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% Translation is only considered in the plane, therefore 2 degrees of
% freedom. The following equation holds: %
%
% Where m is  $0.26 \times 9.11 \times 10^{-31}$ . Effective Mass of the electrons m %
%
%%CONSTANT DECLARATIONS
mass =  $0.26 \times (9.11 \times 10^{-31})$ ; %% eff mass of Electrons
dt =  $10 \times (10^{-15})$ ; %sim for 1000 dt's
kb =  $1.3806 \times 10^{-23}$ ;
vth = sqrt( $(2 \times 300 \times kb) / (mass)$ ); %thermal velocity, 2D
nop = 1000; %number of particles
nos = 1000; %number of steps
P1 = 1; %lower bound
P2 = 3; % upper bound
vnet = zeros(1,nop);
x = zeros(1,nop);
y = zeros(1,nop);
vx = zeros(1,nop);
vy = zeros(1,nop);
T = zeros(1,nop);

for t = 1:nop %initial conditions

    x(t) = rand*200*( $10^{-9}$ );
    y(t) = rand*100*( $10^{-9}$ );
    vx(t) = (vth)*cos(2*pi*rand);
    vy(t) = (vth)*sin(2*pi*rand);
    vnet(t) = sqrt(vx(t)^2 + vy(t)^2);
end

for s = 1:nos %amount of timesteps

    x(1:nop) = x(1:nop) + (vx(1:nop).*dt);
    y(1:nop) = y(1:nop) + (vy(1:nop).*dt);

    for n = 1:nop %boundary conditions
        if (y(n)<=0 || y(n)>=100* $10^{-9}$ )
            vy(n) = -vy(n);
        end
        if(x(n)<=0)
            x(n) = x(n) + 200* $10^{-9}$ ;
        end
        if(x(n)>=200* $10^{-9}$ )
            x(n) = x(n) - 200* $10^{-9}$ ;
        end

    end

    for f = P1:P2

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        colorVec = hsv(5);
        plot(x(f),y(f),'-', 'color', colorVec(f,:));
    end

    T(s) = (mass/(2*kb))*( mean(abs(vx).^2)+ mean(abs(vy).^2) );

    axis([0,200*10^-9,0,100*10^-9]);
    pause(0.00001);
    hold on;
end

figure(2)
h=linspace(0,1000*dt,1000);

plot(h,T)
title('Temp vs. Time');
xlabel('Time (s)');
ylabel('Temp (K)');
axis([0,10^-14,0,400]);
%

% COLLISIONS WITH MEAN FREE PATH
% Temperature varies for each scattering of all particles. Average for
all
% time steps is rough 300K. More with more particles average speeds
tends to
% vth. Most populous bin in histogram approaches vth. Mean free path
and
% mean time between collisions is calculated based on steps/count of %
scattering. With more timesteps, MFP and MTBC converges to analytic %
result.
clear clf

mass = 0.26*(9.11*10^-31); %effective mass
dt = 10*(10^-15); %sim for 1000 dt's
pscat = 1-exp(-(dt)/(0.2*10^(-12)));
kb = 1.3806*10^-23;
vth = sqrt((2*300*kb)/(mass)); %thermal velocity, 2D
nop = 1000; %no of particles
nos = 1000; %no of steps
P1 = 1; %partition lower bound
P2 = 3; %partition upper bound
count=0;

pcomp = zeros(1,nos);
vnet = zeros(1,nop);
x = zeros(1,nop);
y = zeros(1,nop);
vx = zeros(1,nop);
vy = zeros(1,nop);
T = zeros(1,nop);

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for t = 1:nop
    x(t) = rand*200*(10^-9);
    y(t) = rand*100*(10^-9);
    vx(t) = (vth).*randn(1,1)*(1/sqrt(2));
    vy(t) = (vth).*randn(1,1)*(1/sqrt(2));
    vnet(t) = sqrt(vx(t)^2 + vy(t)^2);
    %initial conditions
end

for s = 1:nos
    pcomp(s) = rand;
end

for l = 1:nos
    x(1:nop) = x(1:nop) + (vx(1:nop).*dt);
    y(1:nop) = y(1:nop) + (vy(1:nop).*dt);

    if(pscat > pcomp(l))
        count = count+1;
        for p = 1:nop
            vx(p) = (vth).*randn(1,1)*(1/sqrt(2));
            vy(p) = (vth).*randn(1,1)*(1/sqrt(2));
        end
    end

    for n = 1:nop %boundary conditions
        if(y(n)<=0 || y(n)>=100*10^-9)
            vy(n) = -vy(n);
        end
        if(x(n)<=0)
            x(n) = x(n) + 200*10^-9;
        end
        if(x(n)>=200*10^-9)
            x(n) = x(n) - 200*10^-9;
        end
    end

    for f=P1:P2
        colorVec = hsv(5);
        plot(x(f),y(f),'-', 'color', colorVec(f,:));
    end

    T(l) = (mass/(2*kb))*( mean(abs(vx).^2)+ mean(abs(vy).^2) );

    axis([0,200*10^-9,0,100*10^-9]);
    pause(0.00001);
    hold on;
end
figure(2);
h=linspace(0,1000*dt,1000);
plot(T);
title('Temp vs. Time steps');
xlabel('Time Steps');

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ylabel('Temp (K)');

figure(3);
histogram(vnet,20);
title('Freq vs. Avg Velocity');
xlabel('Avg. Velocity (m/s)');
ylabel('Freq');

mfp = (nos/count)*dt*mean(vnet); %%Calculation for mean free path
meant = dt*(nos/count); %%Mean time between collisions
sprintf('avg. velocity is %0.5e m/s' ,mean(vnet))
sprintf('mean free path is %0.5e m and mean time between collisions is %0.5e s' ,mfp,meant)

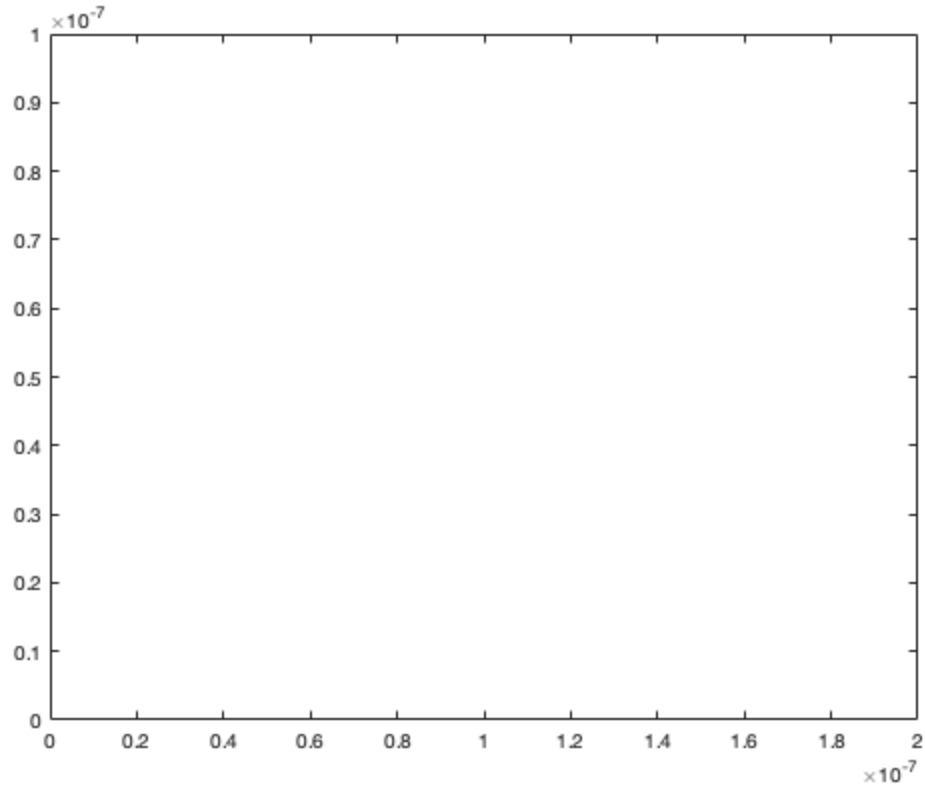
ans =

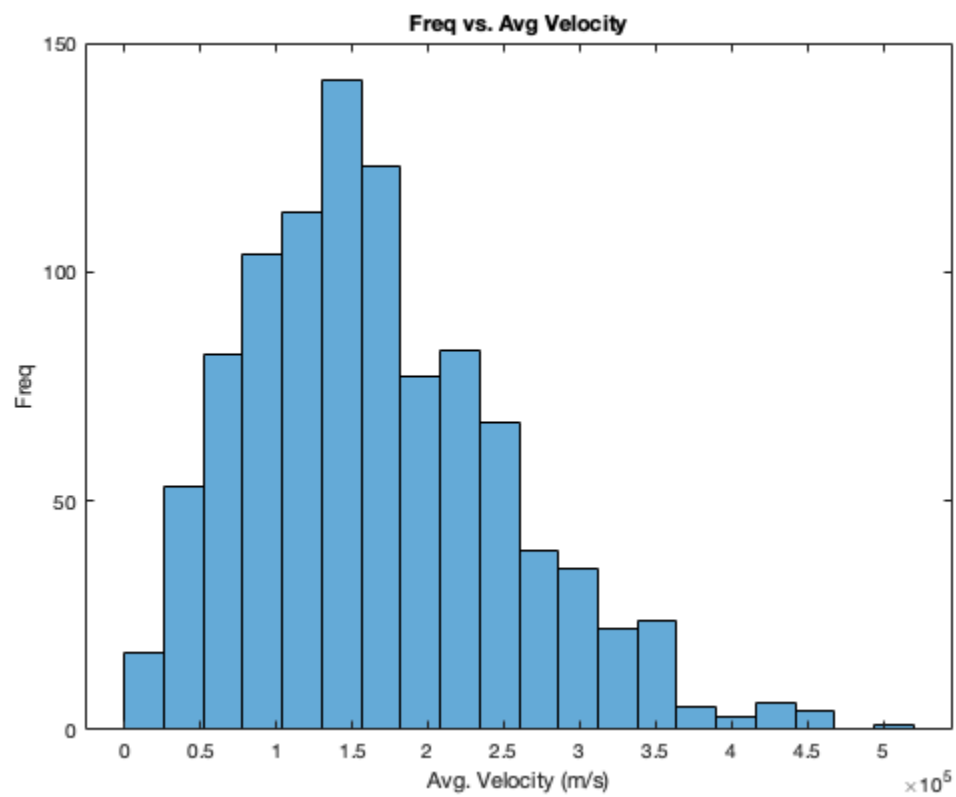
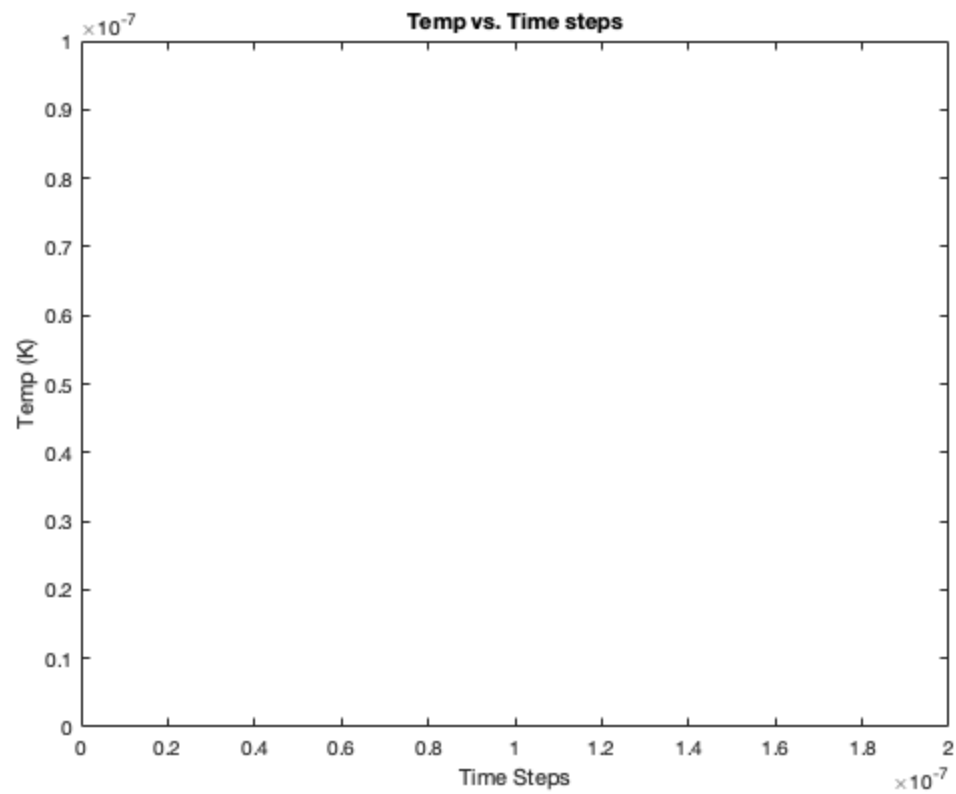
    'avg. velocity is 1.66105e+05 m/s'

ans =

    'mean free path is 4.37118e-08 m and mean time between collisions is 2.63158e-13 s'

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