```
%% Roshan Jaiswal-Ferri
%Section - 01
%Aero 356 Midterm 3: 6/7/25

%% Workspace Prep

warning off
format long     %Allows for more accurate decimals
close all;      %Clears all
clear all;      %Clears Workspace
clc;            %Clears Command Window
```

Assumptions & Constants:

k = 1.38*10^-23 J/K

charge = +/- 1.6e-19 C

permitivity of free space = 8.8 × 10-12 m-3 kg-1 s4 A2

mi = 1.67*10^-27 kg

me = 9.11*10^-31 kg

```
kb = 1.38*10^-23; %J/K
q = 1.6e-19; %C
perm = 8.8*10^-12; %m-3 kg-1 s4 A2
mi = 1.67*10^-27; %kg
me = 9.11*10^-31; %kg
Re = 6378;
```

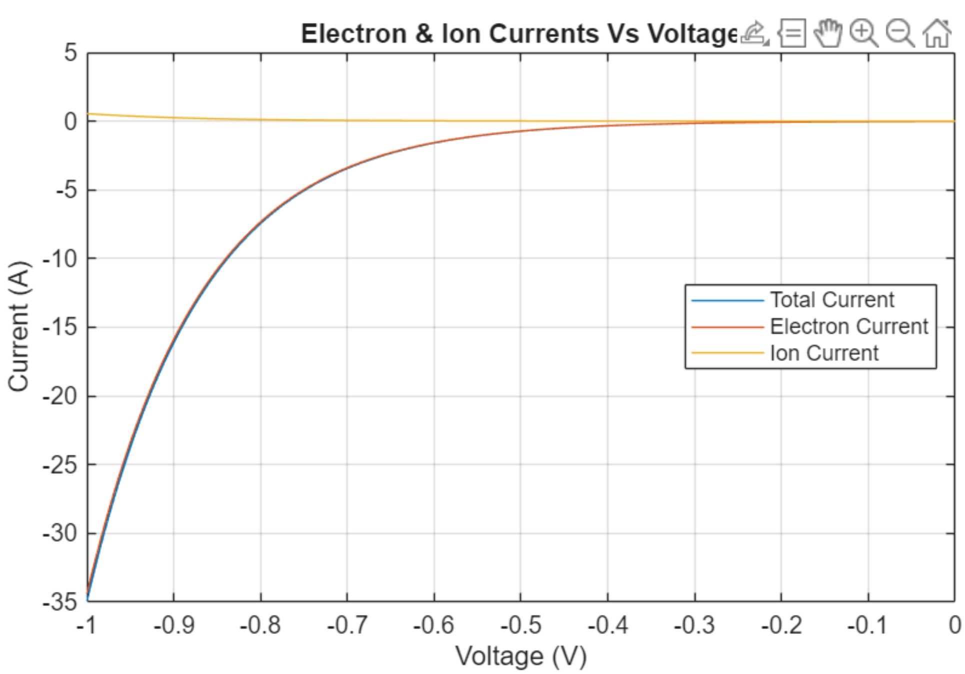
Question 1)

Consider a spherical spacecraft with a radius of 0.5m, orbiting Earth at 300km. The ambient plasma temperature is 1500K and the plasma density is 5x10^11 m^-3. Assume no backscattering, no secondary emission, and no conduction currents.

a) Plot (and attach the plot here) the electron and ion currents due to the spacecraft during eclipse for spacecraft voltages of -1V to 0V.

```
V = linspace(-1,0,200);
Ise = 0;
Isi = 0;
Ibse = 0;
Ic = 0;
Iph = 0; %zero bc eclipse

pT = 1500; %k
n = 5e11;
ni = n;
ne = n;

Ae = 4*pi*0.5^2;
```

```
Ai = 0.25*Ae;

Vth_e = sqrt((8*kb*pT)/(pi*me));
Vth_i = sqrt((8*kb*pT)/(pi*mi));

Ieo = 0.25*-q*ne*Vth_e;
Iio = 0.25*q*ni*Vth_i;

Ie = Ieo*Ae*exp((-q.*V)/(kb*pT));
Ii = Iio*Ai*exp(1-((q.*V)/(kb*pT)));


It = Ie - Ii - Ise - Isi - Ibse - Iph + Ic;


figure('Name','Electron & Ion Currents Vs Voltage')
plot(V,It)
hold on
grid on
plot(V,Ie)
plot(V,Ii)
xlabel('Voltage (V)')
ylabel('Current (A)')
title('Electron & Ion Currents Vs Voltage')
legend('Total Current', 'Electron Current', 'Ion Current',Location='best')
```



Question 1 b)

What value do you expect the spacecraft potential to float to? Identify analytically (via formula). Give results to three decimal places in V.

```
r = 300;
mu = 398600;
```

```
vsc = sqrt(mu/(r+Re));
vsc = vsc*1000;

%pT = 5000;
inside = vsc* sqrt((pi*me)/(8*kb*pT));
Vf = ((kb*pT)/q)*log(inside);
disp(['Floating Potential (V): ', num2str(Vf)])
```

```
Floating Potential (V): -0.44483
```

Question 1 d)

Calculate the debye length [m] Provide your answers in 4 decimal places.

```
deb = sqrt((perm*kb*pT)/(ne*q^2));
disp(['Debye Length (m): ', num2str(deb)])
```

```
Debye Length (m): 0.0037724
```

Question 1 e)

Calculate the Plasma Parameter [unitless] with no decimals

```
pparameter = (4/3)*pi*(deb^3)*ne;
disp(['Plasma Parameter (unitless): ', num2str(pparameter)])
```

```
Plasma Parameter (unitless): 112440.6081
```

Question 1 f)

what is the floating voltage of a spacecraft if you move the spacecraft to GEO? Give results in V with no decimals. Credit for this problem will be partially dependent on the work shown in the pdf.

```
alt = 36000; %new geo altitude in km
rsc = Re + alt;
n = 10^7;
Te = 10^7; %k

syms Vf2
eq = Vf2 == ((kb*Te)/-q)*log(-1*sqrt(1)*1*(1-((q*Vf2)/(kb*Te))));
soln = solve(eq,Vf2);
Vf2 = double(soln); %in GEO the Vf is way higher so ~1000 volts makes sense
disp(['Floating Potential (GEO) (V): ', num2str(-Vf2)])
```

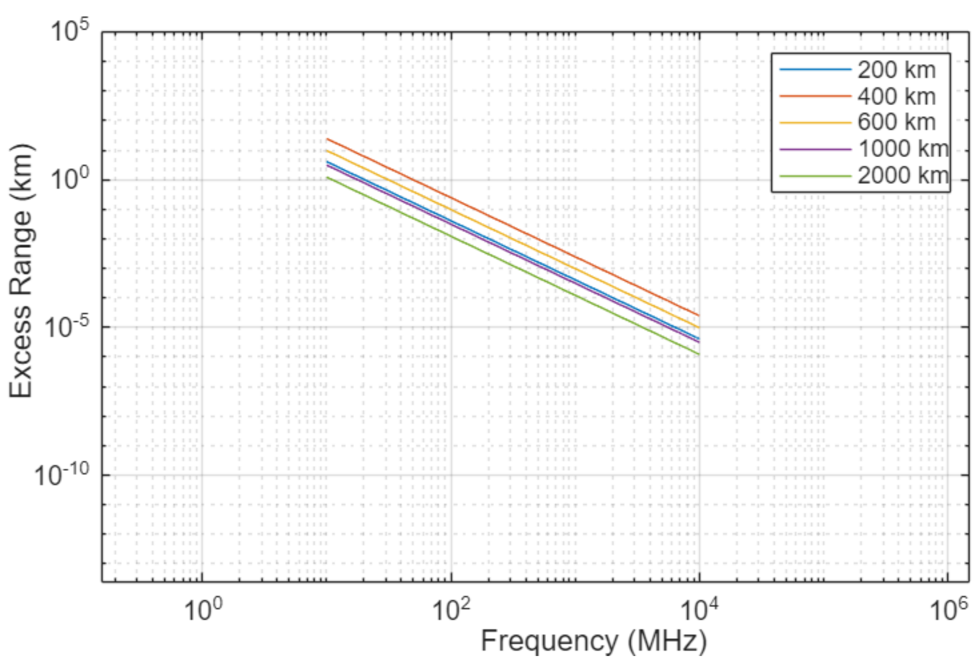
```
Floating Potential (GEO) (V): 1102.6757
```

Question 3 a)

Use this Ionosphere Download Ionosphere data for electron density with altitude in the ionosphere to produce a log-log plot showing the excess range for a spacecraft at 200km, 400km, 600km, 1000km and 2000km over a range of frequencies from 10MHz to 10,000MHz. You may assume that change in path length due to bending can be neglected. Density is in 1/m3 and altitude is in km.

```
ionData = readtable("Ionosphere Data Final Exam.csv");
```

```
alt = ionData.Altitude_km_*1000; %in meters from km in the file
density = ionData.ElectronDensity_m_3_;
c = 2.998e+8;

TEC200 = alt(3)*density(3);
TEC400 = alt(7)*density(7);
TEC600 = alt(11)*density(11);
TEC1000 = alt(19)*density(19);
TEC2000 = alt(39)*density(39);

TEC = [TEC200, TEC400, TEC600, TEC1000, TEC2000];
fsig = linspace(10e6,10000e6,500); %in hz
fsigmhz = fsig*10^-6; %in mhz for plotting


for i = 1:length(TEC)
    dT = (40.31*TEC(i))./((c.*fsig.^2));
    dr(i,:) = (dT.*c)/1000; %converting to km
end

figure('Name','Excess Range vs Frequency')
loglog(fsigmhz,dr(1,:))
hold on
grid on
loglog(fsigmhz,dr(2,:))
loglog(fsigmhz,dr(3,:))
loglog(fsigmhz,dr(4,:))
loglog(fsigmhz,dr(5,:))
xlabel('Frequency (MHz)')
ylabel('Excess Range (km)')
title('Excess Range vs Frequency')
legend('200 km', '400 km', '600 km', '1000 km', '2000 km', Location='best')
```



Question 3 c)

what is the maximum excess range [m] with no decimals?

```
maxexcess =
max([max(dr(1,:)),max(dr(2,:)),max(dr(3,:)),max(dr(4,:)),max(dr(5,:))])*1000;
disp(['Maximum Excess Range of all Altitudes in meters: ', num2str(maxexcess)])
```

```
Maximum Excess Range of all Altitudes in meters: 24508.48
```

Question 3 d)

What is the plasma frequency (max value)? Give in MHz with one decimal place

```
%%
plasmaFreq = 8.98*sqrt(max(density)); %in hz
plfrq = plasmaFreq*10^-6;
disp(['Maximum Plasma Frequency in MHz: ', num2str(plfrq)])
```

```
Maximum Plasma Frequency in MHz: 4.2024
```