Assignment 2

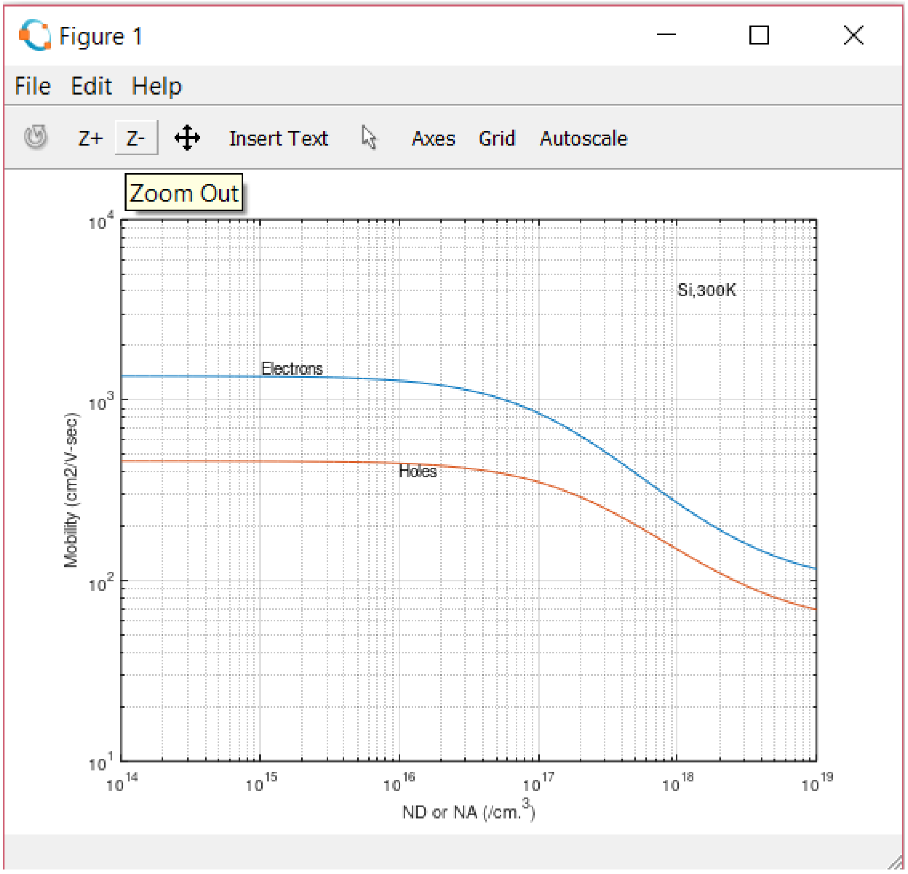
Problem 3.1 (a) →

Octave Code →

prob3.1(a).m

```
#   Graph of mobility vs doping concentration

# parameters

# For n-type
unmin=92;
un0=1268;
Ndref=1.3*(10.^17);
an=0.91;

# For p-type
upmin=54.3;
up0=406.9;
Naref=2.35*(10.^17);
ap=0.88;


# Calculation

N=logspace(14,19);
un=unmin + un0./((1+N/Ndref).^an);
up=upmin + up0./((1+N/Naref).^ap);


# Graph plotting

loglog(N,un,N,up);
grid;
axis([1.0e14 1.0e19 1.0e1 1.0e4]);
xlabel('ND or NA (/cm.^3)');
ylabel('Mobility (cm2/V-sec)');
text(1.0e15,1500,'Electrons');
text(1.0e16,400,'Holes');
text(1.0e18,4000,'Si,300K');
```

Generated Plot →



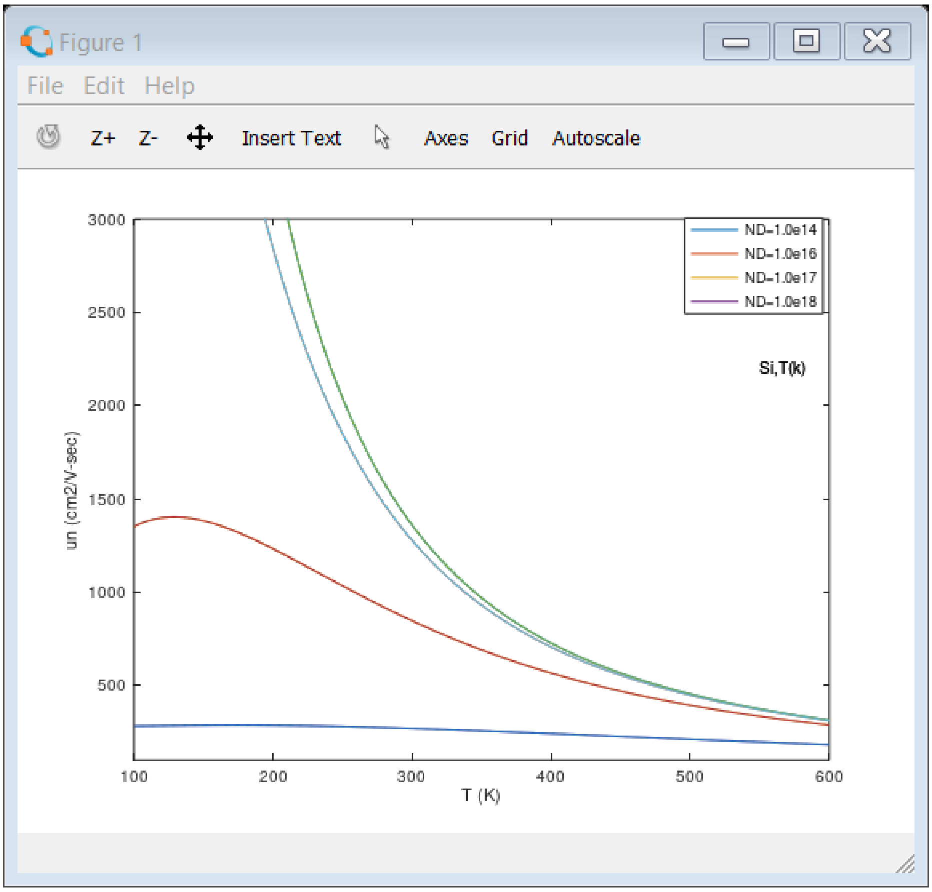
Problem 3.1 (b) →

(i) n-type --->

Octave Code →

```
#  Plotting of Mobility vs T(K);

# Values at T=300K
unmin300=92;
un0300=1268;
Ndref300=1.3*(10.^17);
an300=0.91;
T=100:1:600;

# Values at T(k)
unmin=unmin300*((T/300).^-0.57);
un0=un0300*((T/300).^-2.33);
Ndref=Ndref300*((T/300).^2.4);
an=an300*((T/300).^-0.146);

ND=1.0e14;
un=unmin + un0./((1+ND./Ndref).^an);
plot(T,un);
axis([100 600 1.0e2 3000]);
xlabel('T (K)');
ylabel('un (cm2/V-sec)');
legend('ND=1.0e14');
hold on

ND=1.0e16;
un=unmin + un0./((1+ND./Ndref).^an);
plot(T,un);
axis([100 600 1.0e2 3000]);
legend('ND=1.0e16');
hold on

ND=1.0e17;
un=unmin + un0./((1+ND./Ndref).^an);
plot(T,un);
axis([100 600 1.0e2 3000]);
legend('ND=1.0e17');
hold on

ND=1.0e18;
un=unmin + un0./((1+ND./Ndref).^an);
plot(T,un);
axis([100 600 1.0e2 3000]);
legend('ND=1.0e14', 'ND=1.0e16', 'ND=1.0e17', 'ND=1.0e18');

text(550,2200,'Si,T(k)');
```

Generated Plot →

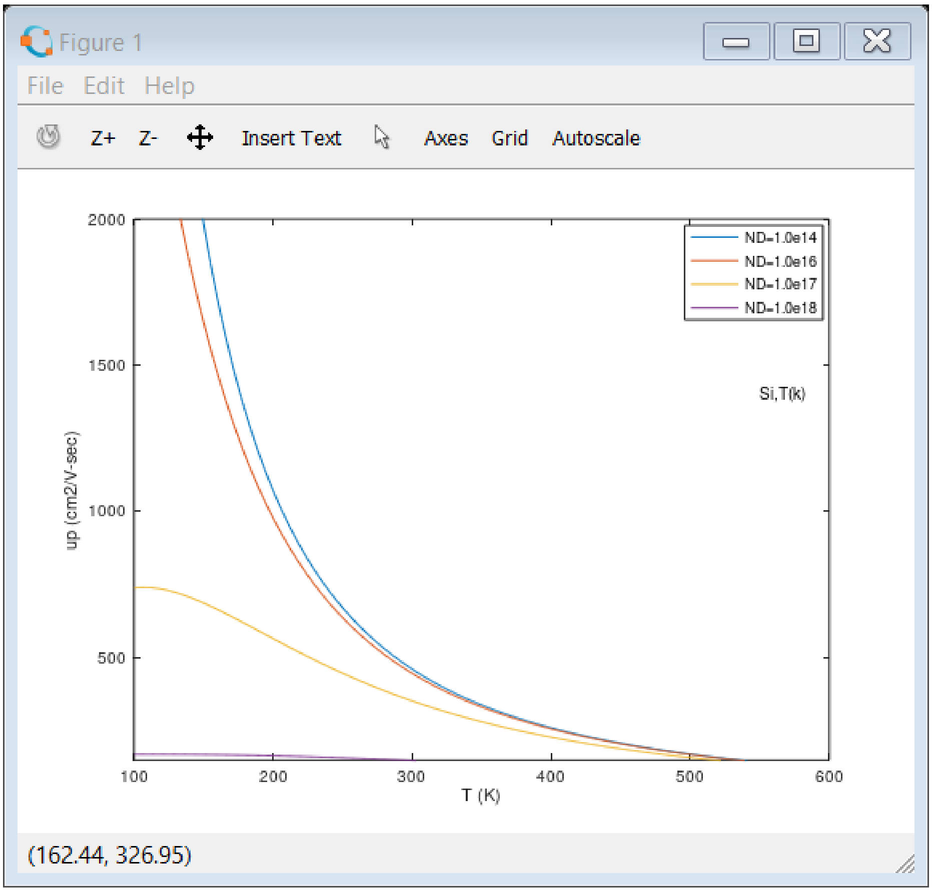


(ii) p-type ---→

Octave Code →

```
#  Plotting of Mobility vs T(K);

# Values at T=300K
upmin300=54.3;
up0300=406.9;
Naref300=2.35*(10.^17);
ap300=0.88;
T=100:1:600;

# Values at T(k)
upmin=upmin300*((T/300).^-0.57);
up0=up0300*((T/300).^-2.23);
Naref=Naref300*((T/300).^2.4);
ap=ap300*((T/300).^-0.146);

NA=1.0e14;
up=upmin + up0./((1+NA./Naref).^ap);
plot(T,up);
axis([100 600 150 2000]);
xlabel('T (K)');
ylabel('up (cm2/V-sec)');
hold on

NA=1.0e16;
up=upmin + up0./((1+NA./Naref).^ap);
plot(T,up);
axis([100 600 150 2000]);
hold on

NA=1.0e17;
up=upmin + up0./((1+NA./Naref).^ap);
plot(T,up);
axis([100 600 150 2000]);
hold on

NA=1.0e18;
up=upmin + up0./((1+NA./Naref).^ap);
plot(T,up);
axis([100 600 150 2000]);
legend('ND=1.0e14', 'ND=1.0e16', 'ND=1.0e17', 'ND=1.0e18');

text(550,1400,'Si,T(k)');
```

Generated Plot →

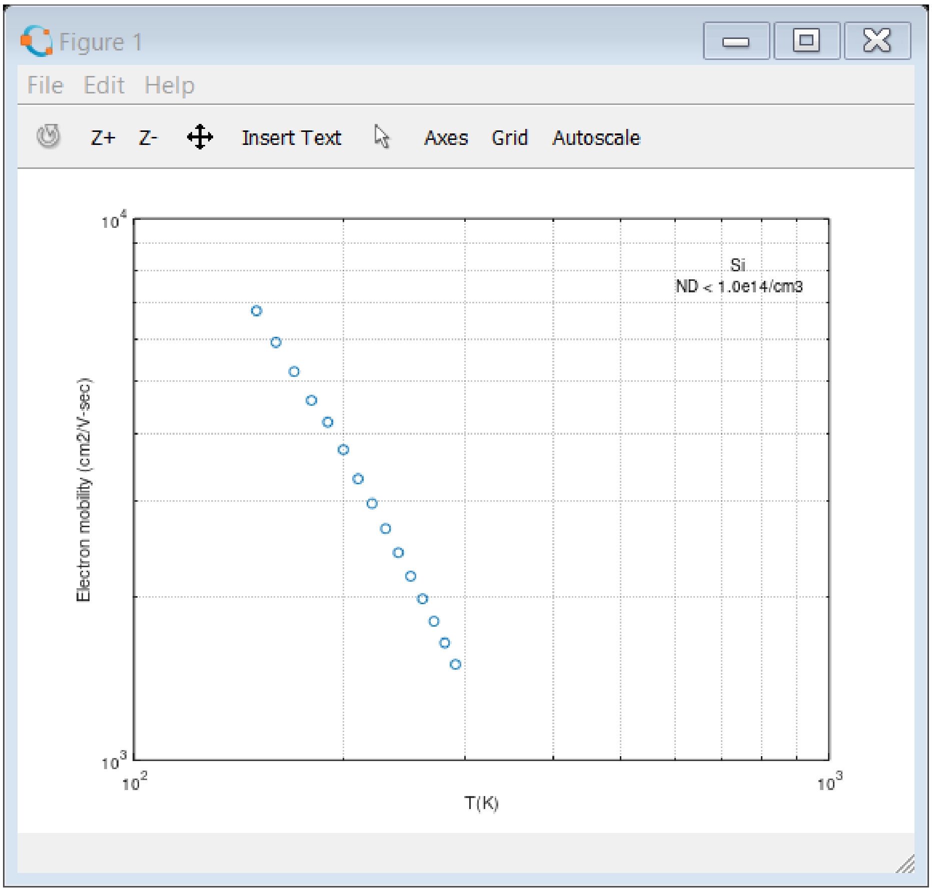


Problem 3.4 (b) →

Octave Code →

```
# taking values

T=150:10:290;
un=[6757 5910 5216 4619 4209 3743 3306 2978 2675 2415 2185 1985 1805 1646 1501];

# taking log of values
u=log(T);
v=log(un);

# Fitting this in equation
x=polyfit(u,v,1);  # v=x(1)+x(2)*u
a=x(1);
b=-x(2);    # log(un)=-b*log(T)+a

T1=120:10:350;
y1=exp(a).*(T1.^(-b));


# Plotting
loglog(T,un, 'o', T1, y1);
grid;
axis([100,1000,1000,10000]);
xlabel('T(K)');
ylabel('Electron mobility (cm2/V-sec)');

text(600, 7500,'ND < 1.0e14/cm3');
text(720, 8200, 'Si');
```

Generated Plot →



Problem 3.4 (c) →

By this plot, we almost fount accurately same value. This plot is very impressive.

The experimentally determined b fit value is almost same to the b-value noted on text-plot (2.29 versus 2.3).

The magnitude is also in close with the fig 3.7(a) plot.

A lowely-doped sample was employed, so that lattice scattering would dominate and a power-law dependence would be observed.

Problem 3.9 (a) →

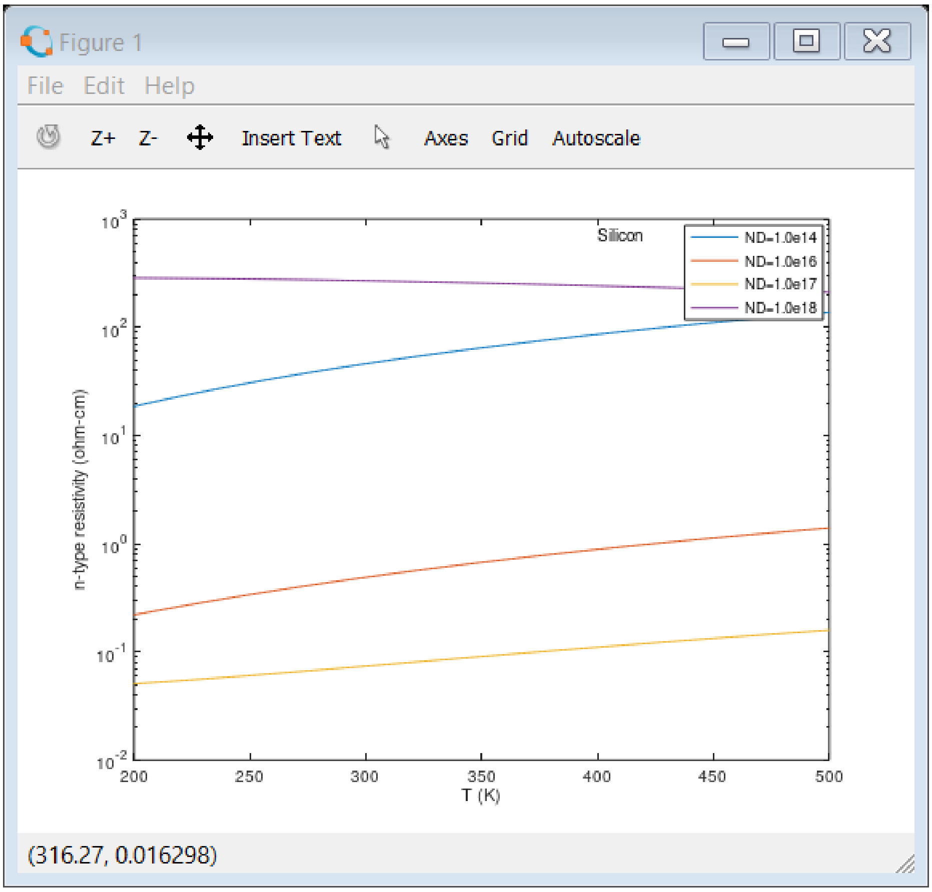
(i) **n-type -→**

Octave Code →

```
#  Plotting of Resistivity vs T(K);

# Values at T=300K
unmin300=92;
un0300=1268;
Ndref300=1.3*(10.^17);
an300=0.91;
T=100:1:600;
q=1.6e-19;

# Values at T(k)
unmin=unmin300*((T/300).^-0.57);
un0=un0300*((T/300).^-2.33);
Ndref=Ndref300*((T/300).^2.4);
an=an300*((T/300).^-0.146);
pn=logspace(-2,3);

ND=1.0e14;
un=unmin + un0./((1+ND./Ndref).^an);
pn=1./(q*un*ND);
semilogy(T,pn);
axis([200 500 1.0e-2 1.0e3]);
xlabel('T (K)');
ylabel('n-type resistivity (ohm-cm)');
hold on

ND=1.0e16;
un=unmin + un0./((1+ND./Ndref).^an);
pn=1./(q*un*ND);
plot(T,pn);
axis([200 500 1.0e-2 1.0e3]);
hold on

ND=1.0e17;
un=unmin + un0./((1+ND./Ndref).^an);
pn=1./(q*un*ND);
```

```
plot(T,pn);
axis([200 500 1.0e-2 1.0e3]);
legend('ND=1.0e17');
hold on

ND=1.0e18;
un=unmin + un0./((1+ND./Ndref).^an);
plot(T,un);
axis([200 500 1.0e-2 1.0e3]);
legend('ND=1.0e14', 'ND=1.0e16', 'ND=1.0e17', 'ND=1.0e18');

text(400,700,'Silicon');
```

Generated Plot →

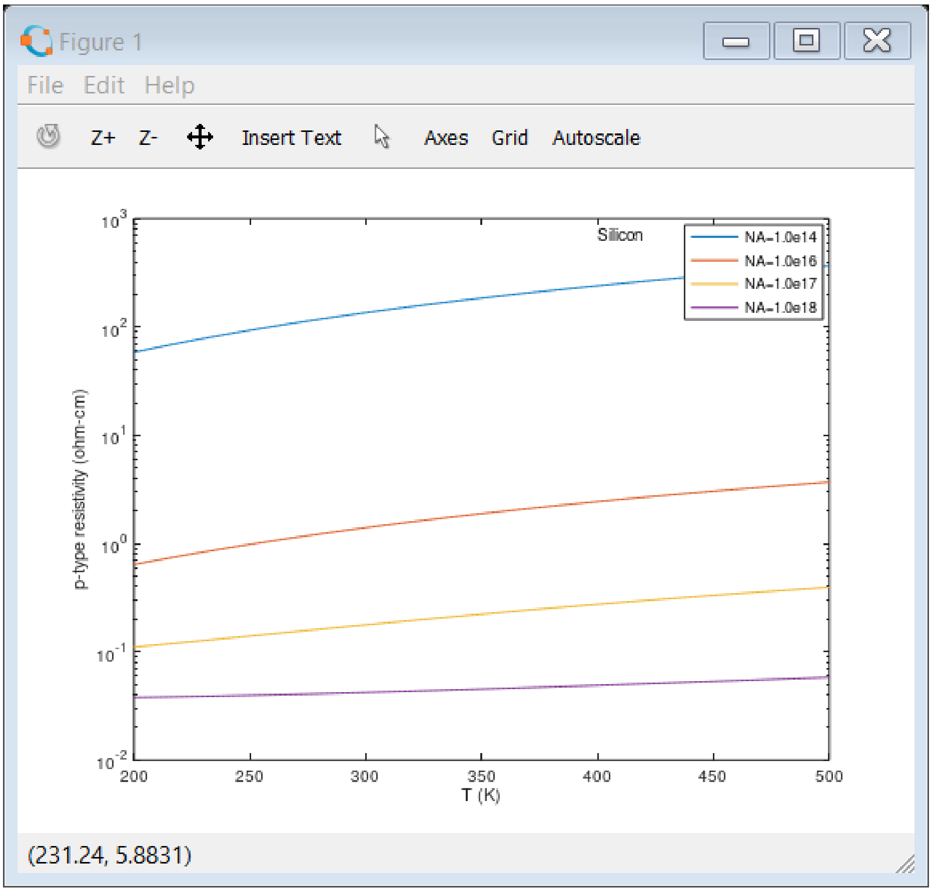


(ii) **p-type --->**

Octave-Code →

```
#  Plotting of Resistivity vs T(K);

# Values at T=300K
upmin300=54.3;
up0300=406.9;
Naref300=2.35*(10.^17);
ap300=0.88;
T=100:1:600;
q=1.6e-19;

# Values at T(k)
upmin=upmin300*((T/300).^-0.57);
up0=up0300*((T/300).^-2.23);
Naref=Naref300*((T/300).^2.4);
ap=ap300*((T/300).^-0.146);

NA=1.0e14;
up=upmin + up0./((1+NA./Naref).^ap);
pn=1./(q*up*NA);
semilogy(T,pn);
axis([200 500 1.0e-2 1.0e3]);
xlabel('T (K)');
ylabel('p-type resistivity (ohm-cm)');
hold on

NA=1.0e16;
up=upmin + up0./((1+NA./Naref).^ap);
pn=1./(q*up*NA);
semilogy(T,pn);
axis([200 500 1.0e-2 1.0e3]);
hold on

NA=1.0e17;
up=upmin + up0./((1+NA./Naref).^ap);
pn=1./(q*up*NA);
semilogy(T,pn);
axis([200 500 1.0e-2 1.0e3]);
hold on

NA=1.0e18;
up=upmin + up0./((1+NA./Naref).^ap);
pn=1./(q*up*NA);
semilogy(T,pn);
axis([200 500 1.0e-2 1.0e3]);
legend('NA=1.0e14', 'NA=1.0e16', 'NA=1.0e17', 'NA=1.0e18');

text(400,700,'Silicon');
```

Generated Plot →



Prob 3.26 →

(a) Octave code →

```
# Given values
Eg=1.1;  # eg of silicon
kT=0.0259;
ni=1e10;

# taking input
ND=input('Give the value of ND in cm-3, ND = ');
pn0=input('Give the value of pn0 in cm-3, pn0 = ');

p0= ni.^2/ND;
t=log(100*pn0/p0);
z=linspace(0,t);

# taking all energies related to Ev
Ec=Eg/kT;
FN=Eg/(2*kT) + log(ND/ni);
FP=Eg/(2*kT) - log(p0/ni+(pn0/ni).*exp(-z));

# plotting
plot(z,FP);
axis([0,t,-5,45])
xlabel('x/LP');
ylabel('(E-Ev)/kT');
hold on

# now comparing with Ec and Ev
x=[0,t];
a1=[Ec,Ec];
a2=[FN,FN];
plot(x,a1,x,a2);
a3=[Ec/2,Ec/2];
a4=[0,0];
plot(x,a3,'--',x,a4,'y');

# labelling
u=t+0.2;
text(u,43.4,'Ec');
text(u,21,'Ei');
text(u/2,FN+1,'FN');
text(u/2,FP(50)-1,'FP');
text(u,0,'Ev');
```

(b)

Taking ND=10e15 /cm-3
And pn0=10e10 /cm-3

Hence, Generated Plot →