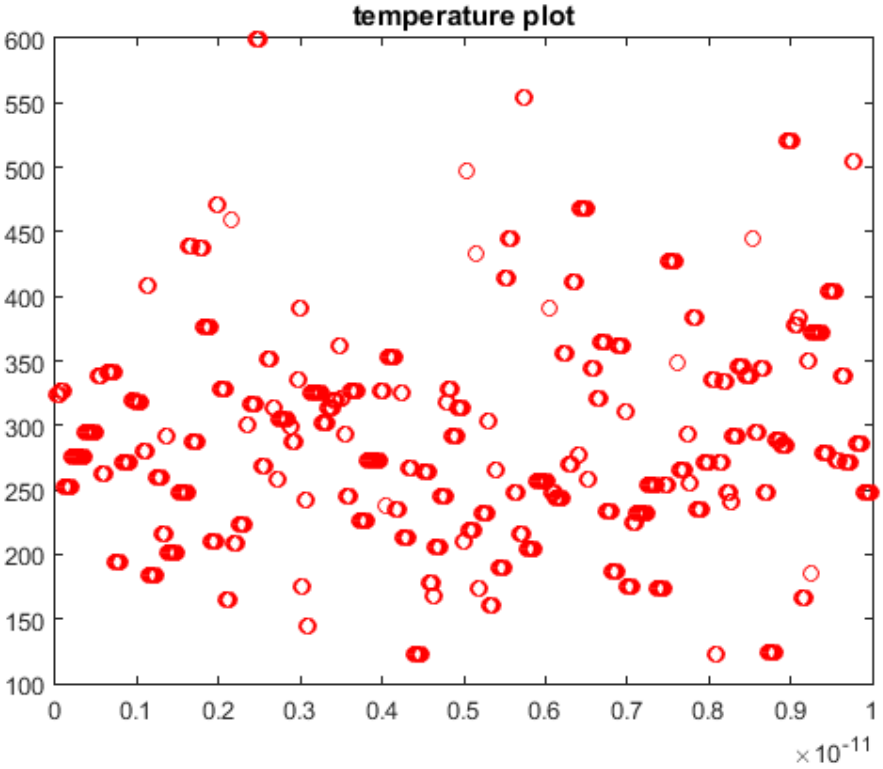
20% is in area 2

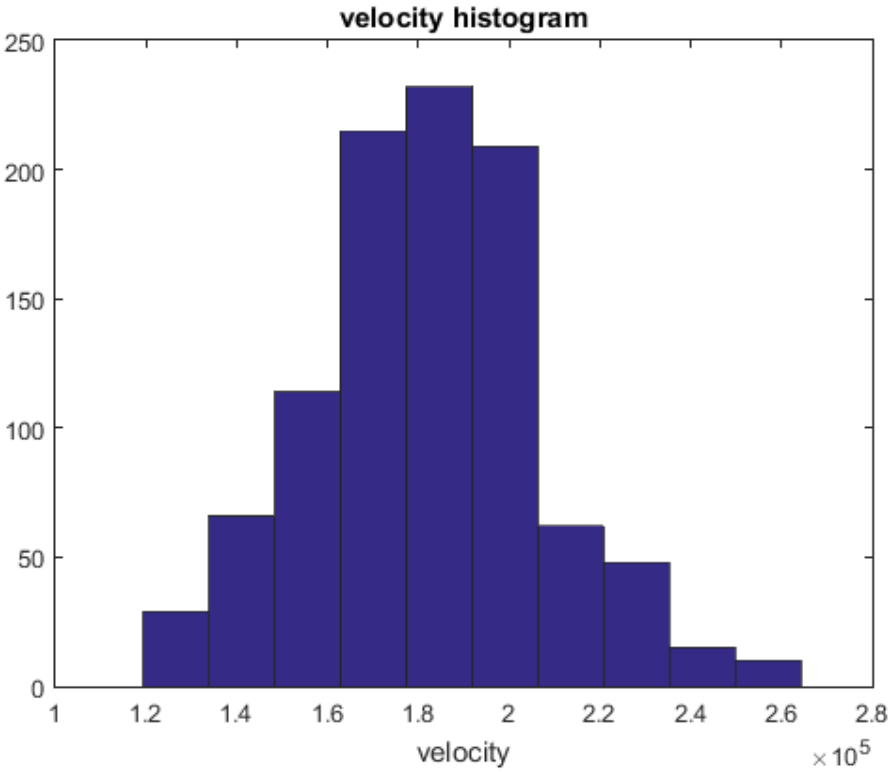
0% is in area 3

40% is in area 4

and 30% is in area 5


×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


temperature plot
600
550
500
450
400
350
300
250
200
150
100
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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