Scilab Textbook Companion for Solid State Devices and Materials by R. K. Singh and D. S. Chauhan[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.

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Chapter 1

Semiconductor And Magnetic Materials

Scilab code Exa 1.2 Conductivity and mobility

```
// Exa 1.2
clc;
clear;
close;
// Given data
format('v',13)
I=0.5;// in A
rho= 7.4;// in   /1000 ft
rho= rho/(3.05*10^4);// in   /cm
sigma= 1/rho;//in cm/
disp(sigma,"Conductivity in   /cm is : ")

// Part (ii)
n= 6.5*10^28;// in per meter cube
q= 1.6*10^-19;// in C
// Formula sigma= n*q*miu_n
miu_n= sigma/(n*q);// in cm^2/Vs
disp(miu_n,"Mobility in cm^2/Vs is : ")

```

```
// Part (iii)
D= 2.5*10^-3;// in m
A= %pi*D^2/4;// in m^2
v_d= I/(n*q*A);// in m/s
disp(v_d,"Drift velocity in m/s is : ")
```

Scilab code Exa 1.3 Hole and electron concentration

```
// Exa 1.3
clc;
clear;
close;
// Given data
format('v',13)
N_D= 6*10^18;// in per cube cm
N_A= 3*10^15;// in per cube cm
ni= 2.5*10^12;
Nn= N_D-N_A;// in per cube cm
rho_n= ni^2/Nn;// in per cube cm
// Part (i)
disp(rho_n,"The concentration of holes in n-type in
    per cm^3 is : ")
disp(Nn,"Concentration  of electrons in n-type in
    per cm^3 is : ")
// Part (ii)
disp("The material is of n-type")
```

Scilab code Exa 1.4 Conductivity and resistivity

```
// Exa 1.4
clc;
clear;
close;
```

```
// Given data
format('v',13)
ni= 2.5*10^19;
q= 1.6*10^-19;// in C
miu_n= 0.36;
miu_p= 0.17;
sigma= q*ni*(miu_n+miu_p);// in s/m
rho= 1/sigma;// in  m
disp(sigma,"The conductivity of Ge in s/m is ")
disp(rho,"The resistivity of Ge in  m is : ")
```

Scilab code Exa 1.5 Conductivity

```
// Exa 1.5
clc;
clear;
close;
// Given data
format('v',13)
e= 1.6*10^-19;// in C
ni= 1.5*10^16;
miu_n= 0.13;
miu_p= 0.05;
atomicDensity= 5*10^28;//atomic density of Si in /m^3
C= 1/(2*10^8);// concentration
N_D= atomicDensity*C;// in /m^3
n=N_D;
p= ni^2/N_D;// in /m^3
sigma= e*(n*miu_n+p*miu_p);// in s/m
disp(sigma,"Conductivity of the extrinsic semiconductor in s/m is : ")
```

Scilab code Exa 1.6 Fraction of the total number of electrons

```
// Exa 1.6
clc;
clear;
close;
// Given data
format('v',13)
Eg= 0.72;// in eV
Ef= Eg/2;//in eV
K= 8.61*10^-5;// in eV/K
T=300;//in K
nc= 1;
n= 1+%e^((Eg-Ef)/(K*T));
ncBYn= nc/n;
disp(ncBYn,"The fraction of the total number or
    electrons is : ")
```

Scilab code Exa 1.7 Ratio of electron to hole concentration

```
// Exa 1.7
clc;
clear;
close;
// Given data
format('v',13)
ni= 1.4*10^18;//in /m^3
N_D= 1.4*10^24;//in /m^3
n=N_D;
p= ni^2/n;// in /m^3
nbyp= n/p;
disp(nbyp,"The ratio of electron to holes
    concentration is : ")
```

Scilab code Exa 1.8 Charge density of free electrons

```
// Exa 1.8
clc;
clear;
close;
// Given data
format('v',13)
d= 2;// in mm
d=d*10^-3;//in m
sigma= 5.8*10^7;// in s/m
miu_c= 0.0032;// in m^2/v-sec
E= 20;//in mV/m
E=E*10^-3;//in V/m
e= 1.6*10^-19;// in C
// Part (a)
n= sigma/(e*miu_c);//in /m^3
disp(n,"Charge density per meter cube is : ")

// Part (b)
J= sigma*E;//in A/m^2
disp(J,"Current density in A/m^2 is : ")

// Part (c)
Area= %pi*d^2/4;// in area of cross-section of wire
    in m^2
I= J*Area;// in A
disp(I,"Current flowing in the wire in amp is : ")

// Part (d)
v= miu_c*E;// in m/sec
disp(v,"Electron drift velocity in m/sec is : ")
```

Scilab code Exa 1.9 Time taken by the electron to travel

```
// Exa 1.9
clc;
clear;
close;
// Given data
format('v',13)
rho= 0.5;// in   -m
miu_c= 0.4;// in m^2/v-sec
J=100;//in A/m^2
distance=10;//  m
distance=distance*10^-6;//in sec
// V= miu_c*E = miu_c*J/sigma = miu_c*J*rho
V=  miu_c*J*rho ;// in m/sec
disp(V,"Drift velocity in m/sec is : ")
T= distance/V;// in second
disp(T,"The time taken by the electron to travel 10 micro meter in the crystal in second is :  ")
```

Scilab code Exa 1.10 Horizontal component of the magnetic intensity

```
// Exa 1.10
clc;
clear;
close;
// Given data
format('v',13)
Bo= 1.7*10^-5;// in weber/meter^2
miu_o= 4*%pi*10^-7 ;// in weber/amp-meter
H= Bo/miu_o;//in A/m
```

```
disp(H,"The horizontal component of the magnetic
   intensity in A/m is : ")
```

Scilab code Exa 1.11 Current sending through the solenoid

```
// Exa 1.11
clc;
clear;
close;
// Given data
H= 5*10^3;// in amp/meter
N= 50;
l= 10;//in cm
l=l*10^-2;// in m
n=N/l;// in turns/meter
i= H/n;// in amp
disp(i,"Current should be sent through the solenoid
   in ampere is : ")
```

Scilab code Exa 1.12 Magnetic moment of the rod

```
// Exa 1.12
clc;
clear;
close;
// Given data
vol= 10^-4;// volume of the rod in m^3
i=0.5;// in amp
n= 5;// turns/cm
n= n*10^2;// turns/meter
miu_r= 1000;
//B= miu_o*(H+I)
// Where I= Bo/miu_o-H and B= miu*H = miu_r*miu_o*H
```

```
// Then I= miu_r*miu_o*H/miu_o - H = (miu_r -1)*H
// H= n*i
I= (miu_r-1)*n*i;// in amp/meter
MagMoment= I*vol;// in Am^2
disp(round(MagMoment),"Magnetic moment in Am^2 is :
   ")
```

Scilab code Exa 1.13 Relative permeability

```
// Exa 1.13
clc;
clear;
close;
format('v',13);
// Given data
Xm= 9.48*10^-9;
miu_r= 1+Xm;//
disp(miu_r,"Relative permeability si : ")
disp("That is  r is slightly greater than 1");
```

Scilab code Exa 1.14 Flux density

```
// Exa 1.14
clc;
clear;
close;
// Given data
fie_B= 2*10^-6;// in weber
A= 10^-4;// in m^2
N= 300;// number of turns
l=30;//in cm
l=l*10^-2;//in meter
i=0.032;// in amp
```

```
miu_o= 4*%pi*10^-7;
B=fie_B/A;// in weber/meter^2
disp(B,"Flux density in weber/meter^2 is : ")
H= N*i/l;// in amp-turn/meter
disp(H,"Magnetic intensity in amp-turn/meter is :")
miu= B/H;// in weber/amp-meter
disp(miu,"Pemeability in weber/amp-meter is :")
miu_r= miu/miu_o;
disp(miu_r,"Relative permeability is : ")
```

Scilab code Exa 1.15 Conductivity of a bar

```
// Exa 1.15
clc;
clear;
close;
// Given data
q=1.6*10^-19;// in C
ni= 1.5*10^16;// in /m^3
miu_n= 0.13;// in m^3/vs
miu_p= 0.05;// in m^3/vs
sigma= q*ni*(miu_n+miu_p);// in    /m
disp(sigma,"The conductivity in    /m is : ")
```

Scilab code Exa 1.16 Hole concentration and conductivity

```
// Exa 1.16
clc;
clear;
close;
// Given data
q=1.6*10^-19;// in C
n=4*10^22;// in /m^3
```

```
ni= 2.4*10^19;// in /mˆ3
miu_n= 3500;// in cmˆ2/vs
miu_n= miu_n*10^-4;// in mˆ2/vs
// Formula n∗p= ni ˆ2
p= ni^2/n;// in mˆ−3
disp(p,"Hole concentration in mˆ−3 is : ")
sigma=q*n*miu_n;// in ( −m)ˆ−1
disp(sigma,"The conductivity of the extrinsic
   semiconductor in ( m )ˆ−1 is :")

// Note : There is miss print in the printed value
   of p and also calculation error in evaluating the
    value of p . So the answer in the book is wrong
```

Scilab code Exa 1.17 Hole and electron concentration

```
// Exa 1.17
clc;
clear;
close;
// Given data
ni= 1.8*10^16;// in /mˆ3
q= 1.6*10^-19;// in C
em=0.14;// electron mobility in mˆ2/v−sec
hm=0.05;// hole mobility in mˆ2/v−sec
resistivity= 1.2;// in  m
n= 1/(q*em*resistivity);// in /mˆ3
disp(n,"The electron concenration in /mˆ3 is :")
p= ni^2/n;// in /mˆ3
disp(p,"The hole concentration in /mˆ3 is : ")
```

Scilab code Exa 1.18 Conductivity of the material

```
// Exa 1.18
clc;
clear;
close;
// Given data
miu= 35.2*10^-4;// in m^2/vs
n=7.87*10^28;
e= 1.6*10^-19;// in C
sigma= n*e*miu;// in s/m
disp(sigma,"Conductivity in s/m is : ")
```

Scilab code Exa 1.19 Conductivity of intrinsic Ge

```
// Exa 1.19
clc;
clear;
close;
// Given data
ni= 2.25*10^13;// in /cm^3
e= 1.6*10^-19;// in C
miu_n= 3800;// in cm^2/vs
miu_p= 1800;// in cm^2/vs
no=ni;
sigma= no*e*(miu_n+miu_p);// in s/cm
disp(sigma,"The intrinsic conductivity in s/cm is :"
    )

// Note: Answer in the book is wrong due to
    calculation error to evaluating the value of
    sigma
```

Scilab code Exa 1.20 Drift velocity of free electrons

```
// Exa 1.20
clc;
clear;
close;
// Given data
e= 1.6*10^-19;// in C
I=100;// in A
n_o= 8.5*10^28;// in m^-3
A=10^-5;// in m^2
// Formula I= n_o*A*e*Vd
Vd= I/(n_o*e*A);// in ms^-1
disp(Vd,"The drift velocity of free electron in ms
    ^-1 is : ")
```

Scilab code Exa 1.21 Conductivity of Si material

```
// Exa 1.21
clc;
clear;
close;
// Given data
miu_n= 0.13;// in m^2/v-sec
lip= 0.05;// in m^2/v-sec
n=5*10^28/10^9;// in /m^3
q= 1.6*10^-19;// in C
sigma= q*n*miu_n;// in ( m)^-1
disp(sigma,"The conductivity of silicon material in
    ( m)^-1 is : ")
```

Scilab code Exa 1.22 Conductivity of Si material

```
// Exa 1.22
clc;
```

```
clear;
close;
// Given data
miu_p= 0.05;// in m^2/v-sec
rho=5*10^28/10^8;// in /m^3
q= 1.6*10^-19;// in C
sigma= q*rho*miu_p;// in ( m)^-1
disp(sigma,"The conductivity of silicon material in
   ( m)^-1 is : ")
```

Chapter 2

Physics Of Semiconductors

Scilab code Exa 2.1 Mobility and drift velocity

```
// Exa 2.1
clc;
clear;
close;
// Given data
miu= 0.3;// in m^2/vs
V= 50;// in mV
V=V*10^-3;// in V
d=0.4;// in mm
d=d*10^-3;// in m
// Part (a)
// miu= vd/E and vd= miu*E, so
vd= miu*V/d;// in m/s
disp(vd,"Drift velocity in m/s is : ")

// Part (b)
T= d/vd;// in sec
disp(T*10^6,"Time required for an electron to move
    in   s is :")
```

Scilab code Exa 2.2 Value of intrinsic conductivities

```
// Exa 2.2
clc;
clear;
close;
// Given data
miu_n= 0.36;// in m^2/vs
miu_p= 0.17;// in m^2/vs
ni= 2.9*10^19;// in /m^3
q=1.6*10^-19;// in C
sigma_i= q*ni*(miu_n+miu_p);// in ( m)^-1
disp(sigma_i,"Intrinsic conductivity of Ge in ( m)^-1 is :")
```

Scilab code Exa 2.3 Free electrons and hole mobilities

```
// Exa 2.3
clc;
clear;
close;
// Given data
rho= 0.60;// in  m
q=1.6*10^-19;// in C
miu_n= 0.38;// in m^2/vs
miu_p= 0.18;// in m^2/vs
sigma= 1/rho;// in ( m)^-1
ni= sigma/(q*(miu_n+miu_p));// in /m^3
disp(ni,"The intrinsic carrier concentration per meter cube is :")
```

Scilab code Exa 2.4 Conductivity of Si sample

```
// Exa 2.4
clc;
clear;
close;
// Given data
N_D= 10^21;// in /m^3
N_A= 2*10^20;// in /m^3
miu_n= 0.15;// in m^2/vs
N_DeshD= N_D-N_A;// in /m^3
n=N_DeshD;// in /m^3
q=1.6*10^-19;// in C
sigma= q*n*miu_n;// in ( m)^-1
disp(sigma,"Conductivity of silicon in ( m)^-1 is :
    ")
```

Scilab code Exa 2.5 Conductivity of copper

```
// Exa 2.5
clc;
clear;
close;
// Given data
n=6.023*10^23*7.4/63.54;
miu= 32.6;// in cm^2/Vs
q=1.6*10^-19;// in C
sigma= n*q*miu;// in ( cm)^-1
disp(sigma,"Conductivity of copper in ( cm)^-1 is :
    ")
```

Scilab code Exa 2.6 Conductivity of hole and electrons in an n typy Si

```
// Exa 2.6
clc;
clear;
close;
// Given data
// For silicon
q=1.6*10^-19;// in C
ni= 2.5*10^12;// in /cm^3
miu_n= 1700;// in cm^2/Vs
miu_p= 600;// in cm^2/Vs
sigma= 0.2;// in ( m )^-1
// Formula sigma= q*n*miu_n
n= sigma/(q*miu_n);// in /cm^3
p= ni^2/n;// in /cm^3
disp("For silicon")
disp(n,"Concentration of electron in /cm^3 is : ")
disp(p,"Concentration of holes in /cm^3 is : ")
// For germanium
ni= 3.4*10^15;// in /cm^3
miu_n= 3600;// in cm^2/Vs
miu_p= 1600;// in cm^2/Vs
sigma= 150;// in ( m )^-1
p= sigma/(q*miu_p);// in /cm^3
n= ni^2/p;// in /cm^3
disp("For germanium")
disp(n,"Concentration of electron in /cm^3 is : ")
disp(p,"Concentration of holes in /cm^3 is : ")
```

Scilab code Exa 2.7 Resistivity of Ge drops

```
// Exa 2.7
clc;
clear;
close;
// Given data
miu_n= 3900;// in cm^2/Vs
miu_p= 1900;// in cm^2/Vs
ni= 2.5*10^10;// in /cm^3
Nge= 4.41*10^22;// in /cm^3
q=1.6*10^-19;// in C
N_D= Nge/10^8;// in /cm^3
n=N_D;// approx
p= ni^2/N_D;// in /cm^2
sigma= q*n*miu_n;// in (cm)^-1
rho= 1/sigma;// in  cm
disp(rho,"Resistivity of the doped germanium in  cm
    is : ")
```

Scilab code Exa 2.8 Resistivity of intrinsic Si

```
// Exa 2.8
clc;
clear;
close;
// Given data
Nsi = 4.9*10^22;// in /cm^3
ni= 2.5*10^12;// in /cm^3
q=1.6*10^-19;// in C
miu_n= 1600;// in cm^2/Vs
miu_p= 400;// in cm^2/Vs
N_D= Nsi/(100*10^6);
sigma= q*ni*(miu_n+miu_p);// in (cm)^-1
rho= 1/sigma;// in  cm
disp(rho,"Resistivity of silicon in  cm is :")
n=N_D;// approx
```

```
p= ni^2/n;// in /cm^3
sigma= q*n*miu_n;// in ( cm)-1
rho= 1/sigma;// in  cm
disp(rho,"Resistivity of doped silicon in  cm is :"
    )
```

Scilab code Exa 2.9 The value of temperature at which the Fermi level coincides

```
// Exa 2.9
clc;
clear;
close;
// Given data
N_D= 5*10^28/(20*10^6);// in /m^3
// For the Fermi level
// E_F= E_C if N_C= N_D,
// N_D= 4.82*10^21 * T^(3/2)  /m^3
T= (N_D/( 4.82*10^21 ))^(2/3);// in K
disp(T,"Temperature in K is : ")
```

Scilab code Exa 2.10 Minority carrier concentration

```
// Exa 2.10
clc;
clear;
close;
// Given data
ni= 1.8*10^15;// in /m^3
rho= 2*10^5;// in  m
q=1.6*10^-19;// in C
dopingConcentration= 10^25;// in /m^3
n=dopingConcentration;
```

```
MCC= ni^2/dopingConcentration; // Minority carrier concentration per cube meter
miu_n= 1/(2*rho*q*ni);// in m^3/Vs
disp(miu_n,"The value of  n in m^3/Vs is : ")

// Part (b)
sigma= q*n*miu_n;//in ( m)^-1
rho= 1/sigma;// in  m
disp(rho,"Resistivity in  m is : ")

// Part(c)
kT= 26*10^-3;//in V
no= n;// in /m^3
Shift_inFermiLevel= kT*log(no/ni);// in eV
disp(Shift_inFermiLevel,"Shift in Fermi level due to doping in eV is :")
disp("Hence, E_F lies "+string(Shift_inFermiLevel)+" eV above Fermi level Ei")

// Part (d)
MCC= ni^2/dopingConcentration; // Minority carrier concentration per cube meter
disp(MCC,"Minority carrier concentration per cube meter when its temperature is increased is : ")
```

Scilab code Exa 2.11 Conductivity and resistivity of intrinsic sample of Si

```
// Exa 2.11
clc;
clear;
close;
// Given data
miu_n= 1700;//in cm^2/Vs
miu_p= 560;//in cm^2/Vs
```

```
ni= 2.5*10^10;// in /cm^3
q=1.6*10^-19;// in C
sigma= q*ni*(miu_n+miu_p);//in ( cm)^-1
rho= 1/sigma;// in  cm
disp(sigma,"Conductivity of intrinsic sample in ( cm)^-1 is : ")
disp(rho,"Resistivity of intrinsic sample in  cm")
```

Scilab code Exa 2.12 Resistivity of Si

```
// Exa 2.12
clc;
clear;
close;
// Given data
ni= 1.45*10^10;// in /cm^3
q=1.6*10^-19;// in C
miu_n= 1300;// in cm^2/Vs
density= 5*10^22;// density of silicon atom in /cm^3
N_D= density/10^12;
n=N_D;
// n*p= ni^2
p= ni^2/n;//in /cm^3
sigma= q*n*miu_n;// in ( cm)^-1
rho= 1/sigma;// in  cm
disp(rho,"Resistivity of silicon in  cm is : ")

// Note: The value of n is putted wrong (5*10^14 at place of 5*10^10) to evaluate the value of sigma. So the answer in the book is wrong .
```

Scilab code Exa 2.13 Total conduction current density

```
// Exa 2.13
clc;
clear;
close;
// Given data
q=1.6*10^-19;// in C
rho=75;//in  cm
N_D= 10^13;// in /cm^3
N_A= 5*10^12;//in /cm^3
E=3;// in V/cm
ni= 2.7*10^12;// in /cm^3
sigma= 1/rho;// in ( cm)^-1
// miu_p/miu_n= 1/3 or miu_n=3*miu_p
// sigma= q*ni*(miu_n+miu_p) = q*ni*(3*miu_p+miu_p)
   = q*ni*(4*miu_p)
miu_p= sigma/(q*ni*4);
miu_n= 3*miu_p;
// n+N_A= p+N_D  or  n= p+N_D-N_A
// n*p= ni^2  or  (p+N_D-N_A)*p= ni^2
// p^2 + (N_D-N_A)*p-ni^2 =0
// values= [1 (N_D-N_A) -ni^2];
p = roots([1 5*10^12 -7.29*10^24])
p=p(2);//discarding -ve value
n=p+N_D-N_A;
I= q*(n*miu_n+p*miu_p)*E// in A/m^2
disp(I,"The total conduction current in A/m^2 is : "
   )

// Note: There is some difference between book
   answer and coding. The reson behind this is that
//          The value of P is evaluated 1.8*10^12
   while accurate value is 1.179674*10^12
```

Scilab code Exa 2.14 The minority carrier concentration at room temperature

```
// Exa 2.14
clc;
clear;
close;
// Given data
N_D= 10^20;// in /cm^3
ni= 2.5*10^12;// in /cm^3
kT=26;// in meV
kT=kT*10^-3;// in eV
n= N_D;// as N_D>>ni
p= ni^2/n;//in /cm^3
disp(p,"The minority carrier concentration per cm^3
    is :")

// Part (b)
LocationOfFermiLevel= kT*log(N_D/ni);// in eV
disp("The Fermi Level will be "+string(
    LocationOfFermiLevel)+" eV above Fermi level")

//Note: The value of Minority carrier concentration
    of part(a) is calculated wrong because the value
    of (2.5*10^12)^2/(10^20) will be 62500 not
    2.5*10^4
```

Scilab code Exa 2.15 Doping level and drift velocity

```
// Exa 2.15
clc;
clear;
close;
// Given data
miu_n= 1300;// in cm^2/Vs
q=1.6*10^-19;// in C
ni= 4.3*10^-6;// in /cm^3
V= 1;// in volt
```

```
L=8;// in cm
A=0.8*0.8;// in cm^2
I=4*10^-3;// in A
// R= rho*L/A = V/I
R= V/I;// in
sigma= L/(R*A);// in (cm)^-1
// sigma= q*n*miu_n
n= sigma/(q*miu_n);
N_D= n;
disp(N_D,"The value of N_D is :")
// Part (b)
d=L;
E= V/d;
vd=miu_n*E;// in cm/s
disp(vd,"Drift velocity in cm/s is : ")
```

Scilab code Exa 2.16 Relaxatime and drift velocity of electron in copper

```
// Exa 2.16
clc;
clear;
close;
// Given data
E= 1;//in v/m
miu= 32*10^-4;// in m^2/Vs
m= 9.1*10^-28;// in gram
m=m*10^-3;// in kg
q=1.6*10^-19;// in C
toh_r= 2*miu*m/q;// in sec
Vd= miu*E;// in m/sec
disp(toh_r,"The relaxation time in sec is :")
disp(Vd*10^2,"Drift velocity in cm/sec is :")
```

Scilab code Exa 2.17 Resistivity of the material

```
// Exa 2.17
clc;
clear;
close;
// Given data
miu_n= 0.145;// in m^2/Vs
miu_p= 0.05;// in m^2/Vs
q=1.6*10^-19;// in C
n=10^15;// per m^3
p=10^2;// per m^3
rho= 1/(q*(n*miu_n+p*miu_p));// in  m
disp(rho,"The resistivity in  m is :")
```

Scilab code Exa 2.18 Conductivity of Si material

```
// Exa 2.18
clc;
clear;
close;
// Given data
miu_n= 0.13;// in m^2/Vs
miu_p= 0.05;// in m^2/Vs
q=1.6*10^-19;// in C
ni=1.5*10^16;// per m^3
sigma_intrinsic= q*ni*(miu_n+miu_p);// in ( m)^-1
disp(sigma_intrinsic,"The conductivity of silicon in Intrinsic condition in ( m)^-1 is : ")

// Part (b)
n= 5*10^28/10^9;
sigma= q*n*miu_n;// in ( m)^-1
disp(sigma,"The conductivity with donar impurity in ( m)^-1 is : ")
```

```
// Part (c)
p= 5*10^28/10^8;
sigma= q*p*miu_p;// in ( m)^-1
disp(sigma,"The conductivity with acceptor impurity
   in ( m)^-1 is : ")

// Part (d)
p_desh= p-n;// in /m^3
sigma= q*p_desh*miu_p;// in ( m)^-1
disp(sigma,"The conductivity with donar and acceptor
    impurity in ( m)^-1 is : ")

// Note : Answer in the book of part (a) may be miss
    printed or wrong
```

Scilab code Exa 2.19 Electron hole concentration in the material

```
// Exa 2.19
clc;
clear;
close;
// Given data
rho= 1.2;// in  m
miu_n= 0.14;// in m^2/Vs
q=1.6*10^-19;// in C
ni= 1.8*10^16;// per m^3
// sigma = 1/rho = q*n*miu_n
n= 1/(rho*q*miu_n);// per m^3
p= ni^2/n;// per m^3
disp(n,"The value of n in per m^3 is :")
disp(p,"The value of p in per m^3 is :")
```

Scilab code Exa 2.20 Resistivity

```
// Exa 2.20
clc;
clear;
close;
// Given data
N_D= 5*10^22/10^8;
q=1.6*10^-19;// in C
ni= 1.45*10^10;// per m^3
miu_n= 1300;// in m^2/Vs
// n*p= ni^2 or N_D*p = ni^2
p= ni^2/N_D;// in /cm^3
sigma= q*miu_n*N_D;// in ( cm)^-1
rho= 1/sigma;//in  cm
disp(rho,"Resistivity in  cm is : ")
```

Scilab code Exa 2.21 Conductivity and mobility for a copper wire

```
// Exa 2.21
clc;
clear;
close;
// Given data
q=1.6*10^-19;// in C
n=8.4*10^28;
rho= 6.51;// in  /1000ft
rho= rho/(3.05*10^4);// in  /cm
sigma= 1/rho;// in mho/cm
sigma=sigma*10^2;// in mho/m
// sigma= n*q*miu
miu= sigma/(n*q);// in m^2/v-s
disp(sigma,"Conductivity in mho/m is : ")
disp(miu,"Mobility in m^2/v-s is : ")
```

Scilab code Exa 2.22 Conductivity and resistivity of an intrinsic Si

```
// Exa 2.22
clc;
clear;
close;
// Given data
miu_n= 1350;// in cm^2/v-sec
miu_p= 480;// in cm^2/v-sec
ni=1.52*10^10;// in /cm^3
q=1.6*10^-19;// in C
sigma= q*ni*(miu_n+miu_p);// in ( cm)^-1
rho= 1/sigma;// in  cm
disp(sigma,"Conductivity in ( cm)^-1 is : ")
disp(rho,"Resistivity in  cm is : ")
```

Scilab code Exa 2.23 The value of intrinsic conductivity

```
// Exa 2.23
clc;
clear;
close;
// Given data
ni=2.5*10^19;// in /m^3
miu_n= 0.38;// in m^2/v-sec
miu_p= 0.18;// in m^2/v-sec
q=1.6*10^-19;// in C
sigma= q*ni*(miu_n+miu_p);// in ( m)^-1
disp(sigma,"Conductivity in ( m)^-1 is : ")
```

Scilab code Exa 2.24 Intrinsic carrier concentration of Ge

```
// Exa 2.24
clc;
clear;
close;
// Given data
rho= 0.5;// in
miu_n= 0.39;// in m^2/v-sec
miu_p= 0.19;// in m^2/v-sec
q=1.6*10^-19;// in C
sigma= 1/rho;// in ( m )^-1
// Formula sigma= q*ni*(miu_n+miu_p)
ni= sigma/(q*(miu_n+miu_p));// in /m^3
disp(ni,"The intrinsic carrier concentration of
   germanium in /m^3 is : ")
```

Scilab code Exa 2.25 Conductivity of Si sample

```
// Exa 2.25
clc;
clear;
close;
// Given data
q=1.6*10^-19;// in C
miu_n= 0.18;// in m^2/v-s
N_D= 10^21;// per m^3
N_A= 5*10^20;// per m^3
N_deshD= N_D-N_A;// per m^3
n=N_deshD;// per m^3
sigma= q*n*miu_n;// in ( m )^-1
disp(sigma,"Conductivity of the silicon sample in (
    m )^-1 is : ")
```

Scilab code Exa 2.26 Conductivity and resistivity of Ge

```
// Exa 2.26
clc;
clear;
close;
// Given data
q=1.6*10^-19;// in C
miu_n= 0.36;// in m^2/v-s
miu_p= 0.17;// in m^2/v-s
ni= 2.5*10^19;// per m^3
sigma= q*ni*(miu_n+miu_p);// in s/m
rho= 1/sigma;// in  m
disp(sigma,"Conductivity of Ge in s/m is : ")
disp(rho,"Resistivity in  m is : ")
```

Scilab code Exa 2.27 Conductivity of extrinsic semiconductor

```
// Exa 2.27
clc;
clear;
close;
// Given data
e=1.6*10^-19;// in C
miu_n= 0.13;// in m^2/v-s
miu_p= 0.05;// in m^2/v-s
N_D= 5*10^28/(2*10^8);// per m^3
n=N_D;// per m^3
ni= 1.5*10^16;// per m^3
p= ni^2/N_D;// per m^3
sigma= e*(n*miu_n+p*miu_p);// in s/m
```

```
disp(sigma,"Conductivity of the intrinsic
   semiconductor in s/m is ")
```

Scilab code Exa 2.28 Fraction of the total number of electrons

```
// Exa 2.28
clc;
clear;
close;
// Given data
format('v',13)
Eg= 0.72;// in eV
Ef= Eg/2;//in eV
K= 8.61*10^-5;// in eV/K
T=300;//in K
nc= 1;
n= 1+%e^((Eg-Ef)/(K*T));
ncBYn= nc/n;
disp(ncBYn,"The fraction of the total number or
   electrons is : ")
```

Scilab code Exa 2.29 Ratio of electron to hole concentration

```
// Exa 2.29
clc;
clear;
close;
// Given data
N_D= 1.4*10^24;// per m^3
ni= 1.4*10^18;// per m^3
n=N_D;//per m^3
p=ni^2/n;// per m^3
R= n/p;// ratio of electron to holes concentration
```

```
disp(R,"Ratio of electron to holes concentraiton is
    : ")
```

Scilab code Exa 2.30 Charge density of free electrons

```
// Exa 2.30
clc;
clear;
close;
// Given data
e=1.6*10^-19;// in C
miu_e= 0.0032;// in m^2/v-s
sigma= 5.8*10^7;// in s/m
E= 20*10^-3;// in V/m
d=0.002;// in m
Area= %pi*d^2/4;// in m^2

// Part (a)
n= sigma/(e*miu_e);// per m^3
disp(n,"The charge density per meter cube is : ")

// Part (b)
J= sigma*E;// in A/m^2
disp(J,"Current density in A/m^2 is : ")

// Part (c)
I= J*Area;// in A
disp(I,"Current flowing in the wire in ampere is : "
    )

// Part (d)
v=miu_e*E;// in m/sec
disp(v,"Electron drift velocity in m/sec is : ")
```

Scilab code Exa 2.31 Drift velocity and time taken by the electron to travel

```
// Exa 2.31
clc;
clear;
close;
// Given data
format('v',13)
rho= 0.5;// in   -m
miu_c= 0.4;// in m^2/v-sec
J=100;//in A/m^2
distance=10;//   m
distance=distance*10^-6;//in sec
// V= miu_c*E = miu_c*J/sigma = miu_c*J*rho
V=  miu_c*J*rho ;// in m/sec
disp(V,"Drift velocity in m/sec is : ")
T= distance/V;// in second
disp(T,"The time taken by the electron to travel 10
    micro meter in the crystal in second is :  ")
```

Scilab code Exa 2.32 Conductivity of intrinsic Ge

```
// Exa 2.32
clc;
clear;
close;
// Given data
e=1.6*10^-19;// in C
miu_e= 3800;// in cm v-s
miu_p= 1800;// in cm v-s
ni= 2.5*10^13;// per cm^3
```

```
N_D= 4.4*10^22*10^-7;// per cm^3
n=N_D;// per cm^3
p= ni^2/N_D;// holes/cm^3
sigma_i= ni*e*(miu_e+miu_p);// in (cm)^-1
sigma_n= e*N_D*miu_e;// in (cm)^-1
disp(sigma_i,"Intrinsic conductivity in (cm)^-1 is : ")
disp(n,"Concentration of electrons per cm^3 is : ")
disp(p,"Concentration of holes per cm^3 is : ")
disp(sigma_n,"The conductivity in n-type Ge semiconductor in (cm)^-1 is : ")
```

Scilab code Exa 2.33 Electron and hole drift velocity

```
// Exa 2.33
clc;
clear;
close;
// Given data
e=1.6*10^-19;// in C
a= 0.004*0.0015;// in m^2
ni= 2.5*10^19;// per m^3
miu_e= 0.38;// in m^2/ v-s
miu_p= 0.18;// in m^2/v-s
V=10;// in V
i= 25;// in mm
i=i*10^-3;// in m
E= V/i;// in V/m
// Part (a)
ve= miu_e*E;// in m/sec
disp(ve,"Electric drift velocity in m/sec is : ")
vp= miu_p*E;// in m/sec
disp(vp,"Hole drift velocity in m/sec is : ")

// Part (b)
```

```
sigma_i= ni*e*(miu_e+miu_p);// in ( cm)^-1
disp(sigma_i,"Intrinsic carrier conductivity of Ge
   in ( cm)^-1 is : ")

// Part (c)
I= sigma_i*E*a;// in A
I=I*10^3;// in mA
disp(I,"Total current in mA is : ")
```

Scilab code Exa 2.34 Intrinsic carrier concentration in Si

```
// Exa 2.34
clc;
clear;
close;
// Given data
miu_e= 0.14;// in m^2/ v-s
miu_p= 0.05;// in m^2/v-s
e=1.6*10^-19;// in C
N=3*10^25;// per m^3
Eg= 1.1;// in eV
Eg= Eg*1.602*10^-19;// in J
k= 1.38*10^-23;// in J/K
T=300;// in K
ni= N*%e^(-Eg/(2*k*T));// in /m^3
sigma= ni*e*(miu_e+miu_p);// in s/m
disp(ni,"The intrinsic carrier concentration in Si
   in /m^3 is : ")
disp(sigma,"Conductivity of Si in s/m is : ")
```

Scilab code Exa 2.35 Junction potential

```
// Exa 2.35
```

```
clc;
clear;
close;
// Given data
N_A= 4.4*10^22/10^8;// in /m^3
N_D= 10^3*N_A;// in /m^3
ni= 2.5*10^13;// /cm^3
Vt= 26;// in mV
Vt= Vt*10^-3;// in V
Vj= Vt*log(N_A*N_D/ni^2);// in V
disp(Vj,"The junction potential in volts is : ")
```

Scilab code Exa 2.36 Current flowing in the diode

```
// Exa 2.36
clc;
clear;
close;
// Given data
I_o= 0.3;// in  A
I_o= I_o*10^-6;// in A
V_F= 0.15;// in V
I= I_o*%e^(40*V_F);// in A
disp(I*10^6,"Current flowing in the diode in  A is
    : ")
```

Scilab code Exa 2.37 Forward current for a Ge diode at room temperature

```
// Exa 2.37
clc;
clear;
close;
// Given data
```

```
format('v',11)
Io= 1;// in nA
Io= Io*10^-9;// in A
T= 27+273;//in K
V_T= T/11600;// in V
V_F= 0.3;// in V
n=1;
I_F= Io*[%e^(V_F/(n*V_T))-1];// in A
disp(I_F,"The forward current of diode in ampere is
    : ")
```

Scilab code Exa 2.38 Dynamic resistance of Ge pn junction diode

```
// Exa 2.38
clc;
clear;
close;
// Given data
format('v',11)
I_F= 2;// in mA
I_F= I_F*10^-3;// in A
V_T= 25;// in mV
V_T=V_T*10^-3;// in V
n=1;
r_F= n*V_T/I_F;// in
disp(r_F,"The dynamic resistance of a Ge p-n
    junction diode in    is : ")
```

Scilab code Exa 2.39 AC resistance of a semiconductor diode

```
// Exa 2.39
clc;
clear;
```

```
close;
// Given data
T=300;// in K
n=1;
V_T= 26;// in mV
V_T=V_T*10^-3;// in V
V_F= 200;// in mV
V_F=V_F*10^-3;// in V
Io= 1;// in  A
Io= Io*10^-6;// in A
r_F= n*V_T/(Io*%e^(V_F/(n*V_T)));// in
disp(r_F,"The ac resistance of a semiconductor diode
    in  ")
```

Scilab code Exa 2.40 Magnitude of r for the Si pn junction

```
// Exa 2.40
clc;
clear;
close;
// Given data
n=2;
V_T= 26;// in mV
V_T=V_T*10^-3;// in V
I= 1;// in mA
I= I*10^-3;// in A
r= n*V_T/I;// in
disp(r,"The magnitude of r in   is : ")
```

Chapter 3

Junction Diode And Capacitance

Scilab code Exa 3.1 The transition capacitance of diode

```
// Exa 3.1
clc;
clear;
close;
// Given data
Co= 20;// in pF
Vr= 5;// in V
V_T= 26;// in mV
V_T= V_T*10^-3;// in V
C_T= Co/(1+(Vr/V_T));// in pF
disp(C_T,"The transition capacitance of diode in pF"
   )
```

Scilab code Exa 3.2 The diffusion capacitance in pn junction diode

```
// Exa 3.2
```

```
clc;
clear;
close;
// Given data
toh= 10^-6;// in sec
I=10;// in mA
I=I*10^-3;// in A
n=1;
V_T= 26;// in mV
V_T= V_T*10^-3;// in V
C_D= toh*I/(n*V_T);// in F
disp(C_D*10^9,"The diffusion capacitance in p-n
    junction diode in nF")

// Note: There are two mistake in the book. First
    one is this that they put the wrong value of I to
     evaluating the value of C_D because the value of
     I is given 10mA (i.e. 10*10^-3= 10^-2 amp) but
    they put 10^-3 at place
//           of 10^-2 and second one is calculation
    error. So the answer in the book is wrong.
```

Scilab code Exa 3.3 The diode current for the forward bias voltage

```
// Exa 3.3
clc;
clear;
close;
// Given data
T=300;// in K
V_T= T/11600;// in V
v= 0.3;// forward bias voltage in volt
I= 10;// leakage current in micro amp
I=I*10^-6;// in amp
id= I*(%e^(v/V_T));// in amp
```

```
disp(id,"The diode current in amp")
```

Scilab code Exa 3.4 The constant n for the diode

```
// Exa 3.4
clc;
clear;
close;
// Given data
Vd_1= 0.3;// in V
V_T= 25;// in mV
V_T= V_T*10^-3;// in V
// when Id_1= 1 mA
Id_1= 1;// in mA
Id_1=Id_1*10^-3;// in A
// Formula Id_1= Io*[%e^(Vd/(n*V_T))-1]= Io*[e^(Vd/(n*V_T))]
// Id_1= Io*[e^(Vd_1/(n*V_T))]               (i)

// when Id_2= 200 mA
Id_2= 200;// in mA
Id_2=Id_2*10^-3;// in A
Vd_2= 0.45;// in V
// Id_2= Io*[e^(Vd_2/(n*V_T))]               (ii)
// Dividing (ii) by (i), we have
n= (Vd_2-Vd_1)/(log(Id_2/Id_1)*V_T);
disp(n,"The value of the constant for the diode is ")
```

Scilab code Exa 3.5 Voltage to be applied across a pn junction

```
// Exa 3.5
clc;
```

```
clear;
close;
// Given data
T=300;// in K
V_T= T/11600;// in V
n=1;// assuming value
Jd=10^5;// in A/m^2
Jo=250;// in mA/m^2
Jo= Jo*10^-3;// in A/m^2
//Formula Id= Io*(%e^(Vd/V_T)-1) and after dividing both the sides by area of the junction, we have
// Jd= Jo*(%e^(Vd/V_T));// approx by neglecting 1
Vd= V_T*log(Jd/Jo);// in volt
disp(Vd,"Voltage to be applied across a p-n junction in volt is : ")
```

Scilab code Exa 3.6 Voltage to be applied across a pn junction

```
// Exa 3.6
clc;
clear;
close;
// Given data
J=10^4;// in A/m^2
Jo=200;// in mA/m^2
Jo= Jo*10^-3;// in A/m^2
T=300;// in K
V_T= T/11600;// in V
e=1.6*10^-19;// electrone charge
k= 1.38*10^-23;
n=1;// assuming value
//Formula I= Io*(%e^(e*V/(n*k*T))-1) and after dividing both the sides by area of the junction, we have
// J= Jo*(%e^(e*V/(n*k*T)));// approx by neglecting
```

```
   1
V= n*k*T*log(J/Jo)/e;
disp(V,"Voltage to be applied across the junction in
    volt is")

// Note:- In the book, the value of T (i.e. 300) has
    not been putted to evaluate the value of V. So
   if we'll not put the value of T to evaluate the
   value of V, then the answer of coding will be
   same as book. Hence the
//                the answer in the book is wrong.
```

Scilab code Exa 3.7 Junction forward bias voltage

```
// Exa 3.7
clc;
clear;
close;
// Given data
n=2;
V_T=26;// in mV
Io= 30;// in mA
// (i) when
I_D= 0.1;// in mA
V_D= n*V_T*log(I_D/Io);// in mV
disp(V_D,"(i) When I_D is 0.1 mA, The junction
   forward-bias voltage in mV is : ")
// (ii) when
I_D= 10;// in mA
V_D= n*V_T*log(I_D/Io);// in mV
disp(V_D,"(ii) When I_D is 10 mA, The junction
   forward-bias voltage in mV is : ")

// Note: There is calculation error in the book so
   answer in the book is wrong.
```

Scilab code Exa 3.8 Voltage at which the reverse in a Ge diode

```
// Exa 3.8
clc;
clear;
close;
// Given data
I_by_Io= -0.9;
V_T=26;// in mV
V_T=V_T*10^-3;//in V
n=1;
// From Diode equation I= Io*[e^(e*V/(n*V_T))-1]
V= n*V_T*log(1+I_by_Io);// in volt
disp(V*10^3,"Voltage in mV is ")
```

Scilab code Exa 3.9 Factor by which the current will get multiplied

```
// Exa 3.9
clc;
clear;
close;
// Given data
nita= 2;
T1= 25;// in  C
T2= 150;// in  C
k= 8.62*10^-5;
V_T150= k*(T2+273);// in V
V_T25= k*(T1+273);// in V
V= 0.4;// in V
// Io150= Io25*2^(T2-T1)
Io150byIo25= 2^((T2-T1)/10);
```

```
I150byI25= Io150byIo25 *( %e^(V/(nita*V_T150))-1)/(
    %e^(V/(nita*V_T25))-1);
disp(I150byI25,"The factor by which the current will
     get multiplied when its temperature is raised
    from 25 C to 150 C is : ")

// Note : There is some difference between coding
    and the answer of the book because in the book
    the values of ( Io150byIo25, V_T150, V_T25 )
// are putted (respectively 5800, 0.0364, 0.026)
    whereas the accurate values of these are
// 5792.6188 , 0.0364626 and 0.0256876
```

Scilab code Exa 3.10 Forward and reverse resistance

```
// Exa 3.10
clc;
clear;
close;
// Given data
I_F= 100;// in mA
I_F=I_F*10^-3;// in A
V_F= 0.75;// in V
R_F= V_F/I_F;// in ohm
disp(R_F,"Forward resistance in ohm is ")
// At
V_R= 50;// in V
I_R= 100;// in nA
I_R= I_R*10^-9;// in A
R_R= V_R/I_R;// in ohm
disp(R_R*10^-6,"Reverse resistance in Mohm is ")
```

Scilab code Exa 3.11 Dynamic resistance

```
// Exa 3.11
clc;
clear;
close;
// Given data
I_F= 70;// in mA
V_F= 26;// in mV
delta_I_F= 60;// in mA
delta_I_F=delta_I_F*10^-3;// in A
delta_V_F= 0.025;// in V
r_d= delta_V_F/delta_I_F;// in ohm
disp(r_d,"Dynamic resistance in ohm is : ")
// and the stimated value of the dynamic resistance
   is
r_d= V_F/I_F;// in ohm
disp(r_d,"The stimated value of the Dynamic
   resistance in ohm is : ")
```

Scilab code Exa 3.12 Forward and reverse dynamic resistance

```
// Exa 3.12
clc;
clear;
close;
// Given data
Io= 1;// in micro amp
Io=Io*10^-6;// in amp
V_F= 0.52;// in V
V_R= -0.52;// in V
nita= 1;
T=300;// in K
V_T= T/11600;// in volt
V_T=round(V_T*10^3);// in mV

// (i)
```

```
r_F= nita*V_T*10^-3/(Io*%e^(V_F/(nita*V_T*10^-3)));
disp(r_F,"Dynamic resistance in the forward biased condition in ohm")

// (ii)
r_r= nita*V_T*10^-3/(Io*%e^(V_R/(nita*V_T*10^-3)));
disp(r_r,"Dynamic resistance in the reverse biased condition in ohm")
```

Scilab code Exa 3.13 Static and dynamic resistance

```
// Exa 3.13
clc;
clear;
close;
// Given data
V_F= 0.2;// in V
T=300;// in K
V_T= T/11600;// in volt
Io= 1;// in micro amp
Io=Io*10^-6;// in amp
Id= Io*(%e^(V_F/V_T)-1)
I_F=Id;
r_dc= V_F/I_F;// in ohm
disp(r_dc,"Dynamic resistance in ohm is : ")
r_ac= .026/I_F;// in ohm
disp(r_ac,"Static resistance in ohm is : ")
```

Scilab code Exa 3.14 DC resistance levels

```
// Exa 3.14
clc;
clear;
```

```
close;
// Given data
// Part (i)
I_D=2;// in mA
I_D=I_D*10^-3;// in amp
V_D= 0.5 ; // in volt
R_DC= V_D/I_D;// in ohm
disp(R_DC,"DC resistance levels for the diode in ohm")

// Part (ii)
I_D=20;// in mA
I_D=I_D*10^-3;// in amp
V_D= 0.8 ; // in volt
R_DC= V_D/I_D;// in ohm
disp(R_DC,"DC resistance levels for the diode in ohm")

// Part (iii)
I_D=-1;// in micro amp
I_D=I_D*10^-6;// in amp
V_D= -10 ; // in volt
R_DC= V_D/I_D;// in ohm
disp(R_DC*10^-6,"DC resistance levels for the diode in Mohm")
```

Scilab code Exa 3.15 Junction dynamic resistance

```
// Exa 3.15
clc;
clear;
close;
// Given data
T1= 25;// in  C
T2= 100;// in  C
```

```
deltaT= T2-T1;// in  C
deltaV_F= -1.8*10^-3;// in mV/ C
I_F= 26;// in mA
V_F1= 0.7;// in V (at T1)
V_F2= V_F1+(deltaT*deltaV_F);// in V (at T2)
// At 25 C
T= 25+273;// in K
rd= 26/I_F*T/298;// in
disp(rd,"Junction dynamic resistance at 25 C in
   is ")
// At 100 C
T= 100+273;// in K
rd= 26/I_F*T/298;// in
disp(rd,"Junction dynamic resistance at 100 C in
    is ")
```

Scilab code Exa 3.16 Dynamic resistance of a diode

```
// Exa 3.16
clc;
clear;
close;
// Given data
I= 2;// in mA
I=I*10^-3;// in A
V_T= 25;// in mV
V_T= V_T*10^-3;// in V
nita= 1;
r_F= nita*V_T/I;// in
disp(r_F,"The dynamic resistance of a diode in   is
    :")
```

Scilab code Exa 3.17 Dynamic resistance

```
// Exa 3.17
clc;
clear;
close;
// Given data
I= 30;// in  A
I=I*10^-6;// in A
T=125+273;// in K
r_F= T/(11600*I*%e^(-0.32/T)*11600);// in
disp(r_F*10^3,"The dynamic resistance in m  is : ")

// Note: There are two error in this example in the book. First one is this that putted value of T in first term of calculation (i.e 3.98/11600) is wrong (correct value is 398 not 3.98).
//           and second one error is this that calculaiton is also wrong for putted value
```

Chapter 4

Optoelectonic Devices

Scilab code Exa 4.1 The slope efficiency

```
// Exa 4.1
clc;
clear;
close;
// Given data
Ep= 0.0153*10^-17;//in J
lamda= 1300;// in nm
nita_ext= 0.1;
e = 1.6*10^-19;//in C
Eg= 1.42*e;// in eV
S= nita_ext*Eg/e;// in W/A  (where S= deltaP/deltaI
    )
disp(S,"Slope of efficiency in W/A is : ")

// Note: In the book, the evaluated value of Eg/e is
    wrong because the value of 1.42*e/e = 1.42 not
   equal to 0.956 , Hence the answer in the book is
   wrong
```

Scilab code Exa 4.2 Power efficiency of a VCSEL diode

```
// Exa 4.2
clc;
clear;
close;
// Given data
e = 1.6*10^-19;//in C
Eg= 1.48*e;// in J
R=1;// in
i_p= 100;// in mA
i_p= i_p*10^-3;// in A
i_F= 10;// in mA
i_F= i_F*10^-3;// in A
Popt= 1.25;// in mW
Popt= Popt*10^-3;// in W
nitaP= Popt/((i_p^2*Eg/e)+i_F^2*R)*100;// in %
disp(nitaP,"Power efficiency in % is : ")
```

Scilab code Exa 4.3 Power radiated by an LED

```
// Exa 4.3
clc;
clear;
close;
// Given data
lamda= 670;// in nm
h_int= 1/100;
EpIn_eV= 1248/lamda;// in eV
I=50;// in mA
P= h_int*EpIn_eV*I;// in mW
disp(P,"Power radiated by an LED in mW is : ")

// Note : There is a calculation error in evaluating the value of P so the answer in the book is
```

```
wrong
```

Scilab code Exa 4.4 Internal quantum efficiency and optical power generated

```
// Exa 4.4
clc;
clear;
close;
// Given data
I=40;// in mA
I=I*10^-3;// in A
lamda=1310*10^-9;// in m
h= 6.62*10^-34; // in Js
c= 3*10^8;// in m/s
e= 1.6*10^-19;// in C
toh_r= 30;// in ns
toh_nr= 100;// in ns
toh= toh_r*toh_nr/(toh_r+toh_nr);
nita_int= toh/toh_r;
disp(nita_int,"The internal quantum efficiency is :
   ")
Ep= h*c/lamda;// in J
P= nita_int*Ep*I/e;// in W
disp(P*10^3,"The optical power generated internally
   to the LED in mW is : ");

// Note : There is a calculation error in evaluating
    the value of P so the answer in the book is
   wrong
```

Scilab code Exa 4.5 Photocurrent

```
// Exa 4.5
clc;
clear;
close;
// Given data
// Part (a)
R= 0.85;// in A/W
Pop= 1;// in mW
Ip= R*Pop;// in mA
disp(Ip,"Part (a)  The photocurrent in mA is : ")
disp("Part (b)  If the incident light power is 2mW
   then it is not proportional to Pop so it can not
   be found the value of photocurrent")
```

Scilab code Exa 4.6 Quantum efficiency of photo detector

```
// Exa 4.6
clc;
clear;
close;
// Given data
N1= 5.4*10^6;// Number of EHPs generated
N2= 6*10^6;// Number of incident photons
nita= N1/N2;
disp(nita*100,"The quantum efficiency at 1300 nm in
   % is : ")
```

Scilab code Exa 4.7 Responsivity of an InGaAs photo diode

```
// Exa 4.7
clc;
clear;
close;
```

```
// Given data
e= 1.6*10^-19;// in C
Eg= 0.75*e;// in J
h= 6.62*10^-34; // in Js
c= 3*10^8;// in m/s
n=70/100;
// Formula Eg= h*c/lamda
lamda= h*c/Eg;// in m
lamda=lamda*10^9;// in nm
R= n*lamda/1248;// in A/W
disp(R,"Responsivity in A/W is : ")
```

Scilab code Exa 4.8 Responsivity

```
// Exa 4.8
clc;
clear;
close;
// Given data
n=50/100;
lamda= 900;// in nm
R= n*lamda/1248;// in A/W
disp(R,"Responsivity in A/W is : ")

// Part (b)
Ip= 10^-6;// in A
Pop= Ip/R;// in W
disp(Pop,"The received optical power in W is : ")

// Part (c)
h= 6.62*10^-34; // in Js
c= 3*10^8;// in m/s
// Pop= n*h*c/lamda
n= Pop*lamda*10^-9/(h*c);
disp(n,"The corresponding number of received photons
```

```
    is : ")

// Note : There is a calculation error in evaluating
    the value of n (number of received photons) , so
    the answer in the book is wrong
```

Scilab code Exa 4.9 Currents in a circuit

```
// Exa 4.9
clc;
clear;
close;
// Given data
V=4;// in V
Vr1= 0.7;// in V
Vr2= 0.3;// in V
R1= 4;// in k
R2= 4;// in k
I1= (V-Vr1)/R1;// in mA
I2= (V-Vr2)/R2;// in mA
disp(I1,"The value of I1 in mA is : ")
disp(I2,"The value of I2 in mA is : ")
```

Scilab code Exa 4.10 Minimum and maximum values of LED current

```
// Exa 4.10
clc;
clear;
close;
// Given data
V_Dmin= 1.5;// in V
V_Dmax= 2.3;// in V
Vs= 10;// in V
```

```
R1= 470;// in
Imax= (Vs-V_Dmin)/R1;// in A
Imin=  (Vs-V_Dmax)/R1;// in A
disp(Imax*10^3,"The maximum value of current in mA
   is : ")
disp(Imin*10^3,"The minimum value of current in mA
   is : ")
```

Scilab code Exa 4.11 Supply voltage

```
// Exa 4.11
clc;
clear;
close;
// Given data
V_Dmin= 1.8;// in V
V_Dmax= 3;// in V
// Case first
Vs= 24;// in V
R1= 820;// in
Imin=  (Vs-V_Dmax)/R1;// in A
Imax= (Vs-V_Dmin)/R1;// in A
disp(Imax*10^3-Imin*10^3,"The variation in current
   in first case in mA is : ")
// Case second
Vs= 5;// in V
R1= 120;// in
Imin=  (Vs-V_Dmax)/R1;// in A
Imax= (Vs-V_Dmin)/R1;// in A
disp(Imax*10^3-Imin*10^3,"The variation in current
   in first case in mA is : ")
disp("The variation in current in first case is
   smaller than in second case, So the brighness in
   the first case will remain constant , whereas in
   the second case it will be changing.")
```

Scilab code Exa 4.12 Smallest standard resistor value

```
// Exa 4.12
clc;
clear;
close;
// Given data
Vout= 8;// in V
V_F= 1.8;// in V
Ip_max= 16;// in mA
Ip_max= Ip_max*10^-3;// in A
I_F= Ip_max;
Rs1= (Vout-V_F)/I_F;// in
disp(Rs1,"If V_F= 1.8, then the value of Rs in     is :")
// If
V_F= 2.0;// in V
Rs2= (Vout-V_F)/I_F;// in
disp(Rs2,"If V_F= 2.0, then the value of Rs in     is :")
disp("In either case, the smallest standard value resistor that has a value greater than "+string(Rs1)+"    and "+string(Rs2));
disp("ohm  resistor .is the 390   ")
```

Scilab code Exa 4.13 Responsivity of the photo diode

```
// Exa 4.13
clc;
clear;
close;
```

```
// Given data
Ip= 1;// in mA
Pop= 1.5;// in mW
R= Ip/Pop;// in A/W
disp(R,"The responsivity of the photodiode in A/W is
    : ")
```

Scilab code Exa 4.14 Power radiated by an LED

```
// Exa 4.14
clc;
clear;
close;
// Given data
lamda= 800;// in nm
EpIn_eV= 1248/lamda;// in eV
h_int= 5/100;
I=50;// in mA
P= h_int*EpIn_eV*I;// in mW
disp(P,"Power radiated by an LED in mW is : ")
```

Scilab code Exa 4.15 Internal quantum efficiency

```
// Exa 4.15
clc;
clear;
close;
// Given data
toh_r= 35;// in ns
toh_nr= 110;// in ns
toh= toh_r*toh_nr/(toh_r+toh_nr);// in ns
nita_int= toh/toh_r;
```

```
disp(nita_int,"The internal quantum efficiency is :
   ")

// Note : There is a calculation error (or miss
   printed ) in evaluating the value of nita_int (
   internal quantum efficiency ) so the answer in
   the book is wrong
```

Scilab code Exa 4.16 Quantum efficiency of photo detector

```
// Exa 4.16
clc;
clear;
close;
// Given data
N1= 6*10^6;// Number of EHPs generated
N2= 8*10^6;// Number of incident photons
nita= N1/N2;
disp(nita*100,"The quantum efficiency of photon
   detector in % is : ")
```

Scilab code Exa 4.17 Responsivity of an InGaAs photo diode

```
// Exa 4.17
clc;
clear;
close;
// Given data
e= 1.6*10^-19;// in C
Eg= 0.75*e;// in J
h= 6.62*10^-34; // in Js
c= 3*10^8;// in m/s
n=90/100;
```

```
// Formula Eg= h*c/lamda
lamda= h*c/Eg;// in m
lamda=lamda*10^9;// in nm
R= n*lamda/1248;// in A/W
disp(R,"Responsivity in A/W is : ")
```

Scilab code Exa 4.18 Minimum and maximum values of LED current

```
// Exa 4.18
clc;
clear;
close;
// Given data
V_Dmin= 1;// in V
V_Dmax= 2;// in V
Vs= 20;// in V
R1= 470;// in
Imax= (Vs-V_Dmin)/R1;// in A
Imin=  (Vs-V_Dmax)/R1;// in A
disp(Imax*10^3,"The maximum value of current in mA")
    ;
disp(Imin*10^3,"The maximum value of current in mA")
    ;
```

Scilab code Exa 4.19 Supply voltage

```
// Exa 4.19
clc;
clear;
close;
// Given data
V_Dmin= 2.5;// in V
V_Dmax= 5;// in V
```

```
// Case First
Vs= 25;// in V
Rs= 250;// in
Imax= (Vs-V_Dmin)/Rs;// in A
Imin= (Vs-V_Dmax)/Rs;// in A
disp(Imax*10^3-Imin*10^3,"The variation in current
    in first case in mA is : ")
// Case sec
Vs= 10;// in V
Rs= 130;// in
Imax= (Vs-V_Dmin)/Rs;// in A
Imin= (Vs-V_Dmax)/Rs;// in A
disp(Imax*10^3-Imin*10^3,"The variation in current
    in second case in mA is : ")
disp("Hence for the 25-V supply, the brightness of
    LED will be constant and for 10 V , it will be
    change")
```

Scilab code Exa 4.20 The value of current in the circuit

```
// Exa 4.20
clc;
clear;
close;
// Given data
V1= 0.3;// in V
V2= 0.7;// in V
R1= 6;// in k
R2= 6;// in k
Vs= 12;// in V
I1= (Vs-V1)/R1;// in mA
I2= (Vs-V2)/R2;// in mA
disp(I1,"The value of I1 in mA is : ")
disp(I2,"The value of I2 in mA is : ")
```

Scilab code Exa 4.21 Responsivity and received optical power

```
// Exa 4.21
clc;
clear;
close;
// Given data
n=40/100;
lamda= 800;// in nm
Ip = 2*10^-6;// in A
R= n*lamda/1248;
// part (b)
Pop= Ip/R;// in W
disp(R,"Responsivity is : ")
disp(Pop,"The received optical power in watt is : ")
```

Scilab code Exa 4.22 Internal quantum efficiency and optical power generated

```
// Exa 4.22
clc;
clear;
close;
// Given data
I=35;// in mA
I=I*10^-3;// in A
lamda=1300*10^-9;// in m
h= 6.62*10^-34; // in Js
c= 3*10^8;// in m/s
e= 1.6*10^-19;// in C
toh_r= 30;// in ns
toh_nr= 90;// in ns
```

```
toh= toh_r*toh_nr/(toh_r+toh_nr);// in ns
nita_int= toh/toh_r;
disp(nita_int,"The internal quantum efficiency is :
   ")
Ep= h*c/lamda;// in J
P= nita_int*Ep*I/e;// in W
disp(P*10^3,"The optical power generated internally
   to the LED in mW is : ");
```

Scilab code Exa 4.23 Power radiated by an LED

```
// Exa 4.23
clc;
clear;
close;
// Given data
lamda= 600;// in nm
h_int= 4/100;
EpIn_eV= 1248/lamda;// in eV
I=50;// in mA
P= h_int*EpIn_eV*I;// in mW
disp(P,"Power radiated by an LED in mW is : ")
```

Scilab code Exa 4.24 Minimum and maximum values of LED current

```
// Exa 4.24
clc;
clear;
close;
// Given data

V_Dmin= 2;// in V
V_Dmax= 4;// in V
```

```
Vs= 15;// in V
R1= 470;// in
Imax= (Vs-V_Dmin)/R1;// in A
Imin=  (Vs-V_Dmax)/R1;// in A
disp(Imax*10^3,"The maximum value of current in mA is : ")
disp(Imin*10^3,"The minimum value of current in mA is : ")
```

Scilab code Exa 4.25 Smallest standard resistor value

```
// Exa 4.25
clc;
clear;
close;
// Given data
Vout= 10;// in V
V_F= 2;// in V
Ip_max= 15;// in mA
Ip_max= Ip_max*10^-3;// in A
I_F= Ip_max;
Rs= (Vout-V_F)/I_F;// in
disp(Rs,"The value of Rs in    is :")
```

Scilab code Exa 4.26 The slope efficiency

```
// Exa 4.26
clc;
clear;
close;
// Given data
Ep= 0.0153*10^-17;//in J
lamda= 1300;// in nm
```

```
nita_ext= 0.1;
e = 1.6*10^-19;//in C
Eg= 1.42*e;// in eV
S= nita_ext*Eg/e;// in W/A  (where S= deltaP/deltaI )
disp(S,"Slope of efficiency in W/A is : ")

// Note: In the book, the evaluated value of Eg/e is wrong because the value of 1.42*e/e = 1.42 not equal to 0.956 , Hence the answer in the book is wrong
```

Scilab code Exa 4.27 Power efficiency of a VCSEL diode

```
// Exa 4.27
clc;
clear;
close;
// Given data
e = 1.6*10^-19;//in C
Eg= 1.48*e;// in J
R=1;// in
i_p= 100;// in mA
i_p= i_p*10^-3;// in A
i_F= 10;// in mA
i_F= i_F*10^-3;// in A
Popt= 1.25;// in mW
Popt= Popt*10^-3;// in W
nitaP= Popt/((i_p^2*Eg/e)+i_F^2*R)*100;// in %
disp(nitaP,"Power efficiency in % is : ")
```

Scilab code Exa 4.28 Probability of exciting electron

```
// Exa 4.28
clc;
clear;
close;
kT= 0.025;// in eV (Let as take T=300 K)
E= 1.42/2;// in ev (Let E = E_C-E_F)
FE= %e^(-E/kT);
disp(FE,"The probability of exciting electrons at
    conduction band will be ")
```

Scilab code Exa 4.29 Ratio of majority to minority charge carrier

```
// Exa 4.29
clc;
clear;
close;
k= 1.38*10^-23;
T= 300;// in K (assume)
V_D= 0.7;// The depletion voltage for silicon
e=1.6*10^-19;// in C
// n_n/n_p= p_p/p_n = %e^(e*V_D/(k*T))
ratio= %e^(e*V_D/(k*T));// ratio of majority to
    minority charge carriers in n and p of a silicon
    semiconductor
disp(ratio,"Ratio of majority to minority charge
    carriers in n and p of a silicon semiconductor is
    : ")
```

Chapter 5

Frequency and High Power Devices

Scilab code Exa 5.1 Tuning range for the circuit

```
// Exa 5.2
clc;
clear;
close;
// Given data
C1= 5; // in pF
C1= C1*10^-12;// in F
C2= 50; // in pF
C2= C2*10^-12;// in F
L= 10;// in mH
L= L*10^-3;// in H
TuningRange= 1/(2*%pi*sqrt(L*C1*C2/(C1+C2)));// in
    Hz
disp(TuningRange*10^-3,"The tuning range for the
    circuit in kHz is : ")

// Note : In the book, this example is not solved.
    Only given data is shown.
```

Scilab code Exa 5.2 The value of CT

```
// Exa 5.2
clc;
clear;
close;
// Given data
C_T1= 15; // in pF
Vb1=8;// in V
Vb2= 12;  // in V
// As C_T proportional to 1/sqrt(Vb), and
// C_T1/C_T2= sqrt(Vb2/Vb1), so
C_T2= C_T1*sqrt(Vb1/Vb2);// in pF
disp(C_T2,"The value of C_T2 in pF is : ")
```

Scilab code Exa 5.3 Space charge capacitance

```
// Exa 5.3
clc;
clear;
close;
// Given data
epsilon_Ge= 16/(36*%pi*10^-11);// in f/C
A=10^-12;
d=2*10^-4;// in cm
// C_T= epsilon_0*A/d= epsilon_Ge*A/d
C_T= epsilon_Ge*A/d;//in pF
disp(C_T,"The space charge capacitance in pF")
```

Scilab code Exa 5.4 The value of CT

```
// Exa 5.4
clc;
clear;
close;
// Given data
D= 0.102;// in cm
sigma_P= 0.286;// in  cm
q= 1.6*10^-19;// in C
miuP= 500;
Vb= 5+0.35;//in V
A= %pi*D^2/4;// in cm^2
N_A= sigma_P/(q*miuP);// at/c
C_T= 2.92*10^-4*(N_A/Vb)^(1/2)*A;//
disp(C_T,"The value of transition in pf/cm^2")
```

Scilab code Exa 5.5 The depletion layer capacitance

```
// Exa 5.5
clc;
clear;
close;
// Given data
epsilon= 12/(36*%pi*10^11);// in F/cm  (value of
    epsilon for silicon)
q= 1.6*10^-19;// in C
// C_T= epsilon*A/d , where d= 2*epsilon*Vi/(q*NA)
    ^(/2)
// Hence    C_T/A= epsilon/d= sqrt(q*epsilon/2)*sqrt
    (NA/Vi)
// Let
value = sqrt(q*epsilon/2);
disp("C_T= "+string(value*10^12)+" sqrt(NA/Vi) in pF
    /cm^2");
```

Scilab code Exa 5.6 Decrease in capacitance

```
// Exa 5.6
clc;
clear;
close;
// Given data
V1= 5;// in V
IncreaseInVolt= 1.5;// in V
C_T1= 20;// in pF
// Formula C_T= lamda/sqrt(V)
lamda= C_T1*sqrt(V1);
// When
V2= V1+IncreaseInVolt;// in V
C_T2= lamda/sqrt(V2);
disp(C_T1-C_T2,"The decrease in capacitance in pF is
    : ")
```

Scilab code Exa 5.7 Diffusion capacitance for a Si diode

```
// Exa 5.7
clc;
clear;
close;
// Given data
Vf= 0.7;// in V
If= 10;// in mA
If= If*10^-3;// in A
toh= 70;// in ns
Cd= toh*If/Vf;// in nf
disp(Cd,"Diffusion capacitance for a si diode in nf
    is :")
```

Scilab code Exa 5.8 Transition capacitance

```
// Exa 5.8
clc;
clear;
close;
// Given data
N_A= 4*10^20;// per m^3
Vi= 0.2;// in V
q= 1.6*10^-19;
V= -1;// in V
A= 0.8*10^-6;/// in m^2
epsilon_r= 16;
epsilon_o= 8.854*10^-12;// in F
epsilon= epsilon_o*epsilon_r;
d= [2*epsilon*(Vi-V)/(q*N_A)]^(1/2);
C_T= epsilon*A/d;// in F
disp(C_T*10^12,"The transition capacitance in pF is
   :")
```

Scilab code Exa 5.9 Decrease in capacitance

```
// Exa 5.9
clc;
clear;
close;
// Given data
V1= 5;// in V
V2 = V1+1;// in V
C_T1= 20;// in pF
// C_T2/C_T1 = sqrt(V1/V2)
```

```
C_T2= C_T1* sqrt(V1/V2);
disp(C_T2,"The capacitance for 1-V increase in bias
    in pF is : ")
disp(C_T1-C_T2,"Therefore, the decrease in
    capacitance in pF is :")

// NOTE: The answer in the book is wrong due to
    calculation error to evalaute the value of C_T2.
```

Scilab code Exa 5.10 Tuning range for the circuit

```
// Exa 5.10
clc;
clear;
close;
// Given data
C1= 4;// in pF
C2= 60;// in pF
L=8*10^-3;// in H
C_Tmin= C1*C1/(C1+C1);// in pF
C_Tmin= C_Tmin*10^-12;// in F
C_Tmax= C2*C2/(C2+C2);// in pF
C_Tmax= C_Tmax*10^-12;// in F
Fc_max= 1/(2*%pi*sqrt(L*C_Tmin));// in Hz
Fc_min= 1/(2*%pi*sqrt(L*C_Tmax));// in Hz
disp(Fc_max*10^-6,"Maximum resonance frequency in
    MHz is :")
disp(Fc_min*10^-6,"Minimum resonance frequency in
    MHz is :")
```

Scilab code Exa 5.11 Tuning range for the circuit

```
// Exa 5.11
```

```
clc;
clear;
close;
// Given data
C1= 6;// in pF
C2= 50;// in pF
L=12*10^-3;// in H
C_Tmin= C1*C1/(C1+C1);// in pF
C_Tmin= C_Tmin*10^-12;// in F
C_Tmax= C2*C2/(C2+C2);// in pF
C_Tmax= C_Tmax*10^-12;// in F
Fc_max= 1/(2*%pi*sqrt(L*C_Tmin));// in Hz
Fc_min= 1/(2*%pi*sqrt(L*C_Tmax));// in Hz
disp(Fc_max*10^-6,"Maximum resonance frequency in
   MHz is :")
disp(Fc_min*10^-6,"Minimum resonance frequency in
   MHz is :")
```

Chapter 6

Bipolar Junction Transistor Fets And Mosfet

Scilab code Exa 6.1 Transfer curve

```
// Exa 6.1
clc;
clear;
close;
// Given data
I_DSS= 10;// in mA
V_P= -4;// in V
 V_GS=[-4:0.1:0];
//V_GS= -3;
I_D= I_DSS*(1-V_GS/V_P)^2
plot(V_GS,I_D);
xlabel("V_GS in volts");
ylabel("I_D in mA")
title("The transfer curve")
disp("Curve is shown in figure")
```

Scilab code Exa 6.2 Transfer curve

```
// Exa 6.2
clc;
clear;
close;
// Given data
I_DSS= 4;// in mA
V_P= 3;// in V
 V_GS=[0:0.1:3];
//V_GS= -3;
I_D= I_DSS*(1-V_GS/V_P)^2
plot(V_GS,I_D);
xlabel("V_GS in volts");
ylabel("I_D in mA ")
title("Characteristic curve ")
```

Scilab code Exa 6.3 Value of Vgs and gm

```
// Exa 6.3
clc;
clear;
close;
// Given data
I_DSS= 1.65;// in mA
I_DSS=I_DSS*10^-3;// in A
V_P= -2;// in V
I_D= 0.8;// in mA
I_D=I_D*10^-3;// in A
V_BB= 24;// in V
// Part (a)
V_GS= V_P*(1-sqrt(I_D/I_DSS));// in V
disp(V_GS,"The value of V_GS in volts is : ")

// Part (b)
```

```
gmo= -2*I_DSS/V_P*10^3;// in ms
gm= gmo*(1-(V_GS)/V_P);// in ms
disp(gm,"The value of gm is : ")
```

Scilab code Exa 6.4 value of Vgs

```
// Exa 6.4
clc;
clear;
close;
// Given data
I_DSS= -40;// in mA
I_DSS=I_DSS*10^-3;// in A
V_P= 5;// in V
I_D= -15;// in mA
I_D=I_D*10^-3;// in A
// Formula I_D= I_DSS*(1+V_GS/V_P)
V_GS= (sqrt(I_D/I_DSS)-1)*V_P;// in volt
disp(V_GS,"The value of V_GS in volts is : ")
```

Scilab code Exa 6.5 The value of transconductance of a FET

```
// Exa 6.5
clc;
clear;
close;
// Given data
delta_I_D= 1.9-1.0;// in mA
delta_V_GS= 3.3-3.0;// in V
gm= delta_I_D/delta_V_GS;//in mA/V
disp("The value of transconductance is "+string(gm)+
    " mA/V or "+string(gm*10^3)+" HmV10s")
```

Scilab code Exa 6.6 The value of Vo and Vi

```
// Exa 6.6
clc;
clear;
close;
// Given data
I_DSS= 5.6*10^-3;// in A
V_P= 4;// in volt
Vi= 10;// in V
R1= 4.7;// in k
R1= R1*10^3;// in
Rs= 10;// in k
Rs= Rs*10^3;// in
V1=-24;// in V
Vs= 12;// in V
// Appling KVL to the gate source loop, we get, Vs=
    I_D*Rs-V_GS
// V_GS= I_D*Rs-Vs              (i)
// I_D= I_DSS*(1-V_GS/V_P)^2 = I_DSS*(1-(I_D*Rs-Vs)/
    V_P)^2
I_D= 1.49;// in mA
I_D= I_D*10^-3;// in A
V_GS= I_D*Rs-Vs;
Vo= Vs-I_D*Rs;// in volt
disp(V_GS,"The value of V_GS in volts is : ")
disp(Vo,"The value of Vo in volts is : ")
```

Scilab code Exa 6.7 Drain to source voltage

```
// Exa 6.7
clc;
```

```
clear;
close;
// Given data
I_D= 5;// in mA
I_D=I_D*10^-3;// in A
V_DD= 10;// in V
R_D= 1;// in k
R_D= R_D*10^3;// in
Rs= 500;// in
Vs= I_D*Rs;// in volt
V_D= V_DD-I_D*R_D;// in V
V_DS= V_D-Vs;// in V
V_GS= -Vs;// in V
disp(V_DS,"The value of drain-to-source voltage in
    volts is : ")
disp(V_GS,"The value of gate-to-sourcce voltage in
    volts is : ")
```

Scilab code Exa 6.8 Maximum transconductance of a certain n channel JFET

```
// Exa 6.8
clc;
clear;
close;
// Given data
I_DSS= 20;// in mA
I_DSS=I_DSS*10^-3;// in A
gmo= 9.4;// in ms
gmo=gmo*10^-3;// in s
// Formula gmo= -2*I_DSS/V_P
V_P= -2*I_DSS/gmo;// in volts
disp(V_P,"Pinch off voltage in volts is : ")
```

Scilab code Exa 6.9 Transconductance

```
// Exa 6.9
clc;
clear;
close;
// Given data
I_DSS= 10;// in mA
I_DSS= I_DSS*10^-3;// in A
I_DS= 2.5;// in mA
I_DS= I_DS*10^-3;// in A
V_P= 4.5;// in V
// Formula I_DS= I_DSS*(1-V_GS/V_P)^2
V_GS= V_P*(1-sqrt(I_DS/I_DSS));// in volts
gm= 2*I_DSS/V_P*(1-V_GS/V_P);// in A/V
disp(gm*10^3,"Transconductance in mA/V is : ")
```

Scilab code Exa 6.10 The value of VGS

```
// Exa 6.10
clc;
clear;
close;
// Given data
I_DSS= 10;// in mA
I_DSS= I_DSS*10^-3;// in A
gm= 10;// in ms
gm=gm*10^-3;// in s
// V_GSoff = V_GS = Vp  so , gm = gmo = -2*I_DSS/
    V_GSSoff
V_GSoff= -2*I_DSS/gm;// in volt
```

```
disp(V_GSoff,"The value of V_GS(off) in volts is : "
   )
```

Scilab code Exa 6.11 Minimum value of VDS

```
// Exa 6.11
clc;
clear;
close;
// Given data
I_DSS= 10;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -4;// in V
V_GS= -2;// in V
I_DS= I_DSS*(1-V_GS/V_P)^2;// in A
V_DS= V_P;// in V
V_DSmin= V_P;// in volt
disp(I_DS*10^3,"The value of I_DS in mA is : ")
disp(V_DSmin,"The minimum value of V_DS in volts is
   : ")
```

Scilab code Exa 6.12 Effective input impedance

```
// Exa 6.12
clc;
clear;
close;
// Given data
R_G= 1;// in M
R_G= R_G*10^6;// in
V_DD= 24;// in V
R_D= 56;// in k
R_D=R_D*10^3;// in
```

```
Rs= 4;// k
Rs= Rs*10^3;// in
// Part (a)
I_DSS= 1;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -1;// in V
V_D= 10;// in V
I_D= (V_DD-V_D)/R_D;// in A
// I_D= I_DSS*(1-V_GS/V_P)^2;// in A
V_GS= V_P*(1-sqrt(I_D/I_DSS));// in V
R1= abs(V_GS)/I_D;// in
disp(R1*10^-3,"The value of R1 in k  is : ")

// Part (b)
gmo= -2*I_DSS/V_P;// A/V
gm= gmo*(1-(V_GS)/V_P);// A/V;
Ri= R_G/(1-gm*Rs/(1+gm*Rs)*Rs/(Rs+R1));// in
disp(Ri*10^-6,"The effective input impedence in M
    is :")
```

Scilab code Exa 6.13 q value of VDS

```
// Exa 6.13
clc;
clear;
close;
// Given data
I_DSS= -4;// in mA
V_P= 4;// in V
R1= 1.3*10^6;// in
R2= 200*10^3;// in
V_DD= -60;// in V
R_D= 18;// in k
R_D= R_D*10^3;// in
Rs= 4;// in k
```

```
Rs= Rs*10^3;// in
V_GG= V_DD*R2/(R1+R2);// in V
R_G= R1*R2/(R1+R2);// in
// V_GS= V_GG-V_P*I_D
//  I_D= I_DSS*(1-(V_GG-V_P*I_D)/V_P)^2;// in mA or
// I_D^2*I_DSS + I_D*(2*(1-V_GG/V_P)*I_DSS-1) +((1-V_GG/V_P)^2*I_DSS)
I_D= [I_DSS (2*(1-V_GG/V_P)*I_DSS-1) ((1-V_GG/V_P)^2*I_DSS)]
I_D=roots(I_D);
I_D=I_D(2);// in mA
I_D=I_D*10^-3;// in A
V_GS= V_GG-Rs*I_D;// in V
V_DS= V_DD-I_D*(R_D+Rs);// in V
disp(I_D*10^3,"The value of I_D in mA is : ")
disp(V_GS,"The value of V_GS in volts is ")
disp(V_DS,"The value of V_DS in volts is ")
```

Scilab code Exa 6.14 The value of VGS and VDS

```
// Exa 6.14
clc;
clear;
close;
// Given data
I_DSS= 4;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -2;// in V
V_DD= 10;// in V
V_SS= V_DD;// in V
V_GS2=0;// in V
I_D= I_DSS*(1-V_GS2/V_P)^2;// in A
// since I_D= I_DSS
V_GS= 0;// in volt
// Formula V_SS= V_DS-V_GS
```

```
V_DS= V_SS-V_GS;// in volt
disp(I_D*10^3,"The value of I_D in mA is :")
disp(V_GS,"The value of V_GS in volt is : ")
disp(V_DS,"The value of V_DS in volts is :")

if V_DS > V_GS-V_P then
    disp("The active region operation of the upper JFET is confirmed ")
end
```

Scilab code Exa 6.15 The value of VGS and ID

```
// Exa 6.15
clc;
clear;
close;
// Given data
I_DSS= 16;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -4;// in V
V_DD= 18;// in V
V_GG= 0;// in V
R_D= 500;// in
Rs= R_D;// in
// V_GS= V_GG-V_P*I_D or = I_D= -V_GS/Rs (as V_GSS= 0) (i)
// I_D= I_DSS*(1-V_GS/V_P)^2 (ii)
// From (i) and (ii)
// V_GS^2*(1/V_P^2) + V_GS*(1/(I_DSS*Rs)-2/V_P) +1 =0
V_GS= [(1/V_P^2) (1/(I_DSS*Rs)-2/V_P) 1]
V_GS= roots(V_GS);
V_GS= V_GS(2);// since 0>= V_GS >=-4
 I_D= I_DSS*(1-V_GS/V_P)^2;// in A
 V_DS= V_DD-I_D*(R_D+Rs);// in V
```

```
disp(I_D*10^3,"The value of I_D in mA is : ")
disp(V_GS,"The value of V_GS in volts is : ");
disp("Since the value of V_DS is greater than the
    difference of V_GS and V_P, So the saturation
    region operation is confirmed ");
```

Scilab code Exa 6.16 The value of VGS and ID

```
// Exa 6.16
clc;
clear;
close;
// Given data

I_DSS= 10;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -4;// in V
V_DD= 12;// in V
V_GG= 0;// in V
// Part (a) when
V_GS= -2;// in V
I_D= I_DSS*(1-V_GS/V_P)^2;// in A
disp(I_D*10^3,"When V_GS= -2 then, the value of I_D
    in mA ")
// Part (b) when
I_D= 9*10^-3;// in A
V_GS= V_P*(1-(sqrt(I_D/I_DSS)));// in V
disp(V_GS,"When I_D = 9 mA, then the value of V_GS
    in volts is : ")
```

Scilab code Exa 6.17 The value of IDS gmo and gm

```
// Exa 6.17
```

```
clc;
clear;
close;
// Given data
I_DSS= 8.7;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -3;// in V
V_GS= -1;// in V
I_DS= I_DSS*(1-V_GS/V_P)^2;// in A
disp(I_DS*10^3,"The value of I_DS in mA is : ")
gmo= -2*I_DSS/V_P*1000;// ms
gm= gmo*(1-V_GS/V_P); // in ms
disp(gmo,"The value of gmo in ms is")
disp(gm,"The value of gm in ms is")
```

Scilab code Exa 6.20 The value of VGS and ID

```
// Exa 6.20
clc;
clear;
close;
// Given data
I_DSS= 6;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -4.5;// in V
// Part (i)
// At V_GS= -2V
V_GS= -2;// in V
I_DS= I_DSS*(1-V_GS/V_P)^2;// in A
disp(I_DS*10^3,"At V_GS= -2V, the value of I_DS in
    mA is : ")
// At V_GS= -3.6V
V_GS= -3.6;// in V
I_DS= I_DSS*(1-V_GS/V_P)^2;// in A
disp(I_DS*10^3,"At V_GS= -3.6V, the value of I_DS in
```

```
mA is : ")

// Part (ii)
// At I_DS= 3mA
I_DS= 3*10^-3;// in A
V_GS= V_P*(1-sqrt(I_DS/I_DSS));
disp(V_GS,"At I_DS= 3mA, the value of V_GS in volts is :")
// At I_DS= 5.5mA
I_DS= 5.5*10^-3;// in A
V_GS= V_P*(1-sqrt(I_DS/I_DSS));
disp(V_GS,"At I_DS= 5.5mA, the value of V_GS in volts is :")

// Note: There is  calculation error in the second part to find the value of V_GS in both the condition . So the answer in the book is wrong
```

Scilab code Exa 6.21 Drain source resistance

```
// Exa 6.21
clc;
clear;
close;
// Given data
I_DSS= 10;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -2;// in V
// Part (i)
// At V_GS= 0V
V_GS= 0;// in V
r_DS= V_P^2/(2*I_DSS*(V_GS-V_P));// in
disp(r_DS,"At V_GS=0 , the drain source resistance in    is : ")
// Part (ii)
```

```
// At V_GS= -0.5V
V_GS= -0.5;// in V
r_DS= V_P^2/(2*I_DSS*(V_GS-V_P));// in
disp(r_DS,"At V_GS=-0.5 , the drain source resistance in  is : ")
```

Scilab code Exa 6.22 The value of Id and VDS

```
// Exa 6.22
clc;
clear;
close;
// Given data
I_DSS= 12;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -4;// in V
R_D= 3;// in k
R_D= R_D*10^3;// in
Rs= 0;// in
V_DD= 15;// in V
V_GS= -2;// in V
I_D= I_DSS*(1-V_GS/V_P)^2;// in A
disp(I_D*10^3,"The value of I_D in mA is :")
V_DS= -I_D*R_D+V_DD;// in V
disp(V_DS,"The value of V_DS in volts is :")
if V_DS>V_GS-V_P then
    disp("The device is operating in the saturation region")
end
```

Scilab code Exa 6.23 The value of RD

```
// Exa 6.23
```

```
clc;
clear;
close;
// Given data
I_DSS= 12;// in mA
I_DSS= I_DSS*10^-3;// in A
V_P= -4;// in V
Rs= 0;// in
V_DD= 15;// in V
V_DS= 0.1;// in V
V_GS= 0;// in V
if V_DS<V_GS-V_P then
    disp("The ohmic region is confirmed.")
I_D= I_DSS*(2*(1-V_GS/V_P)*V_DS/(-V_P)-(V_DS/V_P)^2);// in A
R_D= (V_DD-V_DS)/I_D;// in
disp(I_D*10^6,"The value of I_D in  A is :")
disp(R_D*10^-3,"The value of R_D in k  is :")
end
```

Scilab code Exa 6.24 Channel resistance

```
// Exa 6.24
clc;
clear;
close;
// Given data
ro=9;// in  k
ro= ro*10^3;// in
V_P= -6;// in V
V_GS = -3;// in V
r= ro/(1-V_GS/V_P)^2;// in
disp(r*10^-3,"The value of chanel resistance in k is : ")
```

```
// Note : The unit of chanel resistance i.e. unit of
    resistance in the book is wrong . It will be in
    k  not in
```

Scilab code Exa 6.25 The value of VGS

```
// Exa 6.25
clc;
clear;
close;
// Given data
ro=10;// in k
ro= ro*10^3;// in
r=90;// in k
r= r*10^3;// in
V_P= 5;// in V
// r= ro/(1-V_GS/V_P)^2;// in
V_GS= V_P*(1-sqrt(ro/r));// in V
disp(V_GS,"The value of V_GS in volts is :")
```

Scilab code Exa 6.26 The value of IDSS

```
// Exa 6.26
clc;
clear;
close;
// Given data
V_P= -5;// in V
I_D= 4;// in mA
V_GS= -2;// in V
// Formula I_D= I_DSS*(1-V_GS/V_P)^2
I_DSS= I_D/(1-V_GS/V_P)^2;// in mA
disp(I_DSS,"The value of I_DSS in mA is :")
```

Scilab code Exa 6.27 Minimum value of VDS

```
// Exa 6.27
clc;
clear;
close;
// Given data
I_DSS= 8;// in mA
V_P= -5;// in V
V_GS= -2;// in V
// Formula V_GS+ V_DSmin = V_P
V_DSmin= abs(V_P-V_GS);// in V
disp(V_DSmin,"The minimum value of V_DS in volts is
   :")
I_DS= I_DSS*(1-V_GS/V_P)^2;// in mA
disp(I_DS,"The value of I_DS in mA is :")
```

Chapter 7

Voltage Regulator And Nonlinear Circuits

Scilab code Exa 7.1 Base emitter and zener diode current

```
// Exa 7.1
clc;
clear;
close;
// Given data
bita= 50;
R1= 1;// in k
R1= R1*10^3;//in
R2= 300;// in
R3= 360;// in
R4= 640;// in
V1= 10;// in V
V2= 20;// in V
I_B1=19.2*10^-3;// in A
I_L= 1;//in A
V_Z= 5.6;// in V
V_B= R4*V1/(R3+R4);//in V
V_BE2= V_B-V_Z;// in V
V_A= V1-V_BE2;// in V
```

```
disp(V_A,"The value of V_A in volt is : ")
disp(V_B,"The value of V_B in volt is : ")

// Part (ii)
I1= V1/(R3+R4);// in A
//I1= .01*10^-3;// in A
I2= (V2-V_A)/R2;// in A
I_C2= I2-I_B1;// in A
I_B1= (I1+I_L)/(1+bita);// in A
disp(I_B1*10^3,"The base current of T1 in mA is : ")
I_C2= I2-I_B1;// in A
I_E2= I_C2;// in A
disp(I_E2*10^3,"The emitter current of T2 in mA is :
    ")

// part (iii)
I3= (V2-V_Z)/R1;// in A
I_Z= I3+I_E2;// in A
disp(I_Z*10^3,"Current through zener diode in mA is
    : ")
V_CE= V2-V1;// in V
I_C1= bita*I_B1;// in A
T1= V_CE*I_C1;// in W
disp(T1,"Power dissipation in watt is : ")
```

Scilab code Exa 7.2 Base emitter and zener diode current

```
// Exa 7.2
clc;
clear;
close;
// Given data
bita= 100;
R1= 1;// in k
R1= R1*10^3;//in
```

```
R2= 300;// in
R3= 360;// in
R4= 640;// in
V1= 10;// in V
V2= 20;// in V
I_B1=19.2*10^-3;// in A
I_L= 1;//in A
V_Z= 5.6;// in V
V_B= R4*V1/(R3+R4);//in V
V_BE2= V_B-V_Z;// in V
V_A= V1-V_BE2;// in V
disp(V_A,"The value of V_A in volt is : ")
disp(V_B,"The value of V_B in volt is : ")

// Part (ii)
I1= V1/(R3+R4);// in A
//I1= .01*10^-3;// in A
I2= (V2-V_A)/R2;// in A
I_C2= I2-I_B1;// in A
I_B1= (I1+I_L)/(1+bita);// in A
disp(I_B1*10^3,"The base current of T1 in mA is : ")
I_C2= I2-I_B1;// in A
I_E2= I_C2;// in A
disp(I_E2*10^3,"The emitter current of T2 in mA is :
    ")

// part (iii)
I3= (V2-V_Z)/R1;// in A
I_Z= I3+I_E2;// in A
disp(I_Z*10^3,"Current through zener diode in mA is
   : ")
V_CE= V2-V1;// in V
I_C1= bita*I_B1;// in A
T1= V_CE*I_C1;// in W
disp(T1,"Power dissipation in watt is : ")

// Note: In the part (iv), the wrong value of I_B1
   and bita is putted, these two value is putted of
```

```
the Example 7.1
//          (i.e. I_B1= 19.8 mA and bita= 50) whereas in this example the value of bita is given 100 and the value of
//          of I_B1 is calculated as 10 mA. So the answer of the last part of this example is wrong.
```

Scilab code Exa 7.3 Base emitter and zener diode current

```
// Exa 7.3
clc;
clear;
close;
// Given data
bita= 50;
R1= 1;// in  k
R1= R1*10^3;//in
R2= 500;// in
R3= 400;// in
R4= 600;// in
V1= 10;// in V
V2= 20;// in V
I_B1=19.2*10^-3;// in A
I_L= 1;//in A
V_Z= 5;// in V
V_B= R4*V1/(R3+R4);//in V
V_BE2= V_B-V_Z;// in V
V_A= V1-V_BE2;// in V
disp(V_A,"The value of V_A in volt is : ")
disp(V_B,"The value of V_B in volt is : ")

// Part (ii)
I1= V1/(R3+R4);// in A
//I1= .01*10^-3;// in A
I2= (V2-V_A)/R2;// in A
```

```
//I2= .042;
I_C2= I2-I_B1;// in A
I_B1= (I1+I_L)/(1+bita);// in A
disp(I_B1*10^3,"The base current of T1 in mA is : ")
I_C2= I2-I_B1;// in A
I_E2= I_C2;// in A
disp(I_E2*10^3,"The emitter current of T2 in mA is : ")

// part (iii)
I3= (V2-V_Z)/R1;// in A
I_Z= I3+I_E2;// in A
disp(I_Z*10^3,"Current through zener diode in mA is : ")
V_CE= V2-V1;// in V
I_C1= bita*I_B1;// in A
T1= V_CE*I_C1;// in W
disp(T1,"Power dissipation in watt is : ")

// Note: In the book, the evaluated value of emitter current of T2 i.e. I_E2 and current through zener diode i.e I_Z is wrong because
//           there is a calculation error to evaluate the value of I2 (  (20-9)/500 = 42 mA is wrong, correct value is 22 mA)
```

Scilab code Exa 7.4 Resistance and current

```
// Exa 7.4
clc;
clear;
close;
// Given data
Vmin= 2.2;// in V
Vmax= 4.0;// in V
```

```
I= 11;// in mA
I= I*10^-3;//in A
Resistance= Vmin/I;// in
Current = Vmax/Resistance;// in A
disp(Resistance,"Resistance in   is : ")
disp(Current*10^3,"Current in mA is : ")
```

Scilab code Exa 7.5 Output voltage

```
// Exa 7.5
clc;
clear;
close;
// Given data
V1= 6.2;// in V
V2= 0.6;// in V
V3= 0.6;// in V
Vout= V1-V2-V3;// in V
disp(Vout,"The output voltage in volts is : ")
```