Homework-3

4. For a Silicon p–n junction, the p-side has a doping density of 10^(16)/cm3 , and the n-side has a doping density of 10^(17)/cm3 . Plot the charge density, electric field, electric potential and depletion regions on both p and n side. You can use Matlab, Mathematica or any programming language of your choice to generate the plots. For any missing parameters, refer your text book.

Given values:

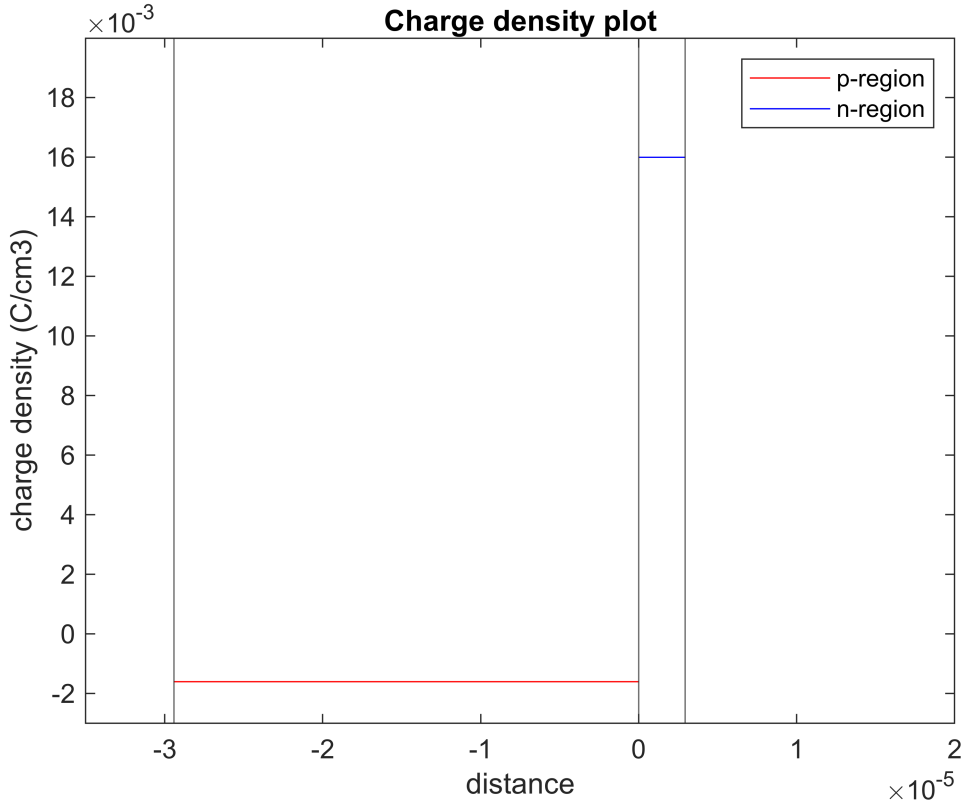
```
Na = power(10,16); % acceptor atom concentration (in /cm3)
Nd = power(10,17); % donor atom concentration (in /cm3)
Ni = 1.5 * power(10,10); % intrinsic carrier concentration (in /cm3)
Vt = 0.0253; % thermal voltage in volts
e = 1.6 * power(10,-19); % charge of electron in coulomb
epsilonNot = 8.85 * power(10,-14); % permittivity of free space
epsilon = 11.68 * epsilonNot; % permittivity of siliconlegend("Position",
[0.6,0.8,0.1,0.1]);
```

Calculating variables

```
% built-in voltage
Vbi = Vt * log( (Na*Nd)/(Ni*Ni) );
% depletion region dimensions
Xp = power( ( (2*epsilon*Vbi*Nd)/(e*Na*(Na + Nd)) ), 0.5); % p-side
Xn = power( ( (2*epsilon*Vbi*Na)/(e*Nd*(Na + Nd)) ), 0.5); % n-side
% range of regions of depletion region
x1 = linspace(-Xp,0,1000);
x2 = linspace(0,Xn,1000);
```

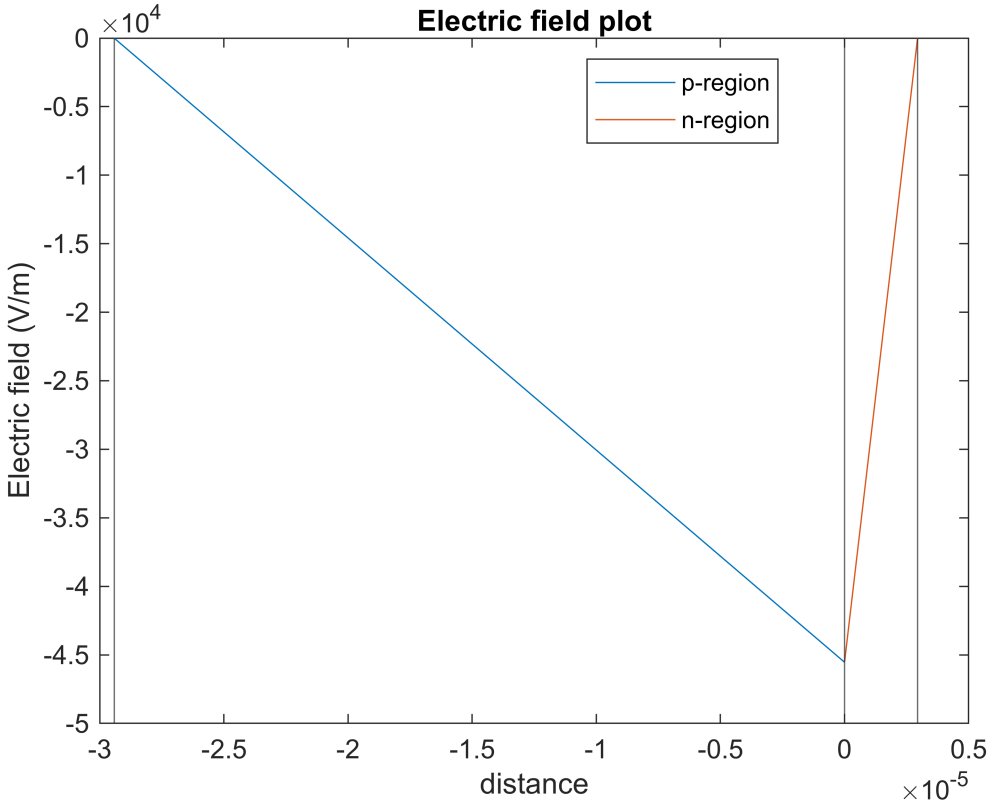
Charge density calculation

```
% charge density of depletion region
rhoP = ones(1,1000)* (-1*e*Na); % n-side charge density
rhoN = ones(1,1000)* (e*Nd); % p-side charge density
plot(x1,rhoP,"r");
hold on
plot(x2,rhoN,"b");
xline(0); xline(-Xp); xline(Xn);
hold off
title("Charge density plot"); xlabel("distance"); ylabel("charge density (C/cm3)");
legend("p-region","n-region");
xlim([-3.5*0.00001 2*0.00001]); ylim([-3*0.001 20*0.001]);
```



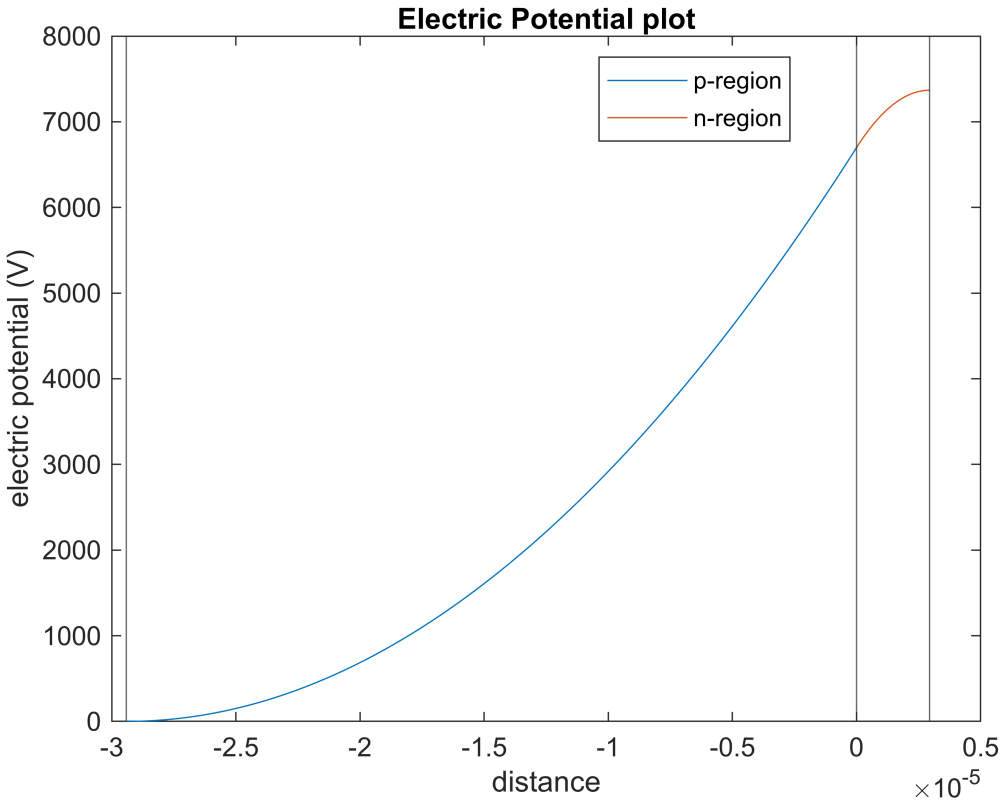
Electric field calculation

```
% Electric field of depletion region
Ep = -e*Na*(x1+ Xp)/epsilon;
En = -e*Nd*(Xn - x2)/epsilon;
plot(x1,Ep);
hold on
plot(x2,En);
hold off
xline(0); xline(-Xp); xline(Xn);
title("Electric field plot"); xlabel("distance"); ylabel("Electric field (V/m)");
legend("p-region", "n-region"); legend("Position", [0.6,0.8,0.1,0.1]);
```



Electric Potential Calculation

```
% Electric potential of depletion region
Vp = 10000*e*Na*power( (x1+Xp),2)/(2*epsilon);
Vn = 10000*(e/epsilon)*( (Nd*((Xn*x2) - (x2.*x2)/2) ) + (Na*Xp*Xp/2));
plot(x1,Vp);
hold on
plot(x2,Vn);
hold off
xline(0); xline(-Xp); xline(Xn);
title("Electric Potential plot"); xlabel("distance"); ylabel("electric potential
(V)");
legend("p-region", "n-region"); legend("Position", [0.6,0.8,0.1,0.1]);
```


Electric Potential plot
p-region
n-region
electric potential (V)
distance
8000
7000
6000
5000
4000
3000
2000
1000
0
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
×10-5