Scilab Textbook Companion for Fundamentals Of Electronics Devices by K. C. Nandi[1]

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 1

Semiconductor Materials and Crystal Properties

Scilab code Exa 1.18.3 Volume density of Si

```
// Exa 1.18.3
clc;
clear;
close;
// Given data
At = 28;// Atomic weight
n = 4;
N_A = 6.023*10^23;
a = 5.3;// in
a = a * 10^-10;// in m
m = At/N_A;// in gm
m = m*10^-3;// in kg
V = (a)^3;// in m^3
Rho = (m*n)/V;// in gm/m^3
Rho = Rho * 10^-3;// in kg/m^3
disp(Rho,"The volume density in kg/m^3 is");
```

Scilab code Exa 1.18.4 Density of copper crystal

```
// Exa 1.18.4
clc;
clear;
close;
// Given data
r = 1.278;// in
a = (4*r)/(sqrt(2));// in
a = a * 10^-10;// in m
V = (a)^3;// in m^3
At = 63.5;// atomic weight
N_A = 6.023*10^23;
m = At/N_A;// in gm
m = m * 10^-3;// in kg
n = 4;
Rho = (m*n)/V;// in gm/m^3
Rho = Rho * 10^-3;// in kg/m^3
disp(Rho,"The density of copper crystal in kg/m^3 is
   ");
```

Scilab code Exa 1.21.1 Wavelength of X ray

```
// Exa 1.21.1
clc;
clear;
close;
// Given data
d = 2.82;// in
d = d * 10^-10;// in m
n = 1;
theta = 10;// in degree
//Formula 2*d*sin(theta) = n*lembda;
lembda = 2*d*sind(theta);// in m
lembda = lembda * 10^10;// in
```

```
disp(lembda,"The wavelength of X-ray in   is ");
```

Scilab code Exa 1.21.2 Spacing of atomic layer

```
// Exa 1.21.2
clc;
clear;
close;
// Given data
lembda = 1.6;// in
lembda = lembda * 10^-10;// in m
theta = 14.2;// in degree
n = 1;
//Formula 2*d*sin(theta) = n*lembda;
d = (n*lembda)/(2*sind(theta));// in m
d = d * 10^10;// in
disp(d,"The spacing of atomic layer in the crystal in   is");
```

Scilab code Exa 1.21.3 Interplaner spacing

```
// Exa 1.21.3
clc;
clear;
close;
// Given data
n = 1;
theta = 30;// in degree
lembda = 1.78;// in
lembda = lembda * 10^-10;// in m
//Formula 2*d*sin(theta) = n*lembda;
d = (n*lembda)/(2*sind(theta));// in m
d = d * 10^10;// in
```

```
disp(d,"The interplaner spacing in  is");
```

Scilab code Exa 1.21.4 Interplaner spacing

```
// Exa 1.21.4
clc;
clear;
close;
// Given data
lembda = 0.58;// in
n = 1;
theta1 = 6.45;// in degree
d = (n*lembda)/(2*sind(theta1));// in
disp(d,"Part (i) : At angle of 6.45 , Interplaner spacing of the crystal in  is ");
theta2 = 9.15;// in degree
d1 = (n*lembda)/(2*sind(theta2));// in
disp(d1,"Part(ii) : At angle of 9.15 , Interplaner spacing of the crystal in  is ");
theta3 = 13;// in degree
n2 = 1;
d2 = (n2*lembda)/(2*sind(theta3));// in
disp(d2,"Part(iii) : At angle of 13 , Interplaner spacing of the crystal in  is ");
// For
n=2;
d2 = (n*lembda)/(2*sind(theta3));// in
disp(d2,"Part (iv) : The interplaner spacing in  is : ")
disp(d1,"The interplaner spacing for some other set of reflecting in  is : ")
```

Scilab code Exa 1.21.5 Glacing angle

```
// Exa 1.21.5
clc;
clear;
close;
// Given data
a = 2.814;// in
h = 1;
k = 0;
l = 0;
d = a/(sqrt( ((h)^2) + ((k)^2) + ((l)^2) ));// in
n = 2;
lembda = 0.710;// in
//Formula 2*d*sin(theta) = n*lembda;
theta = asind(n*lembda/(2*d) );// in degree
disp(theta,"The glacing angle in degree is");
```

Scilab code Exa 1.21.6 Wavelength of X ray

```
// Exa 1.21.6
clc;
clear;
close;
// Given data
a = 3.65;// in
h = 1;
k = 0;
l = 0;
d = a/(sqrt( ((h)^2) + ((k)^2) + ((l)^2) ));// in
n = 1;
theta = 60;// in degree
//Formula 2*d*sin(theta) = n*lembda;
lambda = 2*d*sind(theta);// in
disp(lambda,"Wavelength of X ray in    is");
```

Scilab code Exa 1.21.7 Glacing angle

```
// Exa 1.21.7
clc;
clear;
close;
// Given data
lembda = 1.54;// in
lembda= lembda*10^-8;// in cm
At = 63.54;// atomic weight
density = 9.024;// in gm/cc
n = 1;
N_A = 6.023*10^23;
m = At/N_A;// mass
a =(density*m)^(1/3);// in cm
h = 1;
k = 0;
l = 0;
d = a/(sqrt( ((h)^2) + ((k)^2) + ((l)^2) ));// in cm
n = 1;
//Formula 2*d*sin(theta) = n*lembda;
theta = asind( (lembda)/(2*d) );// in degree
disp(theta,"The glancing angle in degree is");
```

Scilab code Exa 1.21.8 Wavelength of X ray

```
// Exa 1.21.8
clc;
clear;
close;
// Given data
a = 3.615;// in
```

```
theta = 22;// in degree
n = 1;
h = 1;
k = 1;
l = 1;
d = a/(sqrt( ((h)^2) + ((k)^2) + ((l)^2) ));// in
// 2*d*sin(theta) = n*lembda;
lembda = 2*d*sind(theta);// in
disp(lembda,”The wavelength in    is”);
n = 2;
//Formula 2*d*sin(theta) = n*lembda;
theta = asind(n*lembda/(2*d) );// in degree
disp(theta,”The glacing angle for second order in degree is”);
disp(”To get the 2nd order spectrum the position of the detector should be ”+string(2*theta)+”   ”)
```

Scilab code Exa 1.21.9 Lattice constant

```
// Exa 1.21.9
clc;
clear;
close;
// Given data
n = 1;
lembda = 1.54;// in
theta = 21.7;// in degree
//Formula 2*d*sin(theta) = n*lembda;
d = (lembda*n)/(2*sind(theta));// in
h = 1;
k = 1;
l = 1;
// Formula d = a/(sqrt( ((h)^2) + ((k)^2) + ((l)^2) ));
a =  d*(sqrt( ((h)^2) + ((k)^2) + ((l)^2) ));// in
```

```
disp(a,"Lattice constant in    is");
```

Scilab code Exa 1.22.1 Distance between d211 planes

```
// Exa 1.22.1
clc;
clear;
close;
// Given data
a = 4.8;// in
h = 2;
k = 1;
l = 1;
d = a/(sqrt( ((h)^2) + ((k)^2) + ((l)^2) ));// in
disp(d,"The distance between d_211 plains in    is");
```

Scilab code Exa 1.22.2 Density

```
// Exa 1.22.2
clc;
clear;
close;
// Given data
r = 1.28;// in
//Formula r = (a*sqrt(2))/4;
a = (4*r)/(sqrt(2));// in
a = a * 10^-8;// in cm
n = 4;
M = 63.5;
N_A = 6.023*10^23;
Rho = (n*M)/(N_A*((a)^3));// in gm/cc
```

```
disp(Rho,"The density in gm/cc is");
```

Scilab code Exa 1.22.3 Number of atom per unit cell

```
// Exa 1.22.3
clc;
clear;
close;
// Given data
a = 2.9;// in
a = a * 10^-8;// in cm
Rho = 7.87;// in gm/cc
N_A = 6.023*10^23;
M = 55.85
// Rho = (n*M)/(N_A*((a)^3))
n = (Rho*N_A*((a)^3))/M;// in atoms per unit cell
disp(round(n),"The number of atoms per unit cell is
   ");
```

Scilab code Exa 1.22.4 Radius of element atom

```
// Exa 1.22.4
clc;
clear;
close;
// Given data
M =60;// in gm/mole
Rho = 6.23;// in gm/cc
n = 4;
N_A = 6.023*10^23;
// Rho = (n*M)/(N_A*((a)^3));
a = ( (n*M)/(N_A*Rho) )^(1/3);// in cm
r = (a*sqrt(2))/4;// in cm
```

```
r = r * 10^8;// in
disp(r,"The radius in     is");
```

Scilab code Exa 1.22.5 Packing factor

```
// Exa 1.22.5
clc;
clear;
close;
// Given data
Rho = 5.96;// in gm/cc
M = 50;
n = 2;
N_A = 6.023*10^23;
//Formula Rho = (n*M)/(N_A*((a)^3));
a = ( (n*M)/(N_A*Rho) )^(1/3);// in cm
r = (a*sqrt(3))/4;// in cm
P_F = (2*(4/3)*%pi*((r)^3))/((a)^3);// Packing factor
disp(P_F,"The Packing factor is");
```

Scilab code Exa 1.22.6 Number of unit cell

```
// Exa 1.22.6
clc;
clear;
close;
// Given data
d = 5.2;// in gm/cc
n = 2;
M = 120;
N_A = 6.023*10^23;
m = M/N_A;//mass of 1 atom in gm
```

```
m = n*m;//mass of unit cell in gm
g = 20;// in gm
m = g/m;// in unit cells
disp(m,"The number of unit cell in its 20 gm is : ");
```

Scilab code Exa 1.22.7 Distance between K and F

```
// Exa 1.22.7
clc;
clear;
close;
// Given data
Rho = 2.48;// in gm/cc
K = 39;// molecular weight of K
F = 19; // molecular weight of F
M = K+F;// molecular weight of KF
n = 4;
N_A = 6.023*10^23;
//Formula Rho = (n*M)/(N_A*((a)^3));
a = ( (n*M)/(N_A*Rho) )^(1/3);// in cm
a = a * 10^8;// in
r = (a*sqrt(2))/4;// in
r = 2*r;// in
disp(r,"The distance between ions in    is");
```

Chapter 2

Energy Bands And Charge Carriers in Semiconductor

Scilab code Exa 2.6.1 Energy gap

```
// Exa 2.6.1
clc;
clear;
close;
// Given data
lembda = 11000;// in
lembda = lembda * 10^-10;// in m
h = 6.625*10^-34;
c = 3*10^8;// in m/s
e = 1.6*10^-19;// in C
E_g = (h*c)/(lembda*e);// in eV
disp(E_g,"The energy gap in eV is");

// Note: In the book, there is calculation error to evaluate the value of Eg, so the answer in the book is wrong and the answer of coding is correct.
```

Scilab code Exa 2.6.2 Wavelength

```
// Exa 2.6.2
clc;
clear;
close;
// Given data
E_g = 0.75;// in eV
e = 1.6*10^-19;// in C
h = 6.63*10^-34;// in J
c = 3*10^8;// in m/s
//Formula E_g = (h*c)/(lembda*e);
lembda = (h*c)/(E_g*e);// in m
lembda = lembda * 10^10;// in
disp(lembda,"The wavelength in   is");
```

Scilab code Exa 2.15.1 Position of Fermi level

```
//Exa 2.15.1
clc;
clear;
close;
// Given data
del_E = 0.3;// in eV
T1 = 300;// in K
T2 = 330;// in K
// del_E = K * T1 * log(N/N_c) where del_E= E_C-E_F
// del_E1 = K * T2 * log(N/N_c) where del_E1= E_C-E_F at T= 330  K
del_E1 = del_E*(T2/T1);// in eV
disp("The Fermi level will be "+string(del_E1)+" eV below the conduction band")
```

Scilab code Exa 2.15.2 Thermal equilibrium electron concentration

```
//Exa 2.15.2
clc;
clear;
close;
// Given data
N_c = 2.8 * 10^19;// in cm^-3
del_E = 0.25;// fermi energy in eV
KT = 0.0259;
f_F = exp(-(del_E)/KT);
disp(f_F,"The probbaility in the condition band is
   occupied by an electron is ");
n_o = N_c * exp(-(del_E)/KT);// in cm^-3
disp(n_o,"The thermal equilibrium electron
   concentration in cm^-3 is");
```

Scilab code Exa 2.15.3 Thermal equilibrium hole concentration

```
//Exa2.15.3
clc;
clear;
close;
// Given data
T1 = 300;// in K
T2 = 400;// in K
del_E = 0.27;// Fermi level in eV
KT = (0.0259) * (T2/T1);// in eV
N_v = 1.04 * 10^19;// in cm^-3
N_v = N_v * (T2/T1)^(3/2);// in cm^-3
p_o = N_v * exp(-(del_E)/KT);// in per cm^3
```

```
disp(p_o,"The thermal equilibrium hole concentration in per cm^3 is");
```

Scilab code Exa 2.16.1 Mobility of electrons in copper

```
// Exa 2.16.1
clc;
clear;
close;
// Given data
At = 63.5;// atomic weight
Rho = 1.7*10^-6;// in ohm cm
d = 8.96;// in gm/cc
N_A = 6.02*10^23;// in /gm.mole
e = 1.6*10^-19;// in C
n = (N_A/At)*d;
Miu_e = 1/(Rho*n*e);// in cm^2/volt.sec
disp(Miu_e,"The electron mobility in cm^2/volt-sec is");
```

Scilab code Exa 2.16.2 Charge density of free electrons

```
// Exa 2.16.2
clc;
clear;
close;
format('e',9)
// Given data
l = 0.1;// in m
A = 1.7;// in mm^2
A = A * 10^-6;// in m^2
R = 0.1;// in ohm
At = 63.5;// atomic weight
```

```
N_A = 6.02*10^23;
d = 8.96;// in gm/cc
n = (N_A/At)*d;// in /cc
n = n * 10^6;// in /m^3
//Formula R = Rho*(l/A);
Rho = (R*A)/l;// in ohm m
Sigma = 1/Rho;// in mho/m
e = 1.6*10^-19;
// Formula Sigma = n*e*Miu_e
Miu_e = Sigma/(n*e);// in m^2/V.sec
disp(Miu_e,"The mobility in m^2/V-sec is");
```

Scilab code Exa 2.16.3 Drift velocity

```
// Exa 2.16.3
clc;
clear;
close;
// Given data
format('v',7)
d = 10.5;// in gm/cc
At = 108;// atomic weight
N_A = 6.025*10^23;// in /gm mole
r = 10^-3;// in m
q = 1.6*10^-19;// in C
n = (N_A/At)*d;// in /cm^3
n = n * 10^6;// in /m^3
A = %pi*((r)^2);// in m^2
I = 2;// in A
// I = q*n*A*v;
v = I/(n*q*A);// in m/s
disp(v,"The drift velocity in m/s is");

// Note: There is calculation error to find the
   value of drift velocity (i.e v), so the answer in
```

```
   the book is wrong.
```

Scilab code Exa 2.16.4 Mobility of charge carriers

```
// Exa 2.16.4
clc;
clear;
close;
format('e',10)
// Given data
d = 1.03;// in mm
d = d *10^-3;// in m
r = d/2;// in m
R = 6.51;// in ohm
l = 300;// in mm
e = 1.6*10^-19;
n = 8.4*10^28;// in /m^&3
A = %pi*r^2;
// R = Rho*(l/A);
Rho = (R* A)/l;//in ohm m
Sigma = 1/Rho;// in mho/m
disp(Sigma,"The conductivity of copper in mho/m is");
//Formula sigma = n*e*Miu_e
Miu_e = Sigma/(n*e);// in m^2/V.sec
disp(Miu_e,"The mobility in m^2/V-sec is");
```

Scilab code Exa 2.16.5 Resistivity of copper

```
// Exa 2.16.5
clc;
clear;
close;
```

```
format('e',8)
// Given data
At = 63.5;// atomic weight
d = 8.96;// in gm/cc
Miu_e = 43.28;// in cm^2/V.sec
N_A = 6.02*10^23;// in /gm mole
e = 1.6*10^-19;// in C
n = (N_A/At)*d;// in /cc
Rho = 1/(n*e*Miu_e);// in ohm-cm
disp(Rho,"The resistivity in ohm-cm is");
```

Scilab code Exa 2.17.1 Conductivity of pure Si

```
// Exa 2.17.1
clc;
clear;
close;
format('e',9)
// Given data
Mu_e = 1500;// in cm^2/volt sec
Mu_h = 500;// in cm^2/volt sec
n_i = 1.6 * 10^10;// in per cm^3
e = 1.6 * 10^-19;// in C
Sigma = n_i * (Mu_e + Mu_h) * e;// in mho/cm
disp(Sigma,"The conductivity of pure semiconductor
    in mho/cm is");
```

Scilab code Exa 2.17.2 Number of donor atoms

```
// Exa 2.17.2
clc;
clear;
close;
```

```
// Given data
Rho = 10;// in   −cm
Mu_d = 500;// in cm^2/v.s.
e = 1.6*10^-19;
n_d = 1/(Rho * e * Mu_d);// in per cm^3
disp(n_d,"The number of donor atom must be added to
   achieve in per cm^3 is ");
```

Scilab code Exa 2.17.3 Conductivity of speciman

```
//Exa 2.17.3
clc;
clear;
close;
//Given data
AvagadroNumber = 6.02 * 10^23;// in atoms/gm.mole
at_Ge = 72.6;// atom weight of Ge
e = 1.6 * 10^-19;// in C
D_Ge = 5.32;// density of Ge in gm/c.c
Mu = 3800;// in cm^2/v.s.
C_Ge = (AvagadroNumber/at_Ge) * D_Ge;//
   concentration of Ge atoms in per cm^3
n_d = C_Ge/10^8;// in per cc
Sigma = n_d * Mu * e;// in mho/cm
disp(Sigma,"The conductivity in mho/cm is");
```

Scilab code Exa 2.17.4 Mobility of electrons in Ge

```
// Exa2.17.4
clc;
clear;
close;
// Given data
```

```
Rho = 0.3623 * 10^-3;// in Ohm m
Sigma = 1/Rho;//in mho/m
D = 4.42 * 10^28;// Ge density in atom/m^3
n_d = D / 10^6;// in atom/m^3
e = 1.6 * 10^-19;// in C
Mu = Sigma/(n_d * e);// in m^2/V.sec
disp(Mu,”The mobility of electron in germanium in m^2/V.sec is”);
```

Scilab code Exa 2.17.5 Density and mobility of holes

```
//Exa 2.17.5
clc;
clear;
close;
// Given data
AvagadroNumber = 6.025 * 10^26;// in kg.Mole
W = 72.59;// atomic weight of Ge
D = 5.36 * 10^3;//density of Ge in kg/m^3
Rho = 0.42;// resistivity in Ohm m
e = 1.6 * 10^-19;// in C
Sigma = 1/Rho;// in mho/m
n = (AvagadroNumber/W) * D;// number of Ge atoms present per unit volume
// Holes per unit volume, H = n*10^-6%
H= n*10^-8;
a=H;
// Formula sigma= a*e*Mu_h
Mu_h = Sigma/(a * e);// in m^2/V.sec
disp(Mu_h,”Mobility of holes in m^2/V.sec is”);
```

Scilab code Exa 2.17.6 Current produced

```
//Exa 2.17.6
clc;
clear;
close;
// Given data
e = 1.6 * 10^-19;// in C
n_i = 2 * 10^19;// in /m^3
Mu_e = 0.36;// in m^2/v.s
Mu_h = 0.17;// in m^2/v.s
A = 1 * 10^-4;// in  m^2
V = 2;//in volts
l = 0.3;// in mm
l = l * 10^-3;// in m
E=V/l;// in volt/m
Sigma = n_i * e * (Mu_e + Mu_h);// in mho/m
// J = I/A = Sigma * E
I= Sigma*E*A;
disp(I,"The current produced in a small germanium
   plate in amp is");
```

Scilab code Exa 2.17.7 Resistivity of doped Ge

```
// Exa 2.17.7
clc;
clear;
close;
format('e',10)
// Given data
D = 4.2 * 10^28;//density of Ge atoms in atoms/m^3
N_d = D / 10^6;// in atoms/m^3
e = 1.6 * 10^-19;// in C
Mu_e = 0.36;// in m^2/vs
Sigma_n = N_d *  e * Mu_e;// in mho/m
Rho_n = 1/Sigma_n;// in ohm m
disp(Rho_n,"The resistivity of drop Ge in ohm m is "
```

```
   );
```

Scilab code Exa 2.17.8 Current produced in Ge sample

```
// Exa 2.17.8
clc;
clear;
close;
// given data
e = 1.6 * 10^-19;// in C
n_i = 1 * 10^19;// in per m^3
Mu_e = 0.36;// in m^2/volt.sec
Mu_h = 0.17;// in m^2/volt.sec
A = 2;// in cm^2
A = A * 10^-4;// im m^2
t = 0.1;// in mm
t = t * 10^-3;// in m
V = 4;// in volts
Sigma_i = n_i * e * (Mu_e + Mu_h);// in mho/m
J = Sigma_i * (V/t);// in Amp/m^2
I = J * A;// in Amp
disp(I,"The current produced in a Ge sample in Amp
   is");
```

Scilab code Exa 2.17.9 Conductivity of pure Si

```
//Exa 2.17.9
clc;
clear;
close;
format('e',9)
// Given data
e = 1.6 * 10^-19;// in C
```

```
Mu_h = 500;// in cm^2/V.s.
Mu_e = 1500;// in cm^2/V.s.
n_i = 1.6 * 10^10;// in per cm^3
Sigma_i = n_i * e * ( Mu_h + Mu_e);// in mho/cm
disp(Sigma_i,”Conductivity of pure silicon at room temperature in mho/cm is”);
```

Scilab code Exa 2.19.1 Hall voltage produced

```
//Exa 2.19.1
clc;
clear;
close;
//Given data
l= 0.50*10^-2;// width of ribbon in m
d= 0.10*10^-3;// thickness of ribbon in m
A= l*d;// area of ribbon in m^2
B = 0.8;// in Tesla
D = 10.5;//density in gm/cc
I = 2;// in amp
q = 1.6 * 10^-19;// in C
n=6*10^28;// number of elec. per m^3
V_H = ( I * B * d)/(n * q * A);// in volts
disp(V_H,”The hall Voltage produced in volts is”);
```

Scilab code Exa 2.19.2 Hall coefficient and mobility of electrons

```
//Exa 2.19.2
clc;
clear;
close;
format('e',8)
// Given data
```

```
l = 1;// in m
d = 1;// in cm
d = d * 10^-2;// in m
W = 1;// in mm
W = W * 10^-3;// in m
A = d * W;// in m^2
I= 1;// in Amp
B = 1;// Tesla
V_H = 0.074 * 10^-6;// in Volts
Sigma = 5.8 * 10^7;// in mho/m
R_H = (V_H * A)/(B*I*d);// in m^3/c
disp(R_H,"The hall coefficient in m^3/c is");
Mu = Sigma * R_H;// in m^2/volt.sec
disp(Mu,"The mobility  of electrons in copper in m^2/volt-sec is ");
```

Scilab code Exa 2.20.1 Ratio of electron to hole concentration

```
//Exa2.20.1
clc;
clear;
close;
// Given data
n_i = 1.4 * 10^18;// in /m^3
n_D = 1.4 * 10^24;// in /m^3
n=n_D;// in /m^3
p = n_i^2/n;// in /m^3
R = n/p;
disp(R,"The ratio of electrons to hole concentration is");
```

Scilab code Exa 2.20.2 Hall angle

```
//Exa 2.20.2
clc;
clear;
close;
// Given data
B = 0.48;// in wb/m^2
R_H = 3.55 * 10^-4;// in m^3/c
Rho = 0.00912;// in ohm−m
Sigma = 1/Rho;// in (ohm−m)^−1
theta_H = atand( Sigma * B * R_H);// in degree
disp(theta_H,”The hall angle for a hall coefficient in degree is”);
```

Scilab code Exa 2.20.3 Mobility and density of charge carriers

```
//Exa 2.20.3
clc;
clear;
close;
//Given data
R = 9 * 10^-3;// in ohm−m
R_H = 3.6 * 10^-4;// in m^3
e = 1.6 * 10^-19;// in C
Sigma = 1/R;// in (ohm−m)^−1
Rho = 1/R_H;// in coulomb/m^3
n = Rho/e;// in /m^3
disp(n,”Density of charge carriers in per m^3 is”);
Mu = Sigma * R_H;// in m^2/v−s
disp(Mu,”Mobility of charge carriers in m^2/V−s is”);
```

Scilab code Exa 2.24.1 Current density in speciman

```
//Exa 2.24.1
clc;
clear;
close;
// Given data
e = 1.6 * 10^-19;// in C
R_H = 0.0145;// in m^3/coulomb
Mu_e = 0.36;// in m^2/v-s
E = 100;// in V/m
n = 1/(e * R_H);// in /m^3
J = n * e * Mu_e * E;// in A/m^2
disp(J,"The current density of specimen in A/m^2 is");
```

Scilab code Exa 2.24.2 Relaxation time and resistivity of conductor

```
//Exa 2.24.2
clc;
clear;
close;
//Given data
Mu_e = 7.04 * 10^-3;// in m^2/v-s
m = 9.1 * 10^-31;
E_F = 5.5;// in eV
n = 5.8 * 10^28;
e = 1.6 * 10^-19;// in C
Torque = (Mu_e/e) * m;// in sec
disp(Torque,"Relaxation Time in sec is ");
Rho = 1 /(n * e * Mu_e);// in ohm-m
disp(Rho,"Resistivity of conductor in ohm-m is ");
V_F = sqrt((2 * E_F * e)/m);// in m/s
disp(V_F,"Velocity of electrons with fermi-energy in m/s is");
```

Scilab code Exa 2.24.3 Temperature

```
//Exa 2.24.3
clc;
clear;
close;
format('v',5)
// Given data
E= 5.95;// in eV
EF= 6.25;// in eV
delE= 0.01;
 // delE= 1-1/(1+exp((E-EF)/KT))
K=1.381*10^-23;// Boltzman Constant in J/K
T = ((E-EF)/log(1/(1-delE) -1)*1.6*10^-19)/K;// in K
T= round(T)
disp(T,"The temperature in K is : ")
```

Scilab code Exa 2.24.4 Thermal equilibrium hole concentration

```
//Exa 2.24.4
clc;
clear;
close;
// Given data
N_V = 1.04 * 10^19;// in cm^-3
T1 = 300;// in K
T2 = 400;// in K
del_E = 0.27;// in eV
N_V = N_V * (T2/T1)^1.5;// in cm^-3
KT = (0.0259) * (T2/T1);// in eV
P_o = N_V * exp(-(del_E)/KT);// in cm^-3
```

```
disp(P_o,"The thermal equilibrium hole concentration
    in silicon in cm^-3 is ");
```

Scilab code Exa 2.24.5 Minimum donor concentration

```
//Exa 2.24.5
clc;
clear;
close;
//Given data
N_c = 2.8 * 10^19;
N_V = 1.04 *10^19;
T1 = 550;// in K
T2 = 300;// in K
E_g = 1.12;
KT = (0.0259) ;
n_i = sqrt(N_c *N_V *(T1/T2)^3* exp(-(E_g)/KT*T2/T1)
    );// in cm^-3
// n_o = N_d/2 + sqrt((N_d/2)^2 + (n_i)^2)
// 1.05*N_d -N_d/2= sqrt((N_d/2)^2 + (n_i)^2)
N_d=sqrt((n_i)^2/((0.55)^2-1/4));
disp(N_d,"Minimum donor concentration required in cm
    ^-3 is");
```

Scilab code Exa 2.24.6 Quasi Fermi energy levels

```
//Exa 2.24.6
clc;
clear;
close;
//Given data
T = 300;// in K
n_o = 10^15;// in cm^-3
```

```
n_i = 10^10;// in cm^-3
p_o = 10^5;// in cm^-3
del_n = 10^13;// in cm^-3
del_p = del_n;// in cm^-3
KT = 0.0259;// in eV
delta_E1= KT*log(n_o/n_i);// value of E_F-E_Fi in eV
delta_E2= KT*log((n_o+del_n)/n_i);// value of E_Fn-E_Fi in eV
delta_E3= KT*log((p_o+del_p)/n_i);// value of E_Fi-E_Fp in eV
disp(delta_E1,"The Fermi level for thermal equillibrium in eV is : ")
disp(delta_E2,"The quase-Fermi level for electrons in non equillibrium in eV is : ")
disp(delta_E3,"The quasi-Fermi level for holes in non equillibrium in eV is : ")
disp("The quasi-Fermi level for electrons is above E_Fi ")
disp("While the quasi-Fermi level for holes is below E_Fi")
```

Chapter 3

Excess Carriers In Semiconductors

Scilab code Exa 3.21.1 Hole concentration at equilibrium

```
// Exa 3.21.1
clc;
clear;
close;
format('e',9)
// Given data
N_d = 10^17;// atoms/cm^3
n_i = 1.5 * 10^10;// in /cm^3
n_o = 10^17;// in cm^3
// p_o * n_o = (n_i)^2
p_o = (n_i)^2 / n_o;//in holes/cm^3
disp(p_o,"The holes concentration at equilibrium in
   holes/cm^3 is");
```

Scilab code Exa 3.21.3 Fermi level

```
// Exa 3.21.3
clc;
clear;
close;
// Given data
n_i = 1.5 * 10 ^10;// in /cm^3 for silicon
N_d = 10^17;// in atoms/cm^3
n_o = 10^17;// electrons/cm^3
KT = 0.0259;
// E_r - E_i = KT * log(n_o/n_i)
del_E = KT * log(n_o/n_i);// in eV
disp("The energy band for this type material is Ei + "+string(del_E)+" eV");
```

Scilab code Exa 3.21.4 Diffusion coefficients of electrons and holes

```
// Exa 3.21.4
clc;
clear;
close;
format('e',9)
// Given data
K = 1.38 * 10^-23;// in J/K
T = 27;// in degree
T = T + 273;// in K
e = 1.6 * 10^-19;// in C
Mu_e = 0.17;// in m^2/v-s
Mu_e1 = 0.025;// in m^2/v-s
D_n = ((K * T)/e) * Mu_e;// in m^2/s
disp(D_n,"The diffusion coefficient of electrons in m^2/s is");
D_p = ((K * T)/e) * Mu_e1;// in m^2/s
disp(D_p,"The diffusion coefficient of  holes in m^2/s is ");
```

Scilab code Exa 3.21.5 Diffusion length

```
// Exa 3.21.5
clc;
clear;
close;
format('e',9)
// Given data
Mu_n = 0.15;// in m^2/v-s
K = 1.38 * 10^-23; // in J/K
T = 300;// in K
del_n = 10^20;// in per m^3
Toh_n = 10^-7;// in s
e = 1.6 * 10^-19;// in C
D_n = Mu_n * ((K * T)/e);// in m^2/s
disp(D_n,"The diffusion coefficient in m^2/s is");
L_n = sqrt(D_n * Toh_n);// in m
disp(L_n,"The Diffusion length in m is");
J_n = (e * D_n * del_n)/L_n;// in A/m^2
disp(J_n,"The diffusion current density in A/m^2 is"
    );
// Note : The value of diffusion coefficient in the
    book is wrong.
```

Scilab code Exa 3.21.6 Concentration of holes and electrons

```
// Exa 3.21.6
clc;
clear;
close;
// Given data
Sigma = 0.1;// in (ohm-m)^-1
```

```
Mu_n = 1300;
n_i = 1.5 * 10^10;
q = 1.6 * 10^-19;// in C
n_n = Sigma/(Mu_n * q);// in electrons/cm^3
disp(n_n*10^6,"The concentration of electrons per m
   ^3 is");
p_n = (n_i)^2/n_n;// in per cm^3
p_n = p_n * 10^6;// in perm^3
disp(p_n,"The concentration of holes per m^3 is");
```

Scilab code Exa 3.21.7 Electron transit time

```
// Exa 3.21.7
clc;
clear;
close;
// Given data
Mu_e = 0.13;// in m^2/v-s
Mu_h = 0.05;// in m^2/v-s
Toh_h = 10^-6;// in s
L = 100;// in  m
L = L * 10^-6;// in m
V = 2;// in V
t_n =L^2/(Mu_e * V);// in s
disp(t_n,"Electron transit time in seconds is");
p_g = (Toh_h/t_n) * (1 + Mu_h/Mu_e);//photo
   conductor gain
disp(p_g,"Photo conductor gain is");

// Note: There is a calculation error to evaluate
   the value of t_n. So the answer in the book is
   wrong
```

Scilab code Exa 3.21.8 Resistivity of intrinsic Ge

```
// Exa 3.21.8
clc;
clear;
close;
//Given data
n_i = 2.5 * 10^13;
Mu_n = 3800;
Mu_p = 1800;
q = 1.6 * 10^-19;// in C
Sigma = n_i * (Mu_n + Mu_p) * q;// in (ohm-cm)^-1
Rho = 1/Sigma;// in ohm-cm
Rho= round(Rho);
disp(Rho,"The resistivity of intrinsic germanium in
   ohm-cm is");
N_D = 4.4 * 10^22/(1*10^8);// in atoms/cm^3
Sigma_n = N_D * Mu_n * q;// in (ohm-cm)^-1
Rho_n = 1/Sigma_n;// in ohm-cm
disp(Rho_n,"If a donor type impurity is added to the
    extent of 1 atom per 10^8 Ge atoms, then the
   resistivity drops in ohm-cm is");
```

Scilab code Exa 3.21.9 Hole and electron concentration

```
// Exa 3.21.9
clc;
clear;
close;
// Given data
n_i = 10^16;// in /m3
N_D = 10^22;// in /m^3
n = N_D;// in /m^3
disp(n,"Electron concentration per m^3 is");
p = (n_i)^2/n;// in /m^3
```

```
disp(p,"Hole concentration per m^3 is");
```

Scilab code Exa 3.21.10 Ratio of donor atoms to Si atom

```
// Exa 3.21.10
clc;
clear;
close;
format('e',8)
// Given data
Rho = 9.6 * 10^-2;// in ohm-m
Sigma_n = 1/Rho;// in (ohm-m)^-1
q = 1.6 * 10^-19;// in C
Mu_n = 1300 * 10^-4;// in m^2/v-s
N_D = Sigma_n / (Mu_n * q);// in atoms/m^3
A_D = N_D;// Atom density in atoms/cm^3
A_D = A_D * 10^6;// atoms/m^3
R_si = N_D/A_D;// ratio
disp(R_si,"The ratio of donor atom to silicon atom is");

// Note: In the book the wrong value of N_D (5*10^22) is putted to evaluate the value of Atom Density (A_D) whereas the value of N_D is calculated as 5*10^20.
//          So the answer in the book is wrong
```

Scilab code Exa 3.21.11 Equillibrium electron and hole densities

```
// Exa 3.21.11
clc;
clear;
close;
```

```
// Given data
n_i = 1.5 * 10^10;// in per cm^3
n_n = 2.25 * 10^15;// in per cm^3
p_n = (n_i)^2/n_n;// in per cm^3
disp(p_n,"The equilibrium electron density per cm^3
   is");
h_n = n_n;// in cm^3
disp(h_n,"Hole density in per cm^3 is");
```

Scilab code Exa 3.21.12 Carrier concentration

```
// Exa 3.21.12
clc;
clear;
close;
// Given data
N_A = 2 * 10^16;// in atoms/cm^3
N_D = 10^16;// in atoms/cm^3
C_c = N_A-N_D;// C_c stands for Carrier
   concentration in /cm^3
disp(C_c,"Carrier concentration per cm^3 is");
```

Scilab code Exa 3.21.13 Generation rate due to irradiation

```
// Exa 3.21.13
clc;
clear;
close;
// Given data
del_n = 10^15;// in cm^3
Torque_p = 10 * 10^-6;// in sec
R_g = del_n/Torque_p;// in hole pairs/sec/cm^3
```

```
disp(R_g,"The rate of generation of minority carrier in electron hole pairs/sec/cm^3 is ");
```

Scilab code Exa 3.21.14 Mobility of minority charge carrier

```
// Exa 3.21.14
clc;
clear;
close;
// Given data
v = 1/(20 * 10^-6);// in cm/sec
E = 10;// in V/cm
Mu= v/E;// in cm^2/V-sec
disp(Mu,"The mobility of minority charge carrier in cm^2/V-sec is ");
```

Scilab code Exa 3.21.15 Hole and electron diffusion current

```
// Exa 3.21.15
clc;
clear;
close;
// Given data
q = 1.6 * 10^-19;// in C
N_D = 4.5 * 10^15;// in /cm^3
del_p = 10^21;
e=10;// in cm
A = 1;// in mm^2
A = A * 10^-14;// cm^2
l = 10;// in cm
Torque_p = 1;// in microsec
Torque_p = Torque_p * 10^-6;// in sec
Torque_n = 1;// in microsec
```

```
Torque_n = Torque_n * 10^-6;// in sec
n_i = 1.5 * 10^10;// in /cm^3
D_n = 30;// in cm^2/sec
D_p = 12;// in cm^2/sec
n_o = N_D;// in /cm^3
p_o = (n_i)^2/n_o;// in /cm^3
disp(p_o,"Hole concentration at thermal equilibrium per cm^3 is");
l_n = sqrt(D_n * Torque_n);// in cm
disp(l_n,"Diffusion length of electron in cm is");
l_p = sqrt(D_p * Torque_p);// in cm
disp(l_p,"Diffusion length of holes in cm is");
x=34.6*10^-4;// in cm
dpBYdx = del_p *e;// in cm^4
disp(dpBYdx,"Concentration gradient of holes at distance in cm^4 is");
e1 = 1.88 * 10^1;// in cm
dnBYdx = del_p * e1;// in cm^4
disp(dnBYdx,"Concentration gradient of electrons in per cm is");
J_P = -(q) * D_p * dpBYdx;// in A/cm^2
disp(J_P,"Current density of holes due to diffusion in A/cm^2 is");
J_n = q * D_n * dnBYdx;// in A/cm^2
disp(J_n,"Current density of electrons due to diffusion in A/cm^2 is");
```

Scilab code Exa 3.21.16 Energy band gap of semiconductor material used

```
// Exa 3.21.16
clc;
clear;
close;
// Given data
e= 1.6*10^-19;// electron charge in C
```

```
h = 6.626 * 10^-34;// in J-s
h= h/e;// in eV
c = 3 * 10^8;// in m/s
lembda = 5490 * 10^-10;// in m
f = c/lembda;
E = h * f;// in eV
disp(E,"The energy band gap of the semiconductor
   material in eV is");
```

Scilab code Exa 3.21.17 Current density in Si

```
// Exa 3.21.17
clc;
clear;
close;
// Given data
y2 = 6 * 10^16;// in /cm^3
y1 = 10^17;// in /cm^3
x2 = 2;// in  m
x1 = 0;// in  m
D_n = 35;// in cm^2/sec
q = 1.6 *10^-19;// in C
dnBYdx = (y2 - y1)/((x2-x1) * 10^-4);
J_n = q * D_n * dnBYdx;// in A/cm^2
disp(J_n,"The current density in silicon in A/cm^2
   is");
```

Scilab code Exa 3.21.18 Resistance of the bar

```
// Exa 3.21.18
clc;
clear;
close;
```

```
// Given data
q = 1.6 * 10^-19;// in C
n_n = 5 * 10^20;// in /m^3
n_n = n_n * 10^-6;// in cm^3
Mu_n = 0.13;// in m^2/V-sec
Mu_n = Mu_n * 10^4;// in cm^2/V-sec
Sigma_n = q * n_n * Mu_n;// in (ohm-cm)^-1
Rho = 1/Sigma_n;// in   -cm
l = 0.1;// in cm
A = 100;//   m ^2
A = A * 10^-8;// in cm^2
R = Rho * (l/A);// in Ohm
R=round(R*10^-6);// in  M
disp(R,"The resistance of the bar in M   is");
```

Scilab code Exa 3.21.19 Depletion width

```
// Exa 3.21.19
clc;
clear;
close;
// Given data
t_d = 3;// total depletion in   m
D = t_d/9;// in   m
disp(D,"Depletion width in   m is");
```

Scilab code Exa 3.21.20 Minority carrier density

```
// Exa 3.21.20
clc;
clear;
close;
// Given data
```

```
n_i = 1.5 * 10^16;// in /m^3
n_n = 5 * 10^20;// in /m^3
p_n = (n_i)^2/n_n;// in /m^3
disp(p_n,"The majority carrier density per m^3 is");
```

Scilab code Exa 3.21.21 Collector current density

```
// Exa 3.21.21
clc;
clear;
close;
// Given data
D_n = 25;// in cm^2/sec
q = 1.6 * 10^-19;// in C
y2 = 10^14;// in /cm^3
y1 = 0;// in /cm^3
x2 = 0;//in    m
x1 = 0.5;// in   m
x1 = x1 * 10^-4;// in cm
dnBYdx = abs((y2-y1)/(x2-x1));// in /cm^4
J_n = q * D_n * (dnBYdx);// in /cm^4
J_n = J_n * 10^-1;// in A/cm^2
disp(J_n,"The collector current density in A/cm^2 is ");

// Note: In the book, the calculated value of dn by dx (2*10^19) is wrong. Correct value is 2*10^18 so the answer in the book is wrong.
```

Scilab code Exa 3.21.22 Band gap

```
//Exa 3.21.22
clc;
```

```
clear;
close;
// Given data
h = 6.64 * 10^-34;// in J-s
e= 1.6*10^-19;// electron charge in C
c= 3 * 10^8;// in m/s
lembda = 0.87;// in  m
lembda = lembda * 10^-6;// in m
E_g = (h * c)/lembda;// in J-s
E_g= E_g/e;// in eV
disp(E_g,”The band gap of the material in eV is”);
```

Scilab code Exa 3.21.23 Total energy absorbed by sample

```
// Exa 3.21.23
clc;
clear;
close;
// Given data
I_o = 10;// in mW
e = 1.6 * 10^-19;// in J/eV
hv = 2;// in eV
hv1=1.43;// in eV
alpha = 5 * 10^4;// in cm^-1
l = 46;// in  m
l = l * 10^-6;// in m
I_t = round(I_o * exp(-(alpha) * l));// in mW
AbsorbedPower= I_o-I_t;// in mW
AbsorbedPower=AbsorbedPower*10^-3;// in W or J/s
disp(AbsorbedPower,”The absorbed power in watt or J/s is”);
F= (hv-hv1)/hv;// fraction of each photon energy unit
EnergyConToHeat= AbsorbedPower*F;// in J/s
disp(EnergyConToHeat,”The amount of energy converted
```

```
    to heat per second in J/s is : ")
A= (AbsorbedPower-EnergyConToHeat)/(e*hv1);
disp(A,"The number of photon per sec given off from
   recombination events in photons/s is");
```

Scilab code Exa 3.21.24 Hole current

```
// Exa 3.21.24
clc;
clear;
close;
// Given data
format('e',9)
Mu_p = 500;// in cm^2/v-s
kT = 0.0259;
Toh_p = 10^-10;// in sec
p_o = 10^17;// in cm^-3
q= 1.6*10^-19;// in C
A=0.5;// in square meter
del_p = 5 * 10^16;// in cm^-3
n_i= 1.5*10^10;// in cm^-3
D_p = kT * Mu_p;// in cm/s
L_p = sqrt(D_p * Toh_p);// in cm
x = 10^-5;// in cm
p = p_o+del_p* %e^(x/L_p);// in cm^-3
// p= n_i*%e^(Eip)/kT where Eip=E_i-F_p
Eip= log(p/n_i)*kT;// in eV
Ecp= 1.1/2-Eip;// value of E_c-E_p in eV
Ip= q*A*D_p/L_p*del_p*%e^(x/L_p);// in A
disp(Ip,"The hole current in A is : ")
Qp= q*A*del_p*L_p;// in C
disp(Qp,"The value of Qp in C is : ")

// Note: There is a calculation error to evalaute
   the value of hole current but they putted correct
```

```
   value of it to evaluate the value of Qp.
//          Hence the value of hole current in the
   book is wrong
```

Chapter 4

Junction Properties

Scilab code Exa 4.16.1 Contact difference of potential

```
// EXa 4.16.1
clc;
clear;
close;
// Given data
t = 4.4 * 10^22;// total number of Ge atoms/cm^3
n = 1 * 10^8;// number of impurity atoms
N_A = t/n;// in atoms/cm^3
N_A = N_A * 10^6;// in atoms/m^3
N_D = N_A * 10^3;// in atoms/m^3
n_i = 2.5 * 10^13;// in atoms/cm^3
n_i = n_i * 10^6;// in atoms/m^3
V_T = 26;//in mV
V_T= V_T*10^-3;// in V
V_J = V_T * log((N_A * N_D)/(n_i)^2);// in V
disp(V_J,"The contact potential in V is");
// Part (b)
t = 5* 10^22;// total number of Si atoms/cm^3
N_A = t/n;// in atoms/cm^3
N_A = N_A * 10^6;// in atoms/m^3
N_D = N_A * 10^3;// in atoms/m^3
```

```
n_i = 1.5 * 10^10;// in atoms/cm^3
n_i = n_i * 10^6;// in atoms/m^3
V_T = 26;//in mV
V_T= V_T*10^-3;// in V
V_J = V_T * log((N_A * N_D)/(n_i)^2);// in V
disp(V_J,"The contact potential  in V is");
```

Scilab code Exa 4.16.2 Height of the potential energy barrier

```
// Exa 4.16.2
clc;
clear;
close;
// Given data
V_T = 26;// in mV
V_T=V_T*10^-3;// in V
n_i = 2.5 * 10^13;
Sigma_p = 1;
Sigma_n = 1;
Mu_n = 3800;
q = 1.6 * 10^-19;// in C
Mu_p = 1800;
N_A = Sigma_p/(2* q * Mu_p);// in /cm^3
N_D = Sigma_n /(q * Mu_n);// in /cm^3
V_J = V_T * log((N_A * N_D)/(n_i)^2);// in V
disp(V_J,"For Ge the height of the energy barrier in
   V is");
// For Si p-n juction
n_i = 1.5 * 10^10;
Mu_n = 1300;
Mu_p = 500;
N_A = Sigma_p/(2* q * Mu_p);// in /cm^3
N_D = Sigma_n /(q * Mu_n);// in /cm^3
V_J = V_T * log((N_A * N_D)/(n_i)^2);// in V
disp(V_J,"For Si p-n junction  the height of the
```

```
   energy barrier in V is");
```

Scilab code Exa 4.16.3 Forward current

```
//Exa 4.16.3
clc;
clear;
close;
// Given data
Eta = 1;
V_T = 26;// in mV
V_T= V_T*10^-3;// in V
// I = I_o * (%e^(V/(Eta*V_T)) - 1) and I = -(0.9) *
    I_o;
V= log(1-0.9)*V_T;// in V
disp(V,"The voltage in volts is : ")
// Part (ii)
V1=0.05;// in V
V2= -0.05;// in V
ratio= (%e^(V1/(Eta*V_T))-1)/(%e^(V2/(Eta*V_T))-1)
disp(ratio,"The ratio of the current for a forward
   bias to reverse bias is : ")
// Part (iii)
Io= 10;// in  A
Io=Io*10^-3;// in mA
//For
V=0.1;// in V
I = Io * (%e^(V/(Eta*V_T)) - 1);// in mA
disp(I,"For V=0.1 V , the value of I in mA is : ")
//For
V=0.2;// in V
I = Io * (%e^(V/(Eta*V_T)) - 1);// in mA
disp(I,"For V=0.2 V , the value of I in mA is : ")
//For
V=0.3;// in V
```

```
I = Io * (%e^(V/(Eta*V_T)) - 1);// in mA
disp(I*10^-3,"For V=0.3 V , the value of I in A is : ")
disp("From three value of I, for small rise in forward voltage, the diode current increase rapidly")
```

Scilab code Exa 4.16.4 Anticipated factor

```
//Exa 4.16.4
clc;
clear;
close;
// Given data
// Part (i)
T1= 25;// in C
T2= 80;// in C
// Formula Io2= Io1*2^((T2-T1)/10)
AntiFactor= 2^((T2-T1)/10);
disp(round(AntiFactor),"Anticipated factor for Ge is : ")
// Part (ii)
T1= 25;// in C
T2= 150;// in C
AntiFactor= 2^((T2-T1)/10);
disp(round(AntiFactor),"Anticipated factor for Si is : ")
```

Scilab code Exa 4.16.5 Leakage resistance

```
//Exa 4.16.5
clc;
clear;
```

```
close;
// Given data
I=5;// in  A
V=10;// in V
T1= 0.11;// in  C^-1
T2= 0.07;// in  C^-1
// Io+I_R=I                              (i)
// dI_by_dT= dIo_by_dT       (ii)
// 1/Io*dIo_by_dT = T1 and 1/I*dI_by_dT = T2, So
Io= T2*I/T1;// in  A
I_R= I-Io;// in  A
R= V/I_R;// in M
disp(R,"The leakage resistance in M  is : ")
```

Scilab code Exa 4.16.6 Dynamic resistance

```
//Exa 4.16.6
clc;
clear;
close;
// Given data
Eta = 1;
T = 125;// in  C
T = T + 273;// in K
V_T = 8.62 * 10^-5 * 398;// in V
I_o = 30;// in  A
I_o= I_o*10^-6;// in A
v = 0.2;// in V
r_f = (Eta * V_T)/(I_o * %e^(v/(Eta* V_T)));// in ohm
disp(r_f,"The dynamic resistance in the forward direction in ohm is ");
r_r = (Eta * V_T)/(I_o * %e^(-v/(Eta* V_T)));// in ohm
disp(r_r*10^-3,"The dynamic resistance in the
```

```
    reverse direction in kohm is");
```

Scilab code Exa 4.16.7 Barrier capacitance

```
// Exa 4.16.7
clc;
clear;
close;
// Given data
epsilon = 16/(36 * %pi * 10^11);// in F/cm
A = 1 * 10^-2;
W = 2 * 10^-4;
C_T = (epsilon * A)/W;// in F
disp(C_T*10^12,"The barrier capacitance in pF is");
```

Scilab code Exa 4.16.8 Width of the depletion layer

```
//Exa 4.16.8
clc;
clear;
close;
//Given data
A = 1;// in mm^2
A = A * 10^-6;// in m^2
N_A = 3 * 10^20;// in atoms/m^3
q = 1.6 *10^-19;// in C
V_o = 0.2;// in V
epsilon_r=16;
epsilon_o= 8.854*10^-12;// in F/m
epsilon=epsilon_r*epsilon_o;
// Part (a)
V=-10;// in V
// V_o - V = 1/2*((q * N_A )/epsilon) * W^2
```

```
W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A));// m
C_T1 = (epsilon * A)/W;// in F
disp(W*10^6,"The width of the depletion layer  for an applied reverse voltage of 10V in  m is ");
// Part (b)
V=-0.1;// in V
W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A));// m
C_T2 = (epsilon * A)/W;// in F
disp(W*10^6,"The width of the depletion layer  for an applied reverse voltage of 0.1V in  m is ");
// Part (c)
V=0.1;// in V
W = sqrt(((V_o - V) * 2 * epsilon)/(q * N_A));// m
disp(W*10^6,"The width of the depletion layer  for an applied for a forward bias of 0.1V in  m is ");
// Part (d)
disp(C_T1*10^12,"The space charge capacitance for an applied reverse voltage of 10V  in pF is");
disp(C_T2*10^12,"The space charge capacitance for an applied reverse voltage of 0.1V  in pF is");
```

Scilab code Exa 4.16.9 Current in the junction

```
// Exa 4.16.9
clc;
clear;
close;
// Given data
I_o = 1.8 * 10^-9;// A
v = 0.6;// in V
Eta = 2;
V_T = 26;// in mV
V_T=V_T*10^-3;// in V
I = I_o *(%e^(v/(Eta * V_T)));// in A
```

```
disp(I*10^3,"The current in the junction in mA is");
```

Scilab code Exa 4.16.10 Forward biasing voltage

```
// Exa 4.16.10
clc;
clear;
close;
// Given data
I_o = 2.4 * 10^-14;
I = 1.5;// in mA
I=I*10^-3;// in A
Eta = 1;
V_T = 26;// in mV
V_T= V_T*10^-3;// in V
v =log((I + I_o)/I_o) * V_T;// in V
disp(v,"The forward biasing voltage across the
   junction in V is");
```

Scilab code Exa 4.16.11 Theoretical diode current

```
// Exa 4.16.11
clc;
clear;
close;
// Given data
I_o = 10;// in nA
// I = I_o * ((e^(v/(Eta * V_T))) - 1)
// e^(v/(Eta * V_T)<< 1, so neglecting it
I = I_o * (-1);// in nA
disp(I,"The Diode current in nA is  ");
```

Scilab code Exa 4.16.12 Diode dynamic resistance

```
// Exa 4.16.12
clc;
clear;
close;
// Given data
R = 4.5;// in ohm
I = 44.4;// in mA
I=I*10^-3;// in A
V = R * I;// in V
Eta = 1;
V_T = 26;//in mV
V_T=V_T*10^-3;// in V
I_o = I/((%e^(V/(Eta * V_T))) -1);// in A
// At
V = 0.1;// in V
r_f = (Eta * V_T)/(I_o * ((%e^(V/(Eta * V_T)))-1));// in ohm
disp(r_f,"The diode dynamic resistance in    is");
```

Scilab code Exa 4.16.13 Q point

```
// Exa 4.16.13
clc;
clear;
close;
// Given data
V_D = 10;// in V
// V_S = i*R_L + V_D
V_S = V_D;// in V (i * R_L = 0)
```

```
disp(V_S,"when diode is OFF, the voltage in volts is : ");
R_L = 250;// in ohm
I = V_S/R_L;// in A
disp(I*10^3,"when diode is ON, the current in mA is");
V_D= 0:0.1:10;// in V
I= (V_S-V_D)/R_L*1000;// in mA
plot(V_D,I)
xlabel("V_D in volts");
ylabel("Current in mA")
title("DC load line");
disp("DC load line shown in figure")
```

Scilab code Exa 4.16.14 AC resistance of a Ge diode

```
// Exa 4.16.14
clc;
clear;
close;
// Given data
V = 0.25;// in V
I_o = 1.2;// in   A
I_o = I_o * 10^-6;// in A
V_T = 26;// in mV
V_T = V_T * 10^-3;// in V
Eta = 1;
r = (Eta * V_T)/(I_o * (%e^(V/(Eta * V_T))));// in ohm
disp(r,"The ac resistance of the diode in ohm is");
```

Scilab code Exa 4.16.15 Junction potential

```
// Exa 4.16.15
clc;
clear;
close;
// Given data
t = 4.4 * 10^22;// in total number of atoms/cm^3
n = 1 * 10^8;// number of impurity
N_A = t/n;// in atoms/cm^3
N_A = N_A * 10^6;// in atoms/m^3
N_D = N_A * 10^3;// in atoms/m^3
V_T = 26;// in mV
V_T = V_T * 10^-3;// in V
n_i = 2.5 * 10^19;// in /cm^3
V_J = V_T * log((N_A * N_D)/(n_i)^2);// in V
disp(V_J,"The junction potential in V is")
```

Scilab code Exa 4.16.16 Dynamic resistance

```
// Exa 4.16.16
clc;
clear;
close;
// Given data
Eta = 1;
I_o = 30;// in MuA
I_o = I_o * 10^-6;// in A
v = 0.2;// in V
K = 1.381 * 10^-23;// in J/degree K
T = 125;// in  C
T = T + 273;// in K
q = 1.6 * 10^-19;// in C
V_T = (K*T)/q;// in V
r_f = (Eta * V_T)/(I_o * (%e^(v/(Eta * V_T))));// in
    ohm
disp(r_f,"The forward dynamic resistance in ohm is")
```

```
   ;
r_f1 = (Eta * V_T)/(I_o * (%e^(-(v)/(Eta * V_T))));
   // in ohm
disp(r_f1*10^-3,"The Reverse dynamic resistance in
   k  is");
```

Scilab code Exa 4.16.17 Space charge capacitance

```
// Exa 4.16.17
clc;
clear;
close;
// Given data
q = 1.6 * 10^-19;// in C
N_A = 3 * 10^20;// in /m^3
A = 1;// in  m ^2
A = A * 10^-6;// in m^2
V = -10;// in V
V_J = 0.25;// in V
V_B = V_J - V;// in V
epsilon_o = 8.854;// in pF/m
epsilon_o = epsilon_o * 10^-12;// in F/m
epsilon_r = 16;
epsilon = epsilon_o * epsilon_r;
W = sqrt((V_B * 2 * epsilon)/(q * N_A));// in m
disp(W*10^6,"The width of depletion layer in  m is"
   );
C_T = (epsilon * A)/W;// in pF
disp(C_T*10^12,"the space charge capacitance in pF
   is");
```

Scilab code Exa 4.16.18 Barrier capacitance

```
// Exa 4.16.18
clc;
clear;
close;
// Given data
W = 2 * 10^-4;// in cm
W = W * 10^-2;// in m
A = 1;// in mm^2
A = A * 10^-6;// in m^2
epsilon_r = 16;
epsilon_o = 8.854 * 10^-12;// in F/m
epsilon = epsilon_r * epsilon_o;
C_T = (epsilon * A)/W;// in F
disp(C_T*10^12,”The barrier capacitance in pF is”);
```

Scilab code Exa 4.16.19 Diameter

```
// Exa 4.16.19
clc;
clear;
close;
// Given data
C_T = 100;// in pF
C_T=C_T*10^-12;// in F
epsilon_r = 12;
epsilon_o = 8.854 * 10^-12;// in F/m
epsilon = epsilon_r * epsilon_o;
Rho_p = 5;// in ohm-cm
Rho_p = Rho_p * 10^-2;// in ohm-m
V_j = 0.5;// in V
V = -4.5;// in V
Mu_p = 500;// in cm^2
Mu_p = Mu_p * 10^-4;// in m^2
Sigma_p = 1/Rho_p;// in per ohm-m
qN_A = Sigma_p/ Mu_p;
```

```
V_B = V_j - V;
W = sqrt((V_B * 2 * epsilon)/qN_A);// in m
//C_T = (epsilon * A)/W;
A = (C_T * W)/ epsilon;// in m
D = sqrt(A * (4/%pi));// in m
D = D * 10^3;// in mm
disp(D,"The diameter in mm is");
```

Scilab code Exa 4.16.20 Temperature of junction

```
// Exa 4.16.20
clc;
clear;
close;
// Given data
q = 1.6 * 10^-19;// in C
Mu_p = 500;// in cm^2/V-sec
Rho_p = 3.5;// in ohm-cm
Mu_n = 1500;// in cm^2/V-sec
Rho_n = 10;// in ohm-cm
N_A = 1/(Rho_p * Mu_p * q);// in /cm^3
N_D = 1/(Rho_n * Mu_n * q);// in /cm^3
V_J = 0.56;// in V
n_i = 1.5 * 10^10;// in /cm^3
V_T = V_J/log((N_A * N_D)/(n_i)^2);// in V
// V_T = T/11600
T = V_T * 11600;// in K
T = T - 273;// in  C
disp(T,"The Temperature of junction in  C is");
```

Scilab code Exa 4.16.21 Voltage

```
// Exa 4.16.21
```

```
clc;
clear;
close;
// Given data
V_T = 26;// in mV
V_T = V_T * 10^-3;// in V
Eta = 1;
// I = −90% for Io, so
IbyIo= 0.1;
// I  = I_o * ((e^(v/(Eta * V_T)))−1)
V = log(IbyIo) * V_T;// in V
disp(V,”The reverse bias voltage in volts is”);
```

Scilab code Exa 4.16.22 Reverse saturation current

```
// Exa 4.16.22
clc;
clear;
close;
// Given data
R = 5;// in ohm
I = 50;// in mA
I=I*10^-3;// in A
V = R * I;// in V
Eta = 1;
V_T = 26;// in mV
V_T=V_T*10^-3;// in V
I_o = I/((%e^(V/(Eta * V_T))) - 1);// in A
disp(I_o*10^6,”Reverse saturation current in  A is”);
v1 = 0.2;// in V
r = (Eta * V_T)/(I_o * (%e^(v1/(Eta * V_T))));// in ohm
disp(r,”Dynamic resistance of the diode in  is”);
```

Chapter 5

Bipolar Junction Transistors

Scilab code Exa 5.9.1 Value of IC and VCB

```
// Exa 5.9.1
clc;
clear;
close;
// Given data
V_EE = 8;// in V
V_BE = 0.7;// in V
R_E = 1.5;// in k ohm
I_E = (V_EE - V_BE)/R_E;// in mA
I_C = I_E;// in mA
disp(I_C,”The value of I_C in mA is”);
V_CC = 18;// in V
R_C = 1.2;// in  k
V_CB = V_CC - (I_C * R_C);// in V
disp(V_CB,”The value of V_CB in V is”);
```

Scilab code Exa 5.9.2 Base current

```
// Exa 5.9.2
clc;
clear;
close;
// Given data
alpha = 0.9;
I_E = 1;// mA
I_C = alpha * I_E;// in mA
I_B = I_E - I_C;// in mA
disp(I_B,"The value of base current in mA is");
```

Scilab code Exa 5.11.1 Emitter current

```
// Exa 5.11.1
clc;
clear;
close;
// Given data
bita = 50;
I_B= 20;// in  A
I_B=I_B*10^-6;// in A
I_C= bita*I_B;// in A
I_E= I_C+I_B;// in A
I_E = I_E * 10^3;// in mA
disp(I_E,"The Emitter current in mA is");
```

Scilab code Exa 5.11.1.a base current and emitter current

```
// Exa 5.11.1(a)
clc;
clear;
close;
// Given data
```

```
beta_dc = 90;
I_C = 15;// in mA
I_C = I_C * 10^-3;// in A
I_B = I_C/beta_dc;// in A
disp(I_B*10^6,”The base current in   A is”);
I_E = I_C + I_B;// in A
I_E = I_E * 10^3;// in mA
disp(I_E,”The Emitter current in mA is”);
alpha_dc = beta_dc/(1+beta_dc);
disp(alpha_dc,”The value of alpha_dc is”);
```

Scilab code Exa 5.11.3 Change in base current

```
// Exa 5.11.3
clc;
clear;
close;
// Given data
del_ic = 1.8;// in mA
del_ie = 1.89;// in mA
alpha = del_ic / del_ie;
bita = alpha/(1 - alpha);
del_ib = del_ic/bita;// in mA
del_ib = del_ib * 10^3;// in   A
disp(del_ib,”The change in I_B in   A is”);
```

Scilab code Exa 5.11.4 Transistor current

```
//Exa 5.11.4
clc;
clear;
close;
// Given data
```

```
V_CC = 10;// in V
R_C = 3;// in k
R_C= R_C*10^3;// in
bita = 100;
I_CO = 20;// in nA
I_CO = I_CO * 10^-9;// in A
V_BB = 5;// in V
R_B = 200;// in  k
R_B= R_B*10^3;// in
V_BE = 0.7;// in V
// Applying KVL to the base circuit , V_BB= I_B*R_B+V_BE
I_B = (V_BB - V_BE)/R_B;// in A
disp(I_B*10^6,"The base current in   A is");
I_C = (bita * I_B) + I_CO;// in A
disp(I_C*10^3,"The collector current in mA is");
I_E = I_C + I_B;// in A
disp(I_E*10^3,"Emitter current in mA is");
V_CE = V_CC - (I_C * R_C);// in V
disp(V_CE,"Collector emitter voltage in V is");
```

Scilab code Exa 5.11.5 Collector current

```
//Exa 5.11.5
clc;
clear;
close;
// Given data
bita = 100;
I_CBO = 4;// in   A
I_B = 40;// in   A
I_C = (bita * I_B) + ((1+bita) * I_CBO);// in   A
I_C = I_C * 10^-3;// in msA
disp(I_C,"The collector current in mA is");
```

Scilab code Exa 5.11.6 Current gain

```
// Exa 5.11.6
clc;
clear;
close;
// Given data
del_IC = 1 * 10^-3;// in A
del_IB = 10 * 10^-6;// in A
CurrentGain= del_IC/del_IB;
disp(CurrentGain,"The current gain is");
del_IC= del_IC*10^3;// in mA
del_IB= del_IB*10^6;// in  A
I_B=0:0.1:50;// in  A
I_C= I_B/del_IB+del_IC;// in mA
plot(I_B,I_C)
xlabel("Base current in  A");
ylabel("Collector current in mA")
title("Transfer Characteristics ")
disp("Transfer Characteristics is shown in figure")
```

Scilab code Exa 5.11.7 Value of alphaDC and bitaDC

```
//Exa 5.11.7
clc;
clear;
close;
//Given data
I_CEo = 21;// in  A
I_CBO = 1.1;// in  A
beta_dc = (I_CEo/I_CBO) - 1;
disp(beta_dc,"Value of beta_dc is");
```

```
alpha_dc = beta_dc/(1 + beta_dc);
disp(alpha_dc,”The value of alpha_dc is”);
```

Scilab code Exa 5.14.1 Value of alphaDC and emitter current

```
// Exa 5.14.1
clc;
clear;
close;
// Given data
I_CBO = 3;//in  A
I_CBO= I_CBO*10^-3;// in mA
I_C= 15;// in mA
// But it is given that I_C= 99.5% of I_E, SO
I_E= I_C/99.5*100;// in mA
alpha_dc= I_C/I_E;
disp(alpha_dc,”The value of alpha_dc is : ”)
disp(I_E,”The value of I_E in mA is : ”)
```

Scilab code Exa 5.14.2 Value of IC and IB

```
//Exa 5.14.2
clc;
clear;
close;
//Given data
alpha_dc = 0.99;
I_CBO = 10;// in  A
I_CBO= I_CBO*10^-6;// in A
I_E = 10;// in mA
I_E= I_E*10^-3;// in A
I_C = (alpha_dc * I_E) + I_CBO;// in A
disp(I_C*10^3,”The value of I_C in mA is”);
```

```
I_B = I_E - I_C;// in A
I_B = I_B * 10^6;// in  A
disp(I_B,"The value of I_B in  A is");
```

Scilab code Exa 5.14.3 Base current

```
// Exa 5.14.3
clc;
clear;
close;
format('v',9)
// Given data
alpha_dc = 0.99;
I_C = 6;// in mA
I_C= I_C*10^-3;// in A
I_CBO = 15;// in  A
I_CBO= I_CBO*10^-6;// in A
I_E = (I_C - I_CBO)/alpha_dc;// in A
I_B = I_E - I_C;// in A
I_B= I_B*10^6;// in  A
I_B= round(I_B)
disp(I_B,"The value of I_B in  A is");
```

Scilab code Exa 5.14.5 Value of IE

```
//Exa 5.14.5
clc;
clear;
close;
// Given data
alpha_dc = 0.98;
I_CBO = 12;// in  A
I_CBO = I_CBO * 10^-6;// in A
```

```
I_B = 120;// in  A
I_B = I_B * 10^-6;// in A
beta_dc = alpha_dc/(1-alpha_dc);
I_E = ((1 + beta_dc) * I_B) + ((1 + beta_dc) * I_CBO);//in A
I_E = I_E * 10^3;// in mA
disp(I_E,"The value of I_E in mA is");
```

Scilab code Exa 5.14.6 Region of operation of Si transistor

```
//Exa 5.14.6
clc;
clear;
close;
// Given data
bita= 100;
V_BEsat= 0.8;// in V
V_CEsat= 0.2;// in V
V_BEact= 0.7;// in V
V_CC = 10;// in V
V_BB=5;// in V
R_E = 2;// in  k
R_C = 3;// in  k
R_B= 50;// in  k
// Applying KVL to collector loop
// V_CC= I_Csat*R_C +V_CEsat +I_E*R_E and I_E= I_Csat+I_B , So
//I_B= ((V_CC-V_CEsat)-(R_C+R_E)*I_Csat)/R_E;            (i)
// Applying KVL to base loop
// V_BB-I_B*R_B -V_BEsat-I_E*R_E =0 and I_E= I_Csat+I_B , So
//V_BB-V_BEsat= R_E*I_Csat + (R_B+R_E)*I_B              (ii)
// From eq (i) and (ii)
```

```
I_B = ((V_BB-V_BEsat)*5- (V_CC-V_CEsat)*2) / ((R_B+R_E)*5 - R_E*2) ;// in mA
I_Csat= ((V_CC-V_CEsat)-R_E*I_B)/(R_C+R_E);// in mA
I_Bmin= I_Csat/bita;// in mA
if I_B<I_Bmin then
    disp("Since the value of I_B ("+string(I_B*10^3)+" A ) is less than the value of I_Bmin ("+string(I_Bmin*10^3)+" A )");
    disp("So the transistor is not in the saturation region. But it is conducting hence it can not be in cutoff.")
    disp("Therefore the transistor is in the active region")
end
```

Scilab code Exa 5.14.7 Value of IB IC and VCE

```
//Exa 5.14.7
clc;
clear;
close;
// Given data
bita= 100;
V_BEsat= 0.8;// in V
V_CEsat= 0.2;// in V
V_BEact= 0.7;// in V
V_CC = 10;// in V
V_BB=5;// in V
R_E = 2;// in k
R_C = 3;// in k
R_B= 50;// in k
// Applying KVL to input loop
// V_BB= I_B*R_B+(1+bita)*I_B*R_E+V_BEact or
I_B= (V_BB-V_BEact)/(R_B+(1+bita)*R_E);// in mA
I_C= bita*I_B;// in mA
```

```
// Applying KVL to collector circuit
// V_CC= I_Csat*R_C +V_CEsat +(I_C+I_B)*R_E
V_CEact= V_CC-I_B*R_E-I_C*(R_C+R_E);// in V
disp(I_B*10^3,"The value of I_B in  A is : ")
disp(I_C,"The value of I_C in mA is : ")
disp(V_CEact,"The value of V_CE in volts is : ")
```

Scilab code Exa 5.14.8 Region of operation and value of IB and IC

```
//Exa 5.14.8
clc;
clear;
close;
//Given data
bita = 100;
V_CEsat = 0.2;// in V
R_B = 150;// in kohm
R_C = 2;// in kohm
V_CC  = 10;// in V
V_BEsat = 0.8;// in V
I_B = (V_CC - V_BEsat)/R_B;// in mA
I_C = (V_CC - V_CEsat)/R_C;// in mA
I_Bmin = I_C/bita;// in mA
if I_B>I_Bmin then
    disp("Since the value of I_B ("+string(I_B*10^3)+" A) is greater than the value of I_Bmin ("+string(I_Bmin*10^3)+" A)");
    disp("So the transistor is in the saturation region.")
end
```

Scilab code Exa 5.14.9 Value of VBB

```
//Exa 5.14.9
clc;
clear;
close;
//Given data
bita = 100;
V_CE = 0.2;//in V
V_BE = 0.8;// in V
R_C= 500;// in
R_B= 44*10^3;// in
R_E= 1*10^3;// in
V_CC= 15;// in V
V_GE= -15;// in V
// Applying KVL to collector circuit
// V_CC-V_GE - I_Csat*R_C-V_CE-I_E*R_E=0, but I_Csat = bita*I_Bmin and I_E= 1+bita
I_Bmin= (V_CC-V_GE-V_CE)/(R_C*bita+(1+bita)*R_E);// in A
// Applying KVL to the base emitter circuit
// V_BB-I_Bmin*R_B-V_BE-I_E*R_E + V_CC=0
V_BB= I_Bmin*R_B + V_BE + (1+bita)*I_Bmin*R_E-V_CC;// in V
disp(I_Bmin*10^3,"The value of I_B(min) in mA is : ")
disp(V_BB,"The value of V_BB in volts is : ")
```

Scilab code Exa 5.14.10 Minimum value of RC required

```
// Exa 5.14.10
clc;
clear;
close;
// Given data
V_ECsat= 0.2;// in V
V_CC= 10;// in V
```

```
V_EBsat= 0.8;// in V

// Part (i)
bita= 100;
R_B= 220;// in k
// Applying KVL to collector circuit, V_CC= V_EC+ICRC
ICRC= V_CC-V_ECsat;// in V
// Applying KVL to input loop, V_CC= V_EBsat+I_B*R_B (i)
I_B= (V_CC-V_EBsat)/R_B;// in mA
I_C= bita*I_B;// in mA
R_Cmin= ICRC/I_C;// in k
disp(R_Cmin,"The minimum value of R_C in k is : ")
// Part (ii)
R_C= 1.2;// in k
I_Csat= ICRC/R_C;// in mA
I_B= I_Csat/bita;// in mA
// From eq (i)
R_B= (V_CC-V_EBsat)/I_B;// in k
disp(R_B,"The maximum value of R_B in k is : ")
```

Scilab code Exa 5.14.11 Value of RE

```
//Exa 5.14.11
clc;
clear;
close;
// Given data
bita= 100;
V_BEsat= 0.8;// in V
V_CEsat= 0.2;// in V
V_BEact= 0.7;// in V
V_CC = 10;// in V
```

```
R_E = 1;// in  k
R_C = 2;// in  k
R_B= 100;// in  k
bita=100;
alpha= bita/(1+bita);
// Applying KVL to collector circuit
// V_CC= I_Csat*R_C +V_CE +R_E*I_E
// but I_E= alpha*I_Csat
I_Csat= (V_CC-V_CEsat)/(R_C+R_E*alpha);// in mA
I_Bmin= I_Csat/bita;// in mA
// Applying KVL to base loop
// V_CC= I_B*R_B +V_BEsat +I_E*R_E
// but I_E= I_Csat+I_B
I_B= (V_CC-V_BEsat-I_Csat*R_E)/(R_B+R_E);// in mA
disp(I_B*10^3,"The value of I_B in  A is : ")
disp(I_Bmin*10^3,"The minimum value of I_B in  A is : ")
if I_B>I_Bmin then
    disp("Since the value of I_B is greater than the value of I_Bmin, ")
    disp("Hence the transistor is in saturation.")
end
I_E= (1+bita)*I_Bmin;// in mA
R_E= (V_CC-V_BEact-I_Bmin*R_B)/I_E;// in  k
disp(R_E,"The value of R_E in k  is : ")
disp("So R_E should be greater than this value in order to bring the transistor just out of saturation ")
```

Scilab code Exa 5.14.12 Collector voltage

```
// Exa 5.14.12
clc;
clear;
close;
```

```
// Given data
V_CC = 9;// in V
V_BE = 0.8;// in V
V_CE = 0.2;// in V
R_B = 50;// in  k
R_C=2;// in  k
R_E = 1;// in  k
bita=70;
// Applying KVL to input loop, V_CC= I_B*R_B +V_BE + I_E*R_E
// V_CC- V_BE= (R_B+R_E)*I_B + R_E*I_C          (i)
// Applying KVL to output loop, V_CC= R_C*I_C +V_CE +I_C*R_E +I_B*R_E
//I_B = ((V_CC- V_CE)-(R_C+R_E)*I_C)/R_E          (ii)
// From eq (i) and (ii)
I_C= ( (V_CC- V_BE)-(R_B+R_E)* (V_CC- V_CE)/R_E)/(1-(R_B+R_E)*(R_C+R_E));// in mA
I_B = ((V_CC- V_CE)-(R_C+R_E)*I_C)/R_E// in mA
I_Bmin= I_C/bita;// in mA
if I_B>I_Bmin then
    disp("Since the value of I_B ("+string(I_B)+" mA) is greater than the value of I_Bmin ("+string(I_Bmin)+" mA)")
    disp("So the transistor is in saturation ")
end
V_C= V_CC-I_C*R_C;// in V
disp(V_C,"The value of collector voltage in volts is : ")
bita= I_C/I_B;
disp(bita,"The minimum value of bita that will change the state of the trasistor is : ")
```

Chapter 6

Field Effect Transistor

Scilab code Exa 6.9.1 Pinch off voltage

```
//Exa 6.9.1
clc;
clear;
close;
// Given data
q = 1.6 * 10^-19;// in C
N_D = 10^15;// in electrons/cm^3
N_D = N_D * 10^6;// in electrons/m^3
epsilon_r = 12;
epsilon_o = (36 * %pi * 10^9)^-1;
epsilon = epsilon_o * epsilon_r;
a = 3 * 10^-4;// in cm
a = a * 10^-2;// in m
V_P = (q * N_D * a^2)/( 2 * epsilon);// in V
disp(V_P,"The Pinch off voltage in V is");
// V_GS = V_P * (1-(b/a))^2
b = (1-0.707) *a;// in m
disp(b*10^6,"The value of b in  m is : ")
disp("Hence the channel width has been reduced to
    about one third of its value for V_GS = 0");//
// Note : The unit of b in the book is wrong since
```

```
the value of b is calculated in  m.
```

Scilab code Exa 6.9.2 Value of VGS

```
// Exa 6.9.2
clc;
clear;
close;
// Given data
I_DSS = 8;// in mA
V_P = -4;// in V
I_D = 3;// in mA
V_GS = V_P * (1 - sqrt(I_D/I_DSS));// in V
disp(V_GS,”The value of V_GS in V is”);
V_DS = V_GS - V_P;// in V
disp(V_DS,”The value of V_DS in V is”);
```

Scilab code Exa 6.9.3 Drain current

```
// Exa 6.9.3
clc;
clear;
close;
// Given data
V_P = -4;// in V
I_DSS = 9;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_GS = -2;// in V
I_D = I_DSS * ((1 - (V_GS/V_P))^2);// in A
disp(I_D*10^3,”The drain current in mA is ”);
```

Scilab code Exa 6.9.4 Value of transconductance

```
// Exa 6.9.4
clc;
clear;
close;
// Given data
I_DSS = 12;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -(6);// in V
V_GS = -(1);// in V
g_mo = (-2 * I_DSS)/V_P;// in A/V
g_m = g_mo * (1 - (V_GS/V_P));// in S
disp(g_m*10^3,"The value of transconductance in mS
   is");
```

Scilab code Exa 6.9.5 Transconductance and drain current

```
//Exa 6.9.5
clc;
clear;
close;
// Given data
I_DSS = 10;// in mA
I_DSS = I_DSS * 10^-3;// in A
V_P = -(5);// in V
V_GS = -(2.5);// in V
g_m = ((-2 * I_DSS)/V_P) * (1 -(V_GS/V_P));// in S
g_m = g_m * 10^3;// in mS
disp(g_m,"The Transconductance in mS is");
I_D = I_DSS * ((1 - (V_GS/V_P))^2);// in A
disp(I_D*10^3,"The drain current in mA is");
```

Chapter 7

Optoelectonic Devices

Scilab code Exa 7.6.1 Component value

```
// Exa 7.6.1
clc;
clear;
close;
// Given data
O_V = 5;// output voltage in V
V_D = 1.5;//voltage drop in V
R = (O_V - V_D)/O_V;
R = R * 10^3;// in ohm
disp(R,"The resistance value in  is");
disp("As this is not standard value, use R=680 which is a standard value")
```

Scilab code Exa 7.23.1 Open circuit voltage

```
// Exa 7.23.1
clc;
clear;
```

```
close;
// Given data
N_A = 7.5*10^24;// in atoms/m^3
N_D = 1.5*10^22;// in atoms/m^3
I_lembda = 12.5*10^-3;// in A/cm^2
D_e = 25*10^-4;// in m^2/s
D_h = 1*10^-3;// in m^2/s
Torque_eo = 500;// in ns
Torque_ho = 100;// in ns
n_i = 1.5*10^16;// in /m^3
e = 1.6*10^-19;
P_C = 12.5;// in mA/cm^2
L_e = sqrt(D_e*Torque_ho*10^-9);// in m
L_e = L_e * 10^6;// in  m
L_h = sqrt(D_h*Torque_ho*10^-9);// in m
L_h = L_h * 10^6;// in  m
J_s = e*((n_i)^2)*( (D_e/(L_e*10^-6*N_A)) + (D_h/(
   L_h*10^-6*N_D)) );// in A/m^2
J_s = J_s * 10^-4;// in A/cm^2
V_T = 26;// in mV
V_OC = V_T*log( 1+(I_lembda/J_s) );// in mV
V_OC = V_OC * 10^-3;// in V
disp(V_OC,"Open circuit voltage in V is");
```

Scilab code Exa 7.23.2 Photocurrent density

```
// Exa 7.23.2
clc;
clear;
close;
// Given data
Phi_o = 1*10^21;// in m^-2s^-1
Alpha = 1*10^5;// in m^-1
W = 25;// in  m
W =W * 10^-6;// in m
```

```
e = 1.6*10^-19;// in C
G_L1 = Alpha*Phi_o;// in m^-3s^-1
G_L2 = Alpha*Phi_o*%e^( (-Alpha*W) );// in m^-3s^-1
J_L = e*Phi_o*(1-%e^(-Alpha*W));// in A/m^2
J_L = J_L * 10^-1;// in mA/cm^2
disp(J_L,"Photo current density in mA/cm^2 is");
```

Chapter 8

Negative Conductance Micro Devices

Scilab code Exa 8.13.1 The anode current

```
// Exa 8.13.1
clc;
clear;
close;
// Given data
R= 10;// in  k
R= R*10^3;// in
// Part (i)
V=300;// in V
I_A= V/R;// in A
disp("Part (i) : For 300 V voltage : ")
disp(I_A*10^3,"The anode current in mA is : ");
// Part (ii)
V=100;// in V
I_A= V/R;// in A
disp("Part (ii) : For 100 V voltage : ")
disp(I_A*10^3,"The anode current in mA is : ");
```

Scilab code Exa 8.14.1 Peak reverse recovery current

```
// Exa 8.14.1
clc;
clear;
close;
// Given data
t_rr = 10;// in   s
Q_rr = 150;// in   c
I_rr = (2*Q_rr)/t_rr;// in A
disp(I_rr,"The peak reverse recovery current in A is
    ");
```