

ELEC 4700 ASSIGNMENT 1

JALIL (ROHANA) AALAB #100995788



February 4, 2018

CARLETON UNIVERSITY

# ELECTRON MODELLING

## 1.1 Thermal Velocity

From the kinetic theory of gases, the kinetic energy is related to temperature and both mass and velocity through the formula below, where m is mass, v is velocity, k is Boltzmann’s constant and T is temperature:

mv2 = (per degree of freedom)

This simulation modelled electron movement in two dimensions, namely in the x and y directions, and therefore had two degrees of freedom. This changed the formula to:

mv2 = =

The thermal velocity is calculated by rearranging the above formula:

Vth =

The thermal velocity calculation used the above formula while assuming T = 300 K, and an effective electron mass of 2.36834 x 10-31 kilograms. Therefore,

Vth = = 1.8698 x 105

## 1.2 Mean Free Path

The mean free path is defined as the average distance a particle can travel undisturbed prior to a collision with another particle. It is calculated as the product of the thermal velocity and the mean time between collisions. Therefore,

MFP = Vth xτmn.

The velocities of all the particles were fixed at the thermal velocity determined above, and the mean collision time was given as

τmn = 0.2 x 10-12 s

Therefore,

MFP = Vth xτmn = (1.8698 x 105  ) x (0.2 x 10-12 s )= 2.6443 x 10-8 m

## 1.3 2-D Plot of Particle Trajectories and Temperature Plot

The following plot shows the movement of seven different simulated electron paths, which move in different directions at the same thermal velocity. The temperature plot depicts temperature as a function of time in the system, which remains constant.

# COLLISIONS WITH MEAN FREE PATH (MFP)

## 2.1 Histogram

A histogram is a type of data presentation graph that depicts the number of occurrences of a particular result within a set of data. In this section of the simulation, the electrons were initialized with velocities determined from a Maxwell-Boltzmann distribution. The histogram shows the distribution of velocities among the electrons, and the number of electrons that have each particular velocity.

## 2.2 2-D Plot of Particle Trajectories and Temperature Plot

The following 2-D plot shows the movement of electrons in the same area with random scattering. Upon scattering, the electron obtains new velocities determined from the Maxwell-Boltzmann distribution. The accompanying temperature plot displays the average temperature of the system as a function of time.

## 2.3 MFP and τmn

The actual mean free path and meant time between collisions are shown below.

# ENHANCEMENTS

## 3.1 2-D Plot of Particle Trajectories

The following 2-D plot shows the movement of electrons with scattering in an area with bottle neck boundaries located in the center. The boundaries of the bottle neck boxes are designed to reflect the electrons back into the opposite direction from which they came.

## 3.2 Electron Density Map

The following electron density map displays the various final electron positions over the figure after the maximum timesteps have been reached.

## 3.3 Temperature Map

The following temperature map displays the variation of temperature over the figure.